Road pricing

Introduction

This record of evidence forms part of the work undertaken by UKERC's Technology and Policy Assessment team relating to its project on policy strategy for carbon emissions reduction in the passenger transport sector. The material was produced alongside the project's main report and since it supports that report, it was judged appropriate to make this material available to a wider audience. The main report itself '*What Policies are Effective at Reducing Carbon Emissions from Surface Passenger Transport*?', and the supporting evidence can be found at:

http://www.ukerc.ac.uk/ResearchProgrammes/TechnologyandPolicyAssessment/TPAProjects.aspx

Explanation of Content

Evidence on this policy measure has been collected by the TPA team on the basis that it has, or may have, the potential to result in carbon dioxide emissions reductions in the passenger transport sector. This evidence document begins with a summarised description of the policy measure. The evidence itself follows the summary and is presented in table form.

Each piece of evidence has been assigned a separate row and tabulated using four columns:
- Year of publication, arranged chronologically, beginning with the most recent year
- Name of author, including where applicable additional cited authors (and year); and a Reference ID number.
- Type of evidence:
  - Evidence containing quantitative information is denoted by the letter 'Q'
  - Qualitative evidence is denoted by the letter 'C' for 'comment'
- The evidence itself

The evidence was originally gathered and assessed using several sub-headings. The purpose of this was primarily internal i.e. to facilitate the handling of evidence and the production of the main report. These sub-headings have been retained here as follows:

- Policy Measures and Carbon Savings
- Other potential CO_2 Impacts i.e. outside of the immediate policy influence
- Other Benefits e.g. air quality improvement or traffic congestion reduction
- Policy Costs and/or Revenues i.e. to local or national government
- Business and Consumer Costs
- Unintended Consequences e.g. rebound effect
- Reasons/Arguments for Carbon Savings Achievement or Failure
- Policy Suitability for the UK

A list of references follows the evidence tables. Note that the Reference ID numbers are allocated by Reference Manager, the referencing software used by the TPA team.

Any charts, figures and tables referenced in the evidence are not reproduced here but can be found in the original publication or evidence material.

Where no relevant evidence was found for a particular sub-heading, this has been noted.

Policy Description

The evidence recorded here covers policies which charge road users for their transport demand more directly– for example, by charging a car driver for their road use based on the actual distance travelled (including also VMT tax), the time of day trips are made or the type of roads used. Note that congestion charging is specifically excluded from the scope of this evidence table and is covered elsewhere in a specific Congestion Charging evidence table.

Evidence Tables

Carbon Savings and Policy Measure

Year	Author	Type	Evidence
			CO2 emissions reductions
2007	Anable & Bristow (ref 12297) citing DfT, 2006l	Q	Modelling for the Eddington review of UK transport policy produced the following results: reduced congestion by 52%, increased average speeds of 14% reduction in both overall traffic and CO2 emissions of 7% by 2025 (from 2003) (citing DfT, 2006l). Forecast assumes a 1.3%/year increase in vehicle efficiency. Sensitivity analysis reveals that halving this improvement rate leads to emissions 11.3% higher than the 2025 baseline.
2007	Anable & Bristow (ref 12297) citing Graham and Glaister, 2004; and citing Grayling, 2005	Q	Modelling based on revenue neutrality led to increased traffic and CO2 emissions of 7% and 5% respectively, whereas a revenue-raising charge is estimated to increase revenues by 57% and reduce emissions by 8.2% (citing Graham and Glaister, 2004). Grayling, 2005 (cited by Anable & Bristow, 2007) on the other hand presents results that imply a slight fall in both traffic levels and CO2 emissions, 2% and 1% respectively, from a revenue neutral implementation.
2006 2004	LowCVP (ref 11315) citing Open University (UK) and Free University (NL), 2004; Potter et al (ref 11636)	Q	Initial modelling conducted by the Open University and others suggests that, using a CO2 banded car distance charge of 3.3–10.4 p/km, total CO2 emissions would reduce by up to 6% as compared to a base scenario (citing Taxation Futures for Sustainable Mobility. Open University (UK) and Free University (Netherlands), 2004.)
2006	EAC (ref 11267)	Q	EAC (2006) quotes Friends of the Earth on research from the IPPR which showed that a revenue-raising road pricing system could reduce carbon emissions from road transport by 8% whereas a revenue-neutral system….would increase emissions by 5%.
2005	Grayling (ref 11543)	Q	Grayling (2005) presents results from the DfT's National Transport Model that imply a slight fall in both traffic levels and related CO2 emissions, 2% and 1%

Year	Author	Type	Evidence
			respectively, from a revenue neutral implementation.
2003	Harmsen (ref 11449)	Q	A system that involves differentiation according to indicators of environmental pressure (in the Netherlands: vehicle weight and fuel type) and all vehicles will lead to rather significant CO2 reductions. Two alternative calculations point to reductions of 9-10% and 4-5% respectively (in 2010). It should be emphasised that these reductions are estimates merely. The bulk of this reduction comes from passenger cars and mainly through reductions of trip lengths (10%) and number of trips (4%).
2003	Anderson (ref 11240)	Q	Table 6.1 of Anderson (2003) estimates the potential carbon dioxide savings that might be achieved by the introduction of item 6 'Toll Rings' .
2002	Wiegmans (ref 2273)	Q	In the Netherlands, effects of road pricing policy have been estimated by the RIVM. Pricing policy will result in a decrease in car use of 10-13 percent. Emissions (CO2) will be reduced by 2.3 billion kg, a decrease of more than 10 percent. Other emissions (like Nox and fine dust) are also reduced.
2002	IEA (ref 11351)	Q	In most countries, if governments adopt an incentive for all major metropolitan areas to implement cordon-pricing systems, they could reduce fuel consumption and emissions of CO2 for light-duty vehicles nation-wide 3%-6% by 2010.
			Trips and/or vehicles and/or VMT reductions
2005	Wolfram (ref 11380) citing Kollam-thodi and Watkiss 2005	Q	Wolfram et al (2005) cites the UK DfT modelling work (in Kollamthodi and Watkiss 2005) on implementing a national road-pricing scheme in 2015. The scenario is based on the scheme leading to a 3% reduction across all roads in annual vehicle kilometres travelled by all vehicles, including a 6% reduction on urban roads. This leads to the conclusion that national road pricing could be a fairly effective mid-term measure to reduce NOx, PM10 and CO2.
2004	Begg (ref 3472) citing CfIT, 2002	Q	The UK's Commission for Integrated Transport (CfIT) estimate that national charging would reduce overall traffic levels by 5%, with an associated reduction in CO2 (citing CfIT, 2002).
2001	Cooper (ref 11387)	Q	A charge of £1.50 would produce an estimated reduction of 1.4% in total trips and 10.5% fewer car trips.
			Non-national scheme case studies
2008	Hensher (ref 11464)	Q	Imposing a 10 c/km variable user charge on the main Sydney road network (i.e. excluding local streets) between 7 am and 6 pm for all days of the week, maintaining road investments levels unchanged, is forecast in 2015 to reduce CO2 from passenger cars by 4.74%. Hensher (2008) also modelled a $0.05/km variable user charge throughout the Sydney metropolitan area on all main roads, combined with an achieved 15% improvement in the fuel efficiency of the car stock. This

Year	Author	Type	Evidence
			is forecast to deliver in 2015 a 15% reduction in CO_2. This also produces a desirable financial outcome for government given that fuel efficiency improvement alone will shrink government coffers quite markedly.
2006	Robert (ref 4789)	Q	The impact from implementing traffic tolls, similar to that planned for Stockholm in January 2006, was tested by Robert (2006). These tolls would consist of a fee for entering the Stockholm city centre by private car. This would lead to a 9% reduction of CO_2–emissions and a 59% renewable fuel mix in order to reach the emission target.
2001	Ang (ref 9133)	Q	The impact of Singpaore's ALS was immediate with a 33% reduction in the total number of vehicles entering the restricted zone and a 61% reduction in passenger cars. Vehicle speed increased by 22% . Singapores' ALS was replaced in 1998 by the ERP – Electronic Road-pricing System. Average weekday traffic flow into the restricted zone dropped by 22% from the previous ALS levels.
1998	Lindqvist (ref 11235)	Q	A recent road pricing proposal - not implemented – resulted in a 24% reduction of car traffic volumes in the inner city of Stockholm. The estimated impact on the CO_2 emissions would be 141 kiloton reduction which corresponds to a 12% reduction in total emission level. Therefore, road pricing has the strongest impact on the reduction of carbon dioxide levels of all the examined measures.
1996	Michaelis & Davidson (ref 2446) citing Polak et al., 1994; and citing Ramjerdi, 1994	Q	The long-term impact of the Area Licensing Scheme in Singapore was analysed by Polak et al (1994) whilst studying the effectiveness of road pricing: the analysis found that a 10% increase in the cost of peak period travel resulted in a 7% reduction in peak traffic in the short run and a 12% reduction in the long run. Toll rings in Oslo and Trondheim have reduced traffic by 4% and 8%, respectively (citing Polak and Meland, 1994 and Ramjerdi, 1994).

Other CO_2 Impacts

Year	Author	Type	Evidence
2007	Safirova (ref 11477)	C	VMT tax and the substantial decrease of travel that it induces are an effective way to increase urban density.

Other Benefits

Year	Author	Type	Evidence
2005	Dierkers et al. (ref 11455)	C	Various co-benefits to road pricing in addition to air quality: • greater stability in transportation funding

Year	Author	Type	Evidence
			• improved economic efficiency in transportation • increased revenue to fund transportation improvements • promotes a more equitable distribution of highway costs between drivers and taxpayers • The reduction in roadway congestion levels delivers additional benefits to road users, the economy and society as a whole through: o decreased levels of driver stress and loss of time o enhanced driver safety due to reduced accidents o improved freight efficiency o reductions in lost productivity to businesses o lower fuel consumption.
2001	Banister (ref 3381)	C	Outcomes of the London Congestion Charge during 2003-2006: • Traffic entering down 15% • Delays down by 30% • Congestion down by 26% • 15% speed increase in zone • Increase in traffic of 5% on IRR but journey times remain the same • Bus services improved – 4% shift from car to bus • Bus patronage inside area +16% • 100,000 payers/day • Environment – emissions -12% • Net Revenues £123m (2006/07)
2001	Ang (ref 9133)	Q	Singapore's traffic schemes have resulted in decreased air pollution and an improved urban environment – see Table 6 of Ang (2001).

Policy Costs and/or Revenues

Year	Author	Type	Evidence
			General
2008	Hensher (ref 11646)	Q	Financing of public transport investment can be in part provided by a variable user charge assuming that government accepts hypothecation, which is the stumbling block in many countries. The potential to grow public transport revenue by a massive 85.27%, together with an apportionment of revenue from variable user charging, will support the investment needs.
			Set-up
2007	Anable & Bristow (ref 12297)	Q	Anable & Bristow (2007) estimates a nationwide road user charging scheme in the UK would have set-up costs of £23 to £62 billion.
2005	Wolfram (ref 11380)	Q	The DfT carried out modelling work implementing a national road pricing scheme in 2015. They believe the

Year	Author	Type	Evidence
			high costs related to set-up (£11.8 to 31.3 million for 2011-2025) do not make this type of scheme a realistic option for many countries.
2005	Kollam-thodi (ref 11467)	Q	Table 4.10 of Kollamthodi (2005) gives the NPV of costs between 2011 and 2025 for setting up a national scheme; costs are very high, again ranging from £11.9 billion to £31.3 billion.
			Operation
2007	Veitch (ref 11317)	Q	A striking aspect of an Oregon scheme that Veitch (2007) examined is its low operational cost. By working with the existing tax collection system rather than starting from scratch, the new road user pricing fees will be collected relatively easily and cheaply and administrative costs are predicted to be around $1 million per year. This contrasts dramatically with the UK where current annual running costs for a technologically advanced scheme have been placed at £2–3 billion by the DfT and the initial costs of retro-fitting the required technology into vehicles could cost £3 billion. In addition, enforcement and administration costs must also be considered. Compare these DfT figures with the Federal funding for the Oregon project which is only $2.9 million over six years. That said, Veitch (2007) cautions that Oregon is dealing with far fewer vehicles than the UK. While of comparable geographical size to the UK, Oregon has only 3 million registered vehicles – around one-tenth of the UK figure.
2007	Veitch (ref 11317)	C	In order to mitigate environmental impacts, Veitch (2007) advocates a revenue raising charge over a fiscally neutral one - which would obviously raise the costs of motoring for more people. For this reason, road user pricing cannot be carried out in isolation from broader transport policy and suitable alternatives to car travel must be available. In fact, Veitch (2007) concludes that raising fuel duty would potentially be a cheaper and more effective abatement mechanism than road pricing.
2006	LowCVP (ref 11315)	Q	National road charging could be a revenue generator - using a CO_2 banded car distance charge of 3.3–10.4 p/km would generate an additional £3 billion per annum.
2005	Kollam-thodi (ref 11467)	Q	Estimates of the total for a UK road pricing scheme have been based on a price of £36 per vehicle p.a., though it should be noted that in future years these costs may decrease. No estimates are given for CO_2 reductions but Table 4.11 of Kollanthodi (2005) provides a summary of estimated costs, as identified in the Road Pricing Feasibility Study.
2004	Begg (ref 3472)	C	National road charging could be fiscally neutral.

Year	Author	Type	Evidence
2001	Ang (ref 9133)	Q	The first month of Singapore's ERP system collected revenues of S$2 million (23% less than the average under the old ALS scheme). The ERP costs S$9 million p.a. to run compared to S$17 million for the old ALS. The ERP has higher investment cost but lower operation cost.

Business and Consumer Costs

Year	Author	Type	Evidence
2007	US GAO (ref 11191)	C	Noting the limitations of a VMT tax, US GAO (2007) says it could increase the overall costs of driving, and disproportionately affect rural residents and low-income drivers. This could be overcome through "revenue recycling," a measure in which behaviours considered to be valuable to the economy are lowered to offset some or all of an increased tax on behaviors that create additional costs for the public. For example, taxes on income could be lowered to offset increased taxes on gasoline consumption or miles driven.
2006	Yin (ref 1297) citing Johansson, 1997	C	A road user should pay a charge corresponding not only to their own emissions, but also to the increased emissions and fuel consumption of other road users according to Yin (2006) citing Johansson (1997). Johansson's model uses marginal social cost (MSC) pricing to achieve maximum net social benefit by internalizing marginal environment and fuel costs.

Unintended Consequences

Year	Author	Type	Evidence
2007	Veitch (ref 11317) citing Glaister and Graham, 2003	C	Whilst the structure and focus of road pricing should be on alleviating congestion nevertheless some points regarding emissions should be noted: • if road pricing was introduced in tandem with reduction in fuel tax it could become cheaper to drive in some areas leading to increased traffic and emissions. A politically attractive option would be to design a pricing scheme that is revenue neutral. • Veitch (2007) cites modelling by Glaister and Graham (2003) of Imperial College which implies that a revenue neutral charge would not necessarily lead to an overall decrease in carbon dioxide emissions. Indeed, their model suggests that a revenue neutral charge could increase road traffic in England by seven per cent and increase carbon dioxide emissions by five per cent by 2010. • In contrast, a revenue raising charge is estimated to decrease road traffic by seven per

Year	Author	Type	Evidence
			cent and decrease total carbon dioxide emissions by three per cent. • Road pricing does not in theory distinguish between car types. If VED was reduced to make way for road pricing there would be little incentive for owners to choose lower carbon cars. And if fuel duty was also reduced then the problem is magnified by reduced incentive to choose a more fuel-efficient car.
2006	EAC (ref 11267)	C	The central issue is whether pricing is aimed primarily at cutting congestion, or whether it would be equally or mainly targeted at reducing emissions. The danger with the former is that by optimising road use it could actually increase the volume of traffic overall, and with it emissions of CO2 - and these effects would be intensified if road charges were offset by reductions in fuel duty, as is sometimes mooted.
2006	Yin (ref 1297) citing Nagurney, 2000b	C	An improvement in travel time (e.g., by increasing capacities) leads paradoxically to an increase in emissions without any change in travel demand (citing Nagurney, 2000b). Yin (2006) provides an example showing that a system optimal (SO) flow distribution, i.e., one with the minimum total travel time, actually produces more emissions.
2003	Harmsen (ref 11449)	C	It would be unwise to assume that road pricing will always provide CO2 reductions. It can involve a reduced pressure on the roads in question (as some drivers choose alternative routes not subject to pricing), and consequently enable a higher speed for those on the road. This may result increased emissions, especially if the total demand for transport is not reduced, or has even increased as a result of the improved accessibility through the tolled roads.

Reasons/Arguments for Carbon Reduction Achievement and/or Failure

Year	Author	Type	Evidence
2007	Anable & Bristow (ref 12297)	C	It is possible that road user charging schemes will encourage behavioural changes. By highlighting the cost per journey, possibly through a highly visible in-car metering, this measure will force a rethink of habitual patterns and reinforce the link between behaviour, travel costs and potentially also carbon emissions.
2007	Safirova (ref 11477)	C	The effect of VMT tax is a significant decrease in fuel use resulting from reduced VMT. Three causes are identified: • First, as people move to the centre of economic activity, the average trip distance to work and shopping locations is consequently reduced. • Second, there is an important switch to public transit and non-motorized modes of travel. Both of these effects contribute to congestion relief.

Year	Author	Type	Evidence
			• The third and more subtle cause of VMT reduction comes from the fact that the VMT tax causes some people to stop working and, therefore, to stop commuting.
2007	US GAO (ref 11191)	C	A prime limitation of a VMT tax, it is suggested, is an absence of incentives to buy vehicles with higher fuel economy ratings because the tax depends only on mileage.
2006	Eddington (ref 11509)	Q	The Eddington Review remarks that "Introducing markets (pricing) where none exist can have a very powerful and positive economic effect in any sector. The transport sector is no exception, and in particular the potential for benefits from a well-designed, large-scale road pricing scheme is unrivalled by any other intervention". That report goes on to suggest that a UK national road pricing scheme could reduce congestion by some 50% below what it otherwise would be in 2025 and reduce the economic case for additional strategic road infrastructure by some 80%. Benefits could total £28 billion a year in 2025, including £15 billion worth of GDP benefits.
2004	DfT (ref 11546)	C	Research participants in the DfT's 2004 'Feasibility Study of Road Pricing in the UK' agreed that the current system of paying for road use does not encourage drivers to think about their car use and that a potential system of paying at the point of use was more likely to encourage people to think about the journeys they make.
2004	Stopher (ref 517) citing Hyman and Mayhew, 2002; and citing Opiola, 2002	C	A distance-based charging policy is more effective than congestion charging schemes (citing Hyman and Mayhew, 2002). Stopher (2004) also cites Opiola (2002) who argues that a distance-based policy has merits over other policies, and advocates the use of such a charge as a replacement for all or most of the fuel excise charge.
2004	Begg (ref 3472)	C	Regarding UK policy, Begg (2004) describes how the UK's transport emissions were set to increase, as a result of lack of Government commitment to demand management, in particular participation in the debate on road pricing, even though road pricing was a component of two of studies commissioned under the 10 year plan. The government's focus appears to have switched to tackling emissions through reducing vehicle emissions whilst increasing road capacity.
2003	Harmsen (ref 11449)	C	While it takes time for the maximum CO2 effect from a pricing system to be achieved, the implementation period is still relatively short. Once the decision is taken, the 4 year implementation period, which for example applied in Germany, would appear a realistic time frame for deciding on specific systems, cost allocation models etc. However, the full CO2 effect is likely to come later.
2003	Harmsen	C	Examining the 'no regrets' potential of road pricing,

Year	Author	Type	Evidence
	(ref 11449)		Harmsen (2003) notes that whilst tax systems can always be changed and modified there are some aspects that substantially weaken this statement with regard to road pricing: • First, there is the issue of credibility. Those affected by the system need to believe that it will be in place for a long period in order to let the system affect their longer-termed decisions on for example place of living and car purchases. • Furthermore, if the system is implemented in a budget neutral sense and in particular if the budget neutrality involves some transfer of purchase taxes to road taxes, this has serious implications on the annual distribution of costs (for car owners) and revenues (for the government). • Finally, some of the more advanced systems, which are also the most CO2 efficient, do imply substantial investments. Such investments would be lost if the road pricing system is given up within a short time horizon.
2002	BTRE (ref 11429)	C	Road pricing is a win-win measure: it has potential both to reduce greenhouse emissions and improve economic efficiency and, in theory, any ‘losers’ could be fully compensated and society would still be better off for the change.
2002	BTRE (ref 11429)	C	Road-use charges, in particular those calibrated to internalise emission and congestion costs, have the potential, where appropriately applied to all relevant roads in the network, to be of significant benefit to the environment. Fixed road-specific tolls are a different matter. The impact of tolls on emissions could be positive or negative depending on factors such as the level of congestion tolerated and the toll collection mechanism. Fixed tolls may reduce congestion in the short run, by discouraging some drivers, and in the longer term, by raising funds for expansion of the network. If introduced on established roads, tolls may slow the growth in VKT through increasing the cost of travel. On the other hand, if the tolls result in traffic being diverted to secondary roads, often termed ‘rat-running’, congestion on those roads could increase.
1998	Ayres (ref 11245)	C	Admin costs associated with fee collection are the main argument against a VMT fee. To be effective, the fee must be apparent to the driver each time he makes the decision to drive. If these fees are collected annually or semi-annually (e.g., at vehicle registration), the effect will not be as great as that of a gasoline tax collected at each fill-up.

Year	Author	Type	Evidence
			Collecting VMT fees at the pump would make regular collection easier. This would probably require “smart card” technology to record mileage and/or fuel consumption, on which fees would be based. Retrofitting vehicles with this technology could be difficult and expensive, so this policy would be slower to take effect than a gasoline tax. Measuring mileage at regular intervals is problematic since drivers may tamper with odometers. Some proposals suggest VMT fees based on the nationwide average mileage for each type of car, but this gives little incentive to limit vehicle travel. Another proposal is to use sensing devices to identify each vehicle and record its travel.

Policy suitability for UK

Year	Author	Type	Evidence
2007	Veitch (ref 11317)	C	The key aspects of the Oregon scheme could be applied to the UK according to Veitch (2007) and the Energy Saving Trust. Furthermore, they consider the Oregon scheme could be scaled-up to incorporate the carbon dioxide reduction measures required in the United Kingdom.
2003	Harmsen (ref 11449)	C	Country specific features may have an impact upon the exact figures of cost-effectiveness and CO2 reductions. For example, the higher the current congestion level, and the higher the population density, and the more freight transport transit, the more there is to gain from a kilometre charge.

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