ROAD PRICING FOR CARS IN GERMANY?

An evaluation from an environmental and transport policy perspective

Umwelt Bundes Amt
For our Environment

Published by:
Umweltbundesamt (German Federal Environment Agency)
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April 2010

Design: UBA
Cover photo: © DeVIce / Fotolia.de

Content

1. Road pricing within the transport policy debate

Road pricing describes a charge for the use of a particular road network or section of road. The German truck toll (*Lkw-Maut*), which has been operating in Germany since 2005, together with experiences from other countries have engendered great expectations of passenger car road pricing. It is assumed that a financial instrument of this type would not only raise more money for the expansion of the road network and make traffic flows more efficient, but would also bring environmental benefits. The debate currently principally revolves around three different charging models for passenger cars:

- a **time-based charge** (known as a 'vignette' scheme after the toll sticker) allows the unrestricted use of a particular road network, for example the German motorway network, for a specific period of time;
- a **distance-based or pay-as-you-go charge** (the *Pkw-Maut* or passenger car toll) levies a charge per kilometre on the road network covered by the toll. The truck toll which operates in Germany and some other countries falls into this category;
- an **area-based charge** (city centre congestion charge) collects a charge for access to or travel through city centres.

In addition, infrastructure operators often impose a toll for the use of tunnels, bridges and passes. These tolls are usually intended to finance the construction and maintenance of the infrastructure in question. Examples of this are the Warnow Tunnel in Rostock or the Öresund Bridge between Denmark and Sweden. These types of one-off toll do not fit into any of the three above-mentioned models and so are not considered in this background paper.

Historically, road traffic has not covered all the costs it incurs. In Germany, in accordance with the non-hypothecation principle[1], taxes such as the fuel duty are not generally earmarked for a particular purpose. Consequently, there is no real point in setting the relevant taxes against the costs of road traffic, although it is appropriate for the purposes of illustration. It is only by balancing all the economic costs and all government revenues that valid conclusions can be drawn with regard to an appropriate charging rate. If taxes are included, then external costs must be too. In particular, external costs arising as a result of accidents or environmental damage are not currently covered. Table 1 shows the principal taxes and costs of road traffic.

The main difference between the various proposals for road pricing for passenger cars in Germany is their objectives. Most of the proposals are intended to raise revenues to finance infrastructure expansion and maintenance (*the financial objective*). Until now, with the exception of revenues from the truck toll, the road infrastructure has been funded almost entirely by the public purse. The German Federal Ministry of Transport, Building and Urban Development (*Bundesministerium für Verkehr, Bau und Stadtentwicklung (BMVBS)*) is planning a government commission on the 'user pays' principle. The commission's remit will be, "To develop solutions, in consensus with stakeholders, which will secure the stability and continuity of transport infrastructure funding for the future and which are fair to the user."[4]

The introduction of road pricing for passenger cars would support the transition from transport infrastructure being financed through taxation to a system where it would be financed by the users. The revenues could be used in part, as with the

Table 1: Balance of the principal, quantifiable taxes against the principal, relevant economic costs of road traffic in Germany in 2005[2]

	Revenues from (+) or costs of (-) motor vehicle **freight traffic** in billion euro	Revenues from (+) or costs of (-) motor vehicle **passenger traffic** in billion euro	**Total revenues** from or costs of passenger and freight traffic in billion euro
Energy tax on fuel (diesel/ petrol) / earmarked part of VAT on fuel duty (diesel) / truck toll	+11.6[3]	+26.9	+38.5
Vehicle taxes	+2.9	+5.8	+8.7
Parking and other charges	–	+1.6	+1.6
External environmental and accident costs	-15.8	-61.2	-77
Infrastructure costs, such as maintenance and replacement	-11.5	-19.9	-31.4
Total	**-12.8**	**-46.8**	**-59.6**

truck toll, to undertake improvements to other modes of transport. The aim of this would be to increase the possibilities for modal shift (travel shifting from the roads to other modes of transport), thereby reducing pressure on the road network.

The Federal Environment Agency (*Umweltbundesamt* – UBA) believes that transport should not only increasingly be funded by the user but that it should also be made more environmentally sustainable and economically efficient. Apart from the climate impact costs, transport incurs a wide range of other external costs which, from the point of view of society as a whole, should be minimised. These include the costs of air pollution, noise, accidents, land fragmentation and land consumption.

For this reason, the Federal Environment Agency is focusing its research in particular on models of road pricing for passenger cars which, in addition to the financial element, also aim to improve traffic flows and make more efficient use of the existing road infrastructure (*the traffic management objective*). Variations in toll rates depending on location or time can serve to distribute traffic volumes more evenly throughout the day or across the road network, thereby easing congestion and traffic jams and reducing the risk of accidents. In this way traffic flows and road traffic safety can be improved without the need for road expansion or new roads.

Finally, many proposals also have the aim of reducing the environmental impact of car traffic (*the environmental impact reduction objective*). This might be achieved, for instance, by imposing lower toll rates for quieter or lower-emission vehicles or higher charges for the use of areas under especially high pressure or in particular need of protection.

1. The **time-based toll** (*vignette scheme*) primarily fulfils the financial objective and does not provide the means to influence traffic flows or any real possibility of minimising environmental impact.
2. Proposals for a **distance-based toll** have both a financial and a traffic management objective. They can also be used to reduce environmental impact.
3. A **city centre congestion charge** should, in essence, manage traffic flows so that fewer individual motorised vehicles drive into city centres. This also has an important role in reducing environmental pressures. In addition, this charging model can also be used to finance transport infrastructure projects.

This background paper presents the different charging models and evaluates the pros and cons of each one with regard to the three objectives ('financial', 'traffic management' and 'environmental impact reduction') and the administrative costs associated with introducing and monitoring them. The technical aspects of the different charging models are only considered in passing. In addition, for each model this paper also provides a brief overview of other possible instruments which could be used to achieve the objectives of road pricing for passenger cars and summarises the results.

2. Time-based toll: vignette

The time-based toll, also known as the vignette system in reference to the toll sticker or vignette which is displayed on the windscreen of participating vehicles, charges vehicles a time-based fee: for example, a flat rate for the period of one year. The rate is usually based on the average costs incurred per car on a particular road network. The purchase of a vignette allows unlimited use of this road network within the period for which it is valid, for example on all motorways in Germany for a period of 12 months. The advantage of the vignette is that the road network no longer has to be financed from the public purse to the same extent as previously. Instead the users contribute a much higher proportion of the costs. The essential disadvantage, however, is that the vignette can only be used to a very limited extent to fulfil the 'traffic management' and 'environmental impact reduction' objectives.

Austria is an example of a country which has many years' experience of the vignette model for its motorways and expressways. Drivers of vehicles up to 3.5 tonnes who wish to use the motorways and expressways must purchase a one-year, two-month or ten-day vignette from one of around 7,500 sales outlets. The cost of the one-year vignette is currently €76.20. The Austrian road administration company (*Autobahnen- und Schnellstraßen-Finanzierungs-Aktiengesellschaft (ASFiNAG)*) sells around 21 million vignettes each year, in the form of stickers which are applied to the vehicle's windscreen. In addition to the vignette, there is a special, pay-as-you-go charge for Alpine crossings which experience particularly high levels of transit traffic.[5]

2.1. Potential contribution to financing road infrastructure

The German road network is used by around 50 million cars. If the vignette system were to cover the entire costs incurred by cars to the whole road network, the revenues raised through it would have to be around €20 billion per year

(see table 1). This would mean a vignette price of about €400 per year. If the vignette system were to be applied only to the motorway network, the price would be around €100. It would also be possible to finance a proportion of the costs of the road network from the public purse and to set the price of the vignette at a lower rate.

The vignette system could place the entire burden of the road network costs associated with cars on to car drivers and thus replace the current funding from the German Federal government budget. However, this model of placing a flat-rate cost burden on car drivers does not distribute it fairly, as they pay the same amount, whether they drive a lot or only a little. Thus people who only use the road network occasionally would have to contribute disproportionately highly to the financing of the road network. In contrast, for people who drive a great deal the vignette would have the advantage that the average cost per kilometre would be reduced as distance driven increased.

2.2. Potential contribution to traffic management

The vignette system cannot be used for time-based or location-based traffic management and to reduce traffic volumes because it is a model which only affects the decision whether or not to use a particular road network at all. The time-based vignette does not result in traffic flows being redistributed more evenly to reduce congestion and the risk of accidents. In fact, this system may even have a negative effect in this regard, since a vignette restricted to motorways creates an incentive for occasional users to avoid motorways and make greater use of the rest of the road network.

In Austria the vignette caused a proportion of traffic to shift to using the toll-free parts of the road network. When the vignette was introduced in 1997, ASFiNAG, the company responsible for toll collection and monitoring, recorded a shift of around two per cent, which has since declined to around 0.5 per cent.[6] It is likely that this shift would be greater in Germany, as the German road network is denser than in Austria and there are sufficient alternative routes to allow drivers to avoid the motorways and expressways covered by the toll.

2.3. Potential contribution to reducing environmental impact

A vignette system can only contribute to a limited extent to relieving environmental pressures. The increased cost of driving which may be associated with this model could support the decision not to use the car and to transfer to other, more environmentally sustainable modes of transport instead. However, this is not borne out by experiences in Austria, where there is very little evidence that the vignette has led to car drivers transferring to public transport.

If the cost of the vignette were to be varied depending on vehicle emission levels, it could create greater demand for more environmentally sustainable vehicle types and thus promote an increased prevalence of lower-emission vehicles.

Since the cost of the vignette is the same for people who drive a lot and those who only drive a little, it would have very little overall impact on reducing the distances driven and thus the environmental impact of car driving. On the contrary, the vignette could lead to a situation where drivers who previously only occasionally used the trunk road network might make use of detours and shift to using toll-free roads. These alternative routes tend to go through built-up areas more than is the case with trunk roads and so residents in these areas would experience higher levels of noise, air pollution and the risk of accidents.

2.4. Administrative and other aspects

There are fewer legal problems, such as data protection issues, with a vignette model than with a distance-based toll. Furthermore, the costs of introducing, selling and monitoring the vignette are also considerably lower. The cost of selling and monitoring the Austrian passenger car vignette amounts to around eight per cent of the revenues. In comparison, the costs of the special Austrian pay-as-you-go charge represent around ten per cent of revenues and in the case of the Austrian truck toll they are around 14 per cent.

2.5. Possible alternatives

An alternative to the vignette would be a supplement to the vehicle tax, the revenue from which would be used to maintain and expand the road network. This supplement would also be time-based and linked to the vehicle and would not vary depending on the distance driven. In addition, potential undesired consequences, such as a shift to more minor roads, would be avoided, since the supplement would not be linked to the use of a particular road network. It could serve to enhance the incentives already contained in the vehicle tax to buy lower emission vehicles. The inclusion in the vehicle tax since 2009 of a CO_2-emissions element also allows more targeted climate impact management.

One disadvantage of the tax supplement is that it would only apply to vehicles registered in Germany and so foreign-registered vehicles would not make any contribution to financing the German road infrastructure. The administrative

cost of introducing, collecting and monitoring a vehicle tax supplement would be much lower than for the vignette. Since July 2009, the revenues from the vehicle tax, which previously went to the German Länder, now go to the Federal Government (Article 106, para. 2, part 3., Basic Law *(Grundgesetz)*). As a result, it would now be possible to finance the Federal trunk roads with the aid of a vehicle tax supplement.[7]

2.6. Summary

The vignette could involve car drivers in the financing of the road network. However, it does not distribute the burden of costs fairly, as it is a flat rate, regardless of the distance driven. The potential for this model to be used to relieve environmental pressures and influence traffic flows is minimal. In addition, it could lead to drivers taking undesired detours along toll-free minor roads. The administrative costs of introducing this model are comparatively low.

A supplement to the vehicle tax could achieve better financial and environmental results at lower additional costs. Furthermore, the shift in 2009 of revenues from the *Länder* to the German Federal government has the advantage that the Federal government could use the vehicle tax revenues to finance its road network.

3. Distance-based toll: passenger car toll

A distance-based or pay-as-you-go toll is calculated on the number of kilometres driven on a particular road network. It is an instrument which has been used in France, Italy and Canada. This type of toll is often used to fund new road construction, as well as in some cases to generate revenues to finance other aspects of transport policy. It is principally effective at distributing fairly the costs of the road network (infrastructure costs), as well as accident, environmental and health costs. It can replace taxation of vehicles not used for the commercial transportation of goods or people.[8]

If the passenger car toll were to be varied according to traffic volumes by time and by region, it could also have a targeted impact on traffic volumes. A distance-based toll also has environmental benefits because it provides incentives to reduce traffic volumes and effect a shift to other modes of transport. However, this only applies if the overall cost of private car use increases as a result of the toll. Furthermore, by including variations to take account of environmental aspects of vehicles, the toll can promote technical innovations, thereby leading to fleet renewal.

3.1. Potential contribution to financing road infrastructure

If the costs of the German Federal motorway and trunk road networks attributable to passenger cars were to be met through a distance-based toll in their entirety by those incurring them, the tolls for the different types of vehicles would be set as shown in table 2. The table only shows the total infrastructure expenditure for Federal motorways, trunk roads and highways. External costs, such as the damage suffered by residents due to noise and pollution are not accounted for in this table. A passenger car toll for the whole road network would produce similar toll rates.

Table 2: Average infrastructure expenditure in 2007 for German Federal trunk roads in euro per vehicle kilometre (€/km)[9]

Vehicle category	Federal motorways	Federal highways	Federal trunk roads total *
Cars	0.03	0.04	0.03
Trucks under 12 tonnes authorised total weight	0.06	0.09	0.07
Trucks over 12 tonnes authorised total weight	0.17	0.27	0.19

* weighted proportionately by distance travelled

On this basis, cars would pay an average of three euro cents per kilometre for the use of Federal trunk roads.[10] Since the payment of the toll is directly linked to distance travelled, the charge to the driver is fair and proportionate. Foreign vehicles would also contribute proportionately to infrastructure expenditure. However, this would not apply to drivers who mostly or only use toll-free roads, unless the entire road network were to be included in the toll.

3.2. Potential contribution to traffic management

The toll can be varied according to time-based, location-based and environmental criteria, rather similar to the existing truck toll which varies according to emission category. Higher toll rates for accident-prone or frequently congested roads or during periods of particularly high traffic volumes can contribute to a more even distribution of traffic flows, prevention of congestion and traffic jams, a reduction in the risk of accidents and a more efficient use of the existing road infrastructure capacity.

Experience in other countries provides evidence of effectiveness. For example, the operators in France

vary the level of the road-use charge on some motorways according to peak traffic times and emission levels, in order to achieve a better distribution of vehicles over peak and non-peak times, as well as a shift to less busy minor routes. Since 1992 the toll on the A1 motorway from Lille to Paris has been varied depending on time of day and emissions. The toll is 25 per cent higher than the standard rate during peak times and 25 per cent lower during periods with low levels of traffic. This strategy has led to a ten per cent reduction in traffic volumes during peak times.[11]

However, the experiences in France cannot be seamlessly transposed to Germany, since a key factor in the French projects is that there is little in the way of attractive alternative routes. In contrast, the German motorway network is much denser and more tightly interwoven with the rest of the road network, which could thus expect to experience a heavier burden of traffic.

In general, a toll restricted to particular roads produces an undesired effect, namely that a proportion of the traffic will choose to take a detour on other roads in order to avoid the toll. Where the toll road is overloaded, this may have the effect of redistributing the traffic more evenly over the remaining road network capacity. However, this redistribution may often be associated with higher risks of accidents and increased environmental pressures, as many of the toll-free alternative routes go through built-up areas.

The experiences with the truck toll indicate that there is likely to be a great deal of diverted traffic on many parts of the subsidiary road network, especially on short cuts, parallel routes and minor detours. If high levels of diverted traffic were to occur, it might be necessary to impose a toll on these roads as well. This solution has already been applied to some extent in the case of the truck toll. Alternatively, the detour routes must be made sufficiently unattractive, by means of structural alterations and traffic restrictions, so as to discourage diverted traffic.

The problem of diversion would not arise if the passenger car toll were to apply to the entire German road network.

3.3. Potential contribution to reducing environmental impact

A distance-based toll can ensure that environmental costs are paid for proportionately by those responsible for them. It can also provide incentives to reduce the environmental impact of vehicle use. If, in addition to meeting the costs of the road network (see Table 2), the passenger car toll were also to distribute external environmental impact costs fairly among those who incur them, an additional charge of around three euro cents per kilometre would have to be levied.[12]

Environmental benefits can also be delivered by varying the toll rates. A gradation of the toll on the basis of environmental factors could encourage the purchase of more modern, less polluting vehicles (fleet renewal).

The introduction of the truck toll in Germany, and the fact that there was a gradation, initially of 50 per cent depending on emissions category, had the effect that in the period from 2005 to 2006 alone the proportion of truck mileage on German motorways accounted for by low-emission, pollution standard Euro 5 trucks rose from one to six per cent. The proportion of total mileage driven by Euro 1 and Euro 2 trucks decreased by almost exactly the same amount.[13] It may be assumed that the introduction of a passenger car toll scaled according to environmental factors would have a similar effect on the new registration of greener cars, since the average age of cars registered in Germany is 8.2 years, which is very similar to the average age of German-registered trucks (7.9 years)[14]. However, some measure of fleet renewal is to be expected in any case in 2009, as a result of the 'environmental premium'.[15]

A distance-based toll also creates incentives to increase the number of people travelling in each vehicle and to shift journeys to public transport. A distance-based toll induces car drivers to choose less distant destinations or to forego some car journeys altogether, especially in the case of journeys undertaken for the purposes of shopping, leisure and holidays.[16]

If the toll were to be varied on the basis of the environmental sensitivity of particular times and sections of road, for example for noise control purposes, this could also contribute to managing traffic volumes in a more environmentally sustainable way.

3.4. Administrative and other aspects

Passenger car toll based on the existing truck toll system

The satellite-controlled recording system already installed in Germany for the truck toll would, in principle, be suitable for the recording requirements of a distance-based passenger car toll, although it would need to be extended and technically modified. The German truck toll system is a 'free flow' system by means of which the infrastructure user is logged automatically. The key element of the automatic system is an on-board unit (OBU) which performs the vehicle logging func-

tion and the calculation of the charge.[17] However, the technical challenges of expanding the truck toll system to passenger cars are considerable. Around 45 million cars would have to be added to the one million trucks already covered by the system. It is not clear what the costs of installing a passenger car toll system and the running costs for collecting, logging and monitoring the toll would be in relation to the revenues raised through the toll.

An important element in the evaluation of a passenger car toll are the anticipated costs for the installation, collection and monitoring functions of the system. For example, the monitoring element requires mobile units and stationary monitoring units in car parks. Because of the much higher number of participating vehicles, the costs of monitoring would be significantly higher than is the case for the truck toll.

The infrastructure expenditure calculation for Federal trunk roads assumes that the administrative and operating costs of a motorway toll system (excluding the costs of the toll collection system) would be €400 million per year for trucks and €850 million per year for passenger cars. It seems doubtful whether the very much higher number of car journeys (as compared to journeys by truck) could be covered by slightly more than double the budget for administrative and operational costs. It may be assumed that the installation, collection and monitoring costs of a passenger car toll are considerably higher than for the existing truck toll.

It should furthermore be noted that a technically complex solution for a passenger car toll on the model of the German truck toll would also involve additional resource consumption. For example, on-board units may contain toxic materials such as mercury in the circuit boards and consume energy during their production. The electronic monitoring systems, which use steel and concrete masts, also use additional resources.

A passenger car toll on all roads in Germany would not only avoid the issue of diverted traffic, but could also simplify the toll collection process and thereby be cheaper to set up, as there would be no need to differentiate between different road types. The charge would then simply be based on the total mileage travelled by a vehicle within Germany.

A toll system is being planned in the Netherlands which would apply to every kilometre driven by a motor vehicle in the Netherlands. The aim is to have a variable toll, depending on geographical, time-based and, above all, environmental factors. The idea is that incentives would thereby be offered to avoid congestion and thus to manage traffic in a more environmentally sustainable manner. All existing vehicle taxes would then be abolished. Known as the Kilometre Charge, the intention is to bring in the toll for passenger cars in 2012 at an average rate of three euro cents per kilometre and to raise it incrementally until it reaches an average rate of 6.7 euro cents per kilometre in 2018. The cost-benefit analyses are positive for almost all the variations considered. As with the German truck toll, the recording system in the Netherlands is intended to be satellite-controlled. “A GPS device, which will record the distance travelled as well as the time spent travelling and the journey made, will be installed in every vehicle. This device will send the information to a collection facility where invoices will be drafted.”[18]

Passenger car toll using a mileometer

In principle, it would be possible to record the distance travelled using a tamper-proof mileometer in each vehicle. To ensure that journeys made abroad or on parts of the road network not covered by the toll, the mileometer would have to switch off automatically as soon as the vehicle left the part of the road network covered by the toll, for instance at all border crossings. Technical solutions would have to be developed for this, such as a device which would emit a signal at the border.

This type of system is similar to the Swiss distance-based heavy vehicle charging system, the collection costs for which are comparatively lower. The Swiss system operates without satellite-controlled recording and, unlike the German truck toll, does not have to identify with legal certainty on which type of road the toll-paying vehicles are driving. On leaving Switzerland, either the electronic recording unit (OBU) is switched off or the mileage is recorded by hand.

For technical reasons the Federal Environment Agency currently still takes a negative view of the idea of levying tolls on passenger cars based on a reading from the mileometre. The risk of the mileometre being tampered with is high and requires costly technical monitoring solutions. It would only be with the renewal of the car fleet that safer technical solutions could make tampering with mileometres much more difficult, though even then it would not be possible to prevent it altogether. It is also unlikely that it would be possible to retrofit older cars.

Vignette for exceptions

Another important aspect is how to deal with foreign drivers who are only occasional users of

the German road network. This is of particular relevance with a system where charging largely relies on an on-board recording unit, whether it be satellite-controlled or mileometer-based. Requiring foreign users to have an OBU installed in their vehicle would, in certain cases such as for foreign tourists, give rise to disproportionately high costs. One alternative would be a short-term vignette, which the driver could purchase from various entry points to the road network covered by the toll. The cost of the vignette would have to reflect a relatively high mileage and could only be for a short period, such as between one and ten days. The disadvantage – that the mileage driven by foreign drivers would not be priced to accurately reflect the costs incurred – would just have to be accepted for what is a limited number of foreign vehicles.

3.5. Possible alternatives

Might the aims of a distance-based toll be achieved more cheaply with alternative methods? It is important to consider this question, in particular against the background of the investment and administrative costs involved.

It would be possible to raise funds cost-effectively on a user-pays basis by means of a *tax on fuel consumption*, levied for example as an infrastructure expenditure supplement to the energy tax on fuel (fuel duty). In this context, an increase in fuel duty rates in neighbouring countries would be useful, for example forming part of a harmonisation of fuel duty rates in the EU to a higher level than exists today.[19]

If Germany were to go it alone and increase fuel costs by placing a supplement on fuel duty, it might lead to 'grey imports'[20] where large quantities of fuel bought abroad would be imported into Germany in vehicle fuel tanks. This 'grey importing' is of particular significance in the case of trucks plying cross-border routes. In addition, domestic car drivers could travel abroad and fill their tanks under a cheaper taxation regime – known as 'fuel tourism'. Both groups of vehicle users would not thereby be bearing the infrastructure costs they incur.

Traffic can also be managed by tried and tested *transport planning and traffic regulating measures*, for instance with traffic control systems, variable lane direction indicators, speed restrictions, overtaking bans, access restrictions, ramp metering and priority lanes for low-emission vehicles. A combination of such measures could be used to achieve some elements of the environmental benefits for which a passenger car toll might be introduced.

3.6. Summary

An increase in fuel taxation – preferably EU-wide – would be the simplest and most cost-effective means of assigning the costs of road traffic proportionately to the user.

However, a distancebased car toll has a number of advantages over a tax on fuel consumption. In addition to user-pays funding of the transport infrastructure (calculated exactly by distance travelled and road category), there would be the option of achieving traffic management objectives with variable toll rates. This would lead to a more efficient use of the road infrastructure and could make expensive and resource-intensive expansion and construction of new roads unnecessary. Furthermore, criteria-based toll variations (for instance by pollution or noise criteria) could provide incentives to reduce environmental impact.

The Federal Environment Agency sees advantages over other toll models in the introduction of a passenger car toll for the entire road network, since the adverse effects of diverted traffic for residents and the environment could be avoided and the costs of collecting the tolls could potentially be lower. If this model were to be implemented, it would be possible, as planned in the Netherlands, to abolish car tax for all passenger cars not used for the commercial transportation of goods or people.

4. Area-based charge: city centre congestion charge

The city centre congestion charge is restricted to a comparatively small area within a city or region. It levies a toll for entering or driving through a particular area, for instance, the city centre or a particularly congested part of the city centre. The toll rate is not linked to the distance travelled. There have been city centre congestion charging schemes in numerous cities around the world for many years.[21] For example, schemes were introduced in Singapore in 1975 and in the Norwegian cities of Bergen, Oslo and Trondheim at the beginning of the 1990s. All these schemes have been extensively modified and adapted. Since the Congestion Charge was introduced in London in 2003 discussion of this type of instrument has been much more prevalent in policy debates. In 2006 Stockholm introduced a congestion charge and there is one planned for introduction in Gothenburg during 2013. Table 3 uses three case studies to illustrate different possible charging models.

	Stockholm	London	Singapore
Objective, Date of introduction	Environmental and traffic management objectives, 2006	Environmental and traffic management objectives, 2003	Environmental and traffic management objectives, 1975
Income in € million per year	approx. 95	approx. 290	approx. 40 to 50
Type of toll collection and associated costs (as % of revenues)	Cameras and dedicated short-range communication (DSRC)[23], 40% dropping to 25% in 2010	Cameras with registration plate recognition, approx. 50% (2007)	Cameras and DSRC, 15% to 20%
Set-up costs in € million	approx. 200	approx. 150	approx. 100
Charge in €	per entry / exit into/out of charging zone <3.5 tonnes: 2.60 >3.5 tonnes: 5.20	approx. 9.50 per day, residents: 90% discount	Cars: approx. 2.30 per journey Trucks: approx. 10.50 per journey
Differentiation	By day of the week and time	By day of the week and propulsion type	By time, traffic flow and propulsion type
Results	22% less vehicle traffic, shorter journey times, road infrastructure investment	15% less vehicle traffic, congestion reduction of 30% to 40%, investment in public transport	approx. 10-20% less vehicle traffic, traffic flows accelerated, far-reaching investment in public transport

Table 3: Examples of city congestion charging schemes[22]

The above-mentioned urban road pricing schemes are integrated in different ways into a comprehensive package of town planning, transport policy and environmental policy measures, from urban land-use planning to parking management and the designation of 'low emission zones'[24]. Each scheme is a unique solution, tailored to the local characteristics and requirements. An evaluation of the experiences in these cities shows that a congestion charge implemented without being integrated into a raft of other measures will not be able to deliver environmental and transport improvements. Furthermore, the success of a city congestion charge is extremely doubtful if a number of conditions and logistical issues are not taken into account (see Section 4.4).[25]

4.1. Potential contribution to financing road infrastructure

Although the city centre congestion charge is chiefly a transport management tool, it does also contribute to city transport infrastructure funding. For example, the cities of Stockholm, Oslo, Bergen and, until 2005, Trondheim[26] use the revenues from their road charging schemes primarily to finance road infrastructure. London and Singapore use the revenues from their congestion charges in particular to expand public transport provision. In London revenues are lower than expected, since the number of journeys incurring the Congestion Charge has decreased significantly and the cost of collecting the charge is very high.

4.2. Potential contribution to traffic management

A city centre congestion charge can, in principle, be used to manage traffic volumes and flows, for example in order to prevent traffic jams. Experience shows that the introduction of a city centre congestion charge leads to a reduction in traffic volumes during peak times and noticeably speeds up traffic flows.[27] Moreover, a toll which is varied by time and location can also be used in a targeted way to relieve traffic pressures. In Singapore the electronic road pricing system is linked to traffic flow. If the average speed drops, the City increases the charge during peak times by 25 per cent per journey until the average speed reaches the desired level again. The result has been a 20 per cent shift of traffic to less demand-intensive times.[28] In Stockholm the charge is scaled according to the time of day, so that traffic volumes are more evenly distributed over the course of the day.

If revenues are simultaneously put into improving public transport provision, the volume of car traffic decreases further, as has been seen in London, with people transferring to buses and trains. Nevertheless, traffic volumes and parking pressures may increase in and around the toll zone, unless appropriate transport planning measures are implemented to counteract this.

4.3. Potential contribution to reducing environmental impact

The city centre congestion charge can contribute to reducing environmental impact by keeping a proportion of passenger car traffic out of the city

centre and preventing congestion. Unless toll rates include variations based on environmental factors, the only environmental benefits will be those arising from the effect of traffic reduction and modal shift. Lower charges for more environmentally sustainable vehicles could provide added incentives for increased use of low-emission and more efficient vehicles. This also makes it easier for local authorities to comply with the limit values for fine particulate matter and oxides of nitrogen set by the EU air quality directive. In Stockholm, exempting alternative fuel vehicles from the congestion tax led to an increase in such vehicles from three to 11 per cent in less than a year.

The fact that the potential for varying charging rates is so rarely exploited is largely due to the high associated costs of collection and monitoring. In addition, the city centre congestion charge generally only applies to a relatively small area of a city and so has no impact on the vast majority of transport-related pollution.

As mentioned above, from the environmental perspective a city centre congestion charge can lead to undesired diversion effects. Alternative routes and detours, especially in the area immediately adjacent to the toll zone, can lead to increases in traffic volumes.

A congestion charge which is restricted to the very centre of a city can bring about changes in the traffic flows between the city centre and the outskirts and surrounding area. This can also have an impact on the spatial and functional structure of the city, for instance when supermarkets relocate to the 'green belt' on the edge of the city. There are likely to be conflicts with urban development objectives, especially city centre development objectives such as quality of life with cultural diversity and 'short distances'.[29] For example, retailers might be concerned about an absence of car-driving customers and therefore choose locations outside the toll zone, with resulting decline and abandonment in the city centre area. The consequence of this would be longer routes to work and shopping facilities or poorer public transport provision, neither of which are desired environmental policy outcomes.

In order to limit such negative consequences, additional planning and regulatory measures are essential. Attractive provision for non-motorised transport (cycling and walking) within the toll zone is thus indispensable. Continuing modifications to the design of the charging system are also vital for the successful long-term implementation of environmental objectives in and around city centre charging zones.

4.4. Administrative and other aspects

Similar to the distance-based passenger car toll, in the design of a city centre congestion charging scheme there must be a trade-off between the administrative costs and the rate differentiation driven by transport and environmental policy. The greater the variations in rate on the basis of time, place and vehicle, the greater the demands on the technical and administrative collection and monitoring systems. While schemes like the one in Oslo, which have a purely financial objective, only consume ten per cent of revenue for ongoing operational costs, schemes with traffic management objectives require between 20 and 40 per cent.[30]

On the other hand, a charging system with fewer rate variations would not provide transport management and environmental benefits on the same scale. The congestion charging schemes implemented so far have a comparatively simple charging structure. The toll is collected per entry or per transit without any differentiation on the basis of time, vehicle type or emissions. Very few experiments have been undertaken with the technical aspects of variable charging systems and, where they have, it is a matter of one-off solutions and their potential effectiveness is not readily transferable to the situation in German cities. Cost-effective alternatives with comparable results are dealt with in Section 4.5.

There could be data protection issues if the information on individual vehicles gathered for the collection and monitoring of the congestion charge were to be used for other purposes, such as police investigations or combating terrorism.

The key requirement for the meaningful application of a congestion charge is the existence of a city centre with strong, incoming traffic flows, such as is the case in London and Stockholm. If a large number of journeys take place outside the charging zone (perhaps because the zone is too small), the administrative costs may soon exceed the benefits. An extension of the charging zone may not always be the solution in this case, for if too many journeys take place within the charging zone (and the toll rate is lower), the effectiveness of the congestion charge as an instrument would be severely weakened. In particular in cities which are polycentric in structure, such as Berlin, a city centre congestion charge is not a plausible solution.

In transport and environmental policy terms, a city centre congestion charge will only work if it is part of a carefully tailored and coordinated pakkage of measures. Numerous studies on successful and failed city congestion charging schemes consistently list the following success factors:[31]

- severe pressures owing to the scale of traffic problems in the city;
- serious commitment on the part of the city concerned;
- a favourable legal framework and clear division of responsibilities;
- a simple and reliable technical system with effective sanctions for toll dodging;
- good privacy security; and
- free installation of any OBU required to register entry and exit to the charging zone.

In addition, it is important that:
- all stakeholder groups are involved in the planning process from the early stages;
- particularly disadvantaged groups are supported, for example with discounts or tax adjustments;
- there is open communication and information (media marketing); and
- a proportion of the revenues is earmarked for the funding of attractive alternative transport options.

Also of importance are accompanying measures to prevent detour responses and diversions (for example, exempting certain through roads from the congestion charge), as well as enhancing the alternatives to car travel in the city centre (public transport, walking and cycling). Equally important is a parking policy tailored to local requirements (cutting the number of parking spaces and managing them by means of parking charges), traffic planning measures (extensive traffic calming), regulatory measures (for example, local speed restrictions, no thoroughfare for certain types of vehicle and at certain times) and traffic management measures (such as traffic guidance systems or ramp metering).

4.5. Possible alternatives

Extensive traffic calming can be an important factor in encouraging more environmentally sustainable modes of transport, such as walking and cycling and public transport. It leads to a reduction in noise pollution,greenhouse gases and air pollution[32] and to a safer road environment.[33]

Car drivers do not always abide by speed restrictions in urban areas. Instances of the speed limit being broken are contingent not only on enforcement systems but also on the perception of the width of the road and how well designed the road environment is. Therefore, regulatory measures such as speed restrictions should be accompanied by modifications to the road environment. In many German cities residential areas are characterised by parked cars along the sides of the roads and on pavements, meaning that pavements are often only partially usable. Furthermore, in many cases there is a lack of adequate cycle parking facilities.

It is important that, where possible, consideration of traffic calming measures is included at the planning stage for new roads and in urban and neighbourhood development. Slower traffic takes up less room and the space gained can be used for town planning improvements such as cycle paths, wider pavements, unsealing surfaces and other greening measures and enhancements of street life quality.[34] However, local authorities too often end up using the space gained to create parking spaces ‘at the doorstep’ for residents. Parked cars take up space and also encourage the use of cars for short journeys.[35]

For this reason residents’ parking spaces should be situated as compactly as possible at the edge of the residential area. Parking places adjacent to residential buildings should function as short-term stopping places.[36] Local authorities and operators of private car parks (for customer and staff car parks, for example), should charge parking fees which cover their costs. As a guide, economic costs of around €500 per parking space per year might apply.[37] In addition to cost-covering charges for residents’ parking, traffic management is also benefited by managing parking in areas with high levels of incoming traffic, such as city centres.

Germany’s vehicle labelling system has been in force since 2007.[38] It covers the nationwide harmonised labelling of vehicles on the basis of their emission rates and facilitates local authorities in the establishment of ‘low emission zones’. Towns and cities can impose driving restrictions on cars and trucks, depending on emission rates classed according to four emissions categories. Vehicles with particularly high emissions are excluded from driving in the ‘low emission zone’.

If the local authorities were to use the potential of the labelling regulation consistently, it would be possible to effect significant improvements in air quality in German city centres. In addition to the improvements in levels of particulate matter which might be expected, the Federal Environment Agency considers that ‘low emission zones’ can also reduce nitrogen dioxide pollution affecting people and the environment.

In 2008 Berlin was one of the first cities in Germany to introduce a ‘low emission zone’ and was also the first city to produce an impact analysis. In April 2009 the Berlin Senate announced that the ‘Umweltzone’ reduces concentrations of pollutants hazardous to health. In 2008, diesel ex-

haust particulate levels fell by 28 per cent compared with 2007. Nitrogen oxides declined by 18 per cent compared with 2007.[39]

4.6. Summary

Under certain circumstances, a congestion charge can help local authorities to fulfil transport and environmental objectives. However, it may involve high administrative costs. Examples from other countries where, in addition to the financial aims of the scheme, environmental and traffic management objectives were pursued, illustrate that environmental targets were actually exceeded.

However, a city centre congestion charge can be counterproductive if account is not taken of specific local characteristics and success factors, including in particular public transport enhancement and accompanying transport planning measures, which should be commenced in advance of the introduction of road charging. The key requirement for a congestion charge is the existence of a city centre with a high level of incoming traffic. City centre congestion charging schemes often fail due to a lack of public acceptance, unless the objectives are absolutely transparent and there is a binding commitment to earmark at least a proportion of revenues for improving traffic conditions and relieving the pressure on particularly badly affected residents.

A case-by-case assessment is essential for each individual city, with the involvement of all stakeholders, in order to ascertain whether and to what extent a city centre congestion charge would be more suitable than possible alternatives to solving city centre traffic problems. Note should also be taken of the fact that, because of the different conditions which may apply, the experiences of the congestion charge in other countries cannot simply be transposed to German cities.[40] Under the existing legal and administrative conditions in Germany and with the technical solutions currently available for the collection and monitoring of a city centre congestion charge, the Federal Environment Agency believes that overall, although challenging, it would not be impossible to implement congestion charging schemes.

5. Conclusions

Around €47 billion of the costs incurred by car traffic are not covered by the taxes and duties currently levied. Therefore road user charging systems are appropriate.

Road pricing schemes should be designed in such a way that they provide incentives to make transport more environmentally sustainable. The harmful effects of traffic, such as greenhouse gas emissions, noise, air pollution, accidents, land fragmentation and land consumption should be prevented, if possible, or at least reduced.

City centre congestion charging presents a possible solution if certain town planning and transport preconditions are fulfilled. These include the existence of a monocentric city structure with heavy incoming and outgoing traffic flows. In order to be successful and to gain widespread public acceptance, it must form part of a package of local transport and environmental policy measures. Essential to this are, among other things, good communication with the public and investment in attractive public transport and transport planning improvements. A congestion charging scheme must also be accompanied by management of public parking by means of parking charges, as well as management of private parking targeted at modal shift. The price of parking should reflect the costs of parking space provision. A case-by-case assessment should be carried out as to whether these measures might actually be implemented in place of a city centre congestion charge.

From the point of view of environmental protection, the vignette offers very few advantages over the status quo. On the contrary, it may even provide incentives (once a vehicle sticker has been purchased) to increase car use.

An increase in fuel taxation – preferably EU-wide – would be the simplest and most cost-effective means of assigning the costs of road traffic proportionately to the user. However, the distance-related passenger car toll and the congestion charge enable additional incentives to be implemented, as they allow variable charging rates depending on traffic volumes, selected route and intensity of noise pollution and emissions. These variable rates create incentives which speed up the move towards low-emission, quiet, climate-friendly cars. Both charging models also offer the possibility of using variable toll rates for traffic management objectives. This leads to a more efficient use of the road infrastructure and can mean that expensive and resource-intensive new roads and road expansion schemes are no longer necessary.

With regard to the distance-based passenger car toll, it is not currently clear whether the cost of installing a passenger car toll system and the running costs for the installation, collection and monitoring of toll revenues would be proportionate. Furthermore, in terms of protecting resources, the environmental benefits would have to be balanced against the additional environmental impact associated with the recording system. If the car

toll were to be applied to the entire German road network, rather than just part of it, such as the motorway network, the collection costs would be lower due to simplified recording equipment. In addition, unwanted diversions to the rest of the road network would be avoided.

Against this background, the Federal Environment Agency considers the introduction of a distance-based passenger car toll covering the entire German road network to be the most appropriate and goal-oriented of the charging models discussed.

[1] The non-hypothecation principle is a fundamental principle governing the allocation of public spending, according to which all revenues go into a single pot to cover all expenditure. This principle gives the legislator the freedom to decide without restriction how revenues are spent. Thus individual revenue sources are not tied to specific purposes.

[2] Hirte, G. (2008): Abgaben als Instrumente zur Kostenanlastung von externen Kosten und Wegekosten im Straßenverkehr, TU Dresden.

[3] Instead of the toll revenues of €2.6 billion suggested by Hirte (2008), the Federal Environment Agency uses the Federal Ministry of Transport, Building and Urban Development figures to calculate a revenue of €2.9 billion.

[4] Deutscher Bundestag (2009): Finanzierung der Verkehrsinfrastruktur des Bundes – Antwort der Bundesregierung vom 28.12.2009 (Drucksache 17/370), p. 3, Berlin.

[5] ASFINAG: Das österreichische Mautsystem, Salzburg, no date given. www.asfinag.at.

[6] Beckers, T.; Brenck, A.; von Hirschhausen, C.; Klatt, J. P. (2005): Die ASFINAG und das österreichische Modell der Fernstraßenfinanzierung, TU Berlin – Fachgebiet Wirtschafts- und Infrastrukturpolitik (WIP), Working Paper 2005.

[7] Deutscher Bundesrat (2009): Plenarprotokoll 856. Sitzung, Berlin, Friday, 6 March 2009, Pressemitteilung des Bundesrates No. 38/2009, 06.03.2009.

[8] According to case law of the European Court of Justice, exempting German transport operators from the vehicle tax on introduction of a toll would contravene the provision prohibiting less favourable treatment contained in Article 92 TFEU (ex Article 72 TEC).

[9] IWW / progtrans (2007): Aktualisierung der Wegekostenrechung für die Bundesfernstraßen in Deutschland (Endbericht), Basel/Karlsruhe. / Federal trunk roads total: calculation by the UBA.

[10] This does not take account of the costs of introducing, collecting and monitoring the toll. These costs would have to be added. Furthermore, this calculation does not take account of journeys which, as a result of the toll, might be made by alternative routes, shifted to other modes of transport or not made at all. These factors would also increase the toll rate which would need to be charged.

[11] Kossak, A. (2004): 'Straßenbenutzungsgebühren', in: Internationales Verkehrswesen, 12/2004, p. 538 f.

[12] UBA (2007): Hintergrundpapier: Externe Kosten kennen – Umwelt besser schützen: Die Methodenkonvention zur Schätzung externer Kosten am Beispiel Energie und Verkehr, Dessau.

[13] Bundesamt für Güterverkehr (BAG) (2006): Marktbeobachtung Güterverkehr, Sonderbericht: Eineinhalbjahre streckenbezogene Maut – Wirkungen auf das deutsche Güterverkehrsgewerbe, p. 22ff, Cologne.

[14] Federal Motor Transport Authority (Kraftfahrzeugbundesamt (KBA)), as at January 2009.

[15] The German Federal Government intended the 'environmental premium' (scrappage premium) to encourage the scrapping of old cars and the sale of new ones. In this way old cars with high emissions of pollutants would be replaced by new, cleaner vehicles. Cf. 'Richtlinie zur Förderung des Absatzes von Personenkraftwagen vom 20. Februar 2009 mit Änderungen der Richtlinie vom 17. März 2009 und vom 26. Juni 2009'.

[16] Verkehr in Zahlen 2007/8, p. 22. In 2007, shopping, leisure and holiday journeys represented 60 per cent of kilometres per person travelled in motorised private vehicles, Hamburg.

[17] Evangelinos, C. (2009): 'Mauteinführung, Mauterhöhung und Nutzerreaktionen in Deutschland', in: Wirtschaftsdienst 2009/8, p. 559, Hamburg.

[18] Ministerie van Verkeer en Waterstaat (Netherlands) (2009): Kilometre charge: most people will end up paying less; Press release, 14 November 2009; The Hague. <http://www.verkeerenwaterstaat.nl/english/news/newsitems/kilometrechargemostpeoplewillenduppayingless.aspx> (As at 29 March 2010 the political majority for the passenger car toll planned for the Netherlands from 2012 appears uncertain.)

[19] According to EU Directive 2003/96 of 27 October 2003, the minimum level of taxation applicable to diesel in the EU from 1 January 2004 is 30.2 cents per litre and from 1 January 2010 33 cents per litre. The rate for petrol (lead-free) is 35.9 cents per litre.

[20] The Federal Environment Agency estimated this effect as being in the order of almost five per cent of fuel sales in Germany in 2004. Cf. UBA (2005): Was bringt die Ökosteuer – weniger Kraftstoffverbrauch oder mehr Tanktourismus? (UBA background paper), Dessau <http://www.umweltdaten.de/verkehr/downloads/oekosteuer.pdf>

[21] A summary and evaluation of experience with city congestion charging can be found in: Sachverständigenrat für Umweltfragen: Umwelt und Straßenverkehr: Hohe Mobilität – Umweltverträglicher Verkehr, Sondergutachten, Berlin 2005. <http://www.umweltrat.de/cln_135/SharedDocs/Pressemitteilungen/DE/Archiv/2005_02_pressemitteilung.html>

[22] Mietsch, F. (2007): City-Maut: Internationale Erfahrungen, Perspektiven für Deutschland, Berlin. / Der Rat von Sachverständigen für Umweltfragen (SRU)

(2005): Umwelt und Straßenverkehr, Sondergutachten, p. 263, Berlin. / Transport for London (2008): Central London Congestion Charging – impacts monitoring, p. 220, London, <http://www.tfl.gov.uk/assets/downloads/sixth-annual-impacts-monitoring-report-2008-07.pdf>

[23] The European DSRC is a semi-passive transponder unit with a very short-range communication radius and is the de facto standard in Europe for electronic toll collection. DSRC has also been implemented outside Europe as a national standard for toll collection and toll zone access monitoring.

[24] Germany's 'Environmental Zones' (Umweltzonen) are zones were only low-emission vehicles are allowed. They have been established in cities to improve environmental conditions and quality of life. Cars may enter these zones only if they have a 'Environment Zone' sticker displayed on their windscreen. The stickers are colour-coded (red, orange and green), depending on the emission levels of the vehicle and certain zones are only open to those vehicles with a green sticker and, correspondingly, low emissions.

[25] Mietsch, F. (2007): City-Maut: Internationale Erfahrungen, Perspektiven für Deutschland, Berlin.

[26] The Trondheim Toll Scheme operated from 1991 to 2005. Once the financial objectives (tunnel and bridge construction and investment in public transport, the environment and safety) had been attained, it was abolished, despite a high level of acceptance.

[27] Der Rat von Sachverständigen für Umweltfragen (SRU) (2005): Umwelt und Straßenverkehr, Sondergutachten, p. 263, Berlin.

[28] Mietsch, F. (2007): City-Maut: Internationale Erfahrungen, Perspektiven für Deutschland, p. 26ff., Berlin.

[29] A 'city of short distances' is an urban development concept aimed at increasing accessibility to everyday activities in the vicinity of where people live, so that shopping, health, educational, work and leisure facilities are within walking or cycling distance instead of always requiring car use.

[30] Credit Suisse (2008): Brennpunkt Road Pricing – Eine Option für die Schweiz?, p. 17, Zürich.

[31] Deutsches Institut für Wirtschaftsforschung (DIW) (2007): Erfolgsfaktoren von City-Maut-Systemen (DIW-Wochenbericht 09/2007), p. 141ff, Berlin. Mietsch, F. (2007): City-Maut: Internationale Erfahrungen, Perspektiven für Deutschland, p.37ff., Berlin.

[32] This applies particularly on roads with heavy traffic which suffer from high levels of air pollution due to vehicle traffic. For example, a speed limit of 30 km/h on Schildhornstraße in Berlin led to a reduction in fine particulate air pollution (PM10) of six per cent. Cf.: Senatsverwaltung für Stadtentwicklung: Luftreinhalte- und Aktionsplan Berlin 2005-2010.

[33] UBA (2007): Verbesserung der Umweltqualität in Kommunen durch geschwindigkeitsbeeinflussende Maßnahmen auf Hauptverkehrsstraßen (UBA-Texte 09/2007), Dessau.

[34] UBA (2000): Planungsempfehlungen für eine um¬weltentlastende Verkehrsberuhigung. Minderung von Lärm- und Schadstoffemissionen an Wohn- und Verkehrsstraßen (UBA-Texte 52/2000), Berlin.

[35] Short journeys by car involve particularly high fuel consumption and thus lead to higher CO2 emissions: operating temperature is usually only reached after four kilometres and it is only then that a normal fuel consumption rate begins.

[36] Exemptions may be applied for disabled people and commercial businesses.

[37] Eschert calculates a rate of between €350 and €850 for the economic costs of car parks and on-street parking in Dresden city centre. A comparison with other types of economic use of the spaces (opportunity costs) produces even higher rates of €1,600-€2,300 per parking space. Cf. Eschert, R. (2008): 'Ruhender Verkehr: Was er tatsächlich kostet', in: Internationales Verkehrswesen 5/2008, p. 177ff.

[38] Cf. 'Verordnung zum Erlass und zur Änderung von Vorschriften über die Kennzeichnung emissionsarmer Fahrzeuge vom 16.10.2006'

[39] Die Senatsverwaltung für Gesundheit, Umwelt und Verbraucherschutz (2009): Senatorin Lompscher: Die Umweltzone wirkt, Pressemeldung des Landes Berlin vom 15.04.2009, Berlin. <http://www.berlin.de/landespressestelle/archiv/2009/04/15/125521/index.html>

[40] In contrast to many other countries, there is stiff competition between local authorities to attract people and businesses because German local authorities are less restricted by regional planning. This leads to a situation where traffic management measures such as congestion charging, which are perceived by tradespeople and people in general as restrictive, are not implemented, in order that the area remains attractive in the future to tax-paying tradespeople and residents. This makes it much more difficult to agree measures such as congestion charging with neighbouring local authorities and to optimise them with regard to the existing urban structure (perhaps polycentrically, for example).