DRAFT Policy Brief on the Impacts of Road User Pricing Based on a Review of the Empirical Literature

Steven Spears and Marlon Boarnet, University of California, Irvine
Susan Handy, University of California, Davis

Policy Description

Road user pricing has been implemented for various purposes in three basic forms, as explained below. All forms of road user pricing can be considered travel demand management measures (TDM), which include policies that are designed to affect the amount, time, or place that people travel. The most common road user pricing strategy is link or point charging. This type of charge requires users to pay for access to a roadway segment such as a toll road or bridge. Toll roads and bridges are generally used to provide funding for the construction and maintenance of transportation infrastructure. Variable rate tolls, where toll levels increase as congestion increases, have also been implemented as a congestion management measure.

The second type of road user pricing is the cordon toll. Under cordon pricing, drivers are charged when crossing the boundary of a predefined tolling area. Cordon tolls are generally suitable for travel demand management in central business districts (CBDs) of major cities, where congestion and pollution mitigation are desired and where trip substitution using other modes is feasible. Cordon tolls normally comprise part of a comprehensive TDM program, and revenues are often directed toward facilitating mode shift away from private cars.

The third type of road user pricing is distance charging. With distance charging, users pay according to distance driven on the regional, state, or national road network. Driving distances are measured by satellite and/or on-board monitoring devices. Distance charges can be applied at a flat rate or can vary based on vehicle type, congestion level, and environmental conditions.

Impacts of Road User Pricing

Effect Size

Table 1 shows the impact on traffic volume derived from various empirical studies of toll roads and bridges. The sensitivity of traffic volume to price changes, given in terms of elasticities, fall within a range of -0.1 and -0.45. This means that a 1 percent toll increase would result in a 0.10 to 0.45 percent decrease in traffic volume on the tolled segment. Variations within the range of elasticities for toll facilities can be attributed to local conditions that influence their effectiveness. These conditions include the existence of non-tolled alternative routes, availability of alternative travel modes, predominant trip purpose, and congestion level. Routes where alternatives are less available, a higher proportion of trips are essential, and congestion is high are more likely to have elasticities at the low end of the range. Studies of numerous Norwegian toll projects by Odeck and Bråthen (2007) found that traffic reductions on urban facilities tend to be at the lower end of the range. For suburban and rural toll roads, the range of impacts tend to vary over the entire range due to greater local variations in the factors noted above.

For cordon tolls, studies have generally focused on before and after comparisons of traffic flows at entry points. Table 2 gives a summary of the impacts of cordon tolls in six cities. Traffic reductions of between 12 and 22 percent have been achieved through cordon pricing in five major European cities. These reductions reflect counts of vehicles crossing the cordon boundary during the charging period. In Singapore, where cordon charging has been in place since the 1970s, traffic volume is estimated to decrease by 2 to 3 percent for every 10 percent increase in the cordon charge.

No operational distance charging programs for passenger cars currently exist. Therefore, evidence on effect size is available only from models and pilot programs. Models of a national distance charge for England predict a reduction in vehicle miles traveled (VMT) of 9 to 19 percent for several price scenarios, based on existing road and rail transportation price elasticities. A pilot program in Portland, Oregon that charged a per-mile rate approximately equivalent to the existing gas tax resulted in VMT reductions of 11 and 14.6 percent for two experimental groups, compared to a control group that paid gas tax as usual. The smaller reduction was for a flat rate, while the larger was associated with a premium charge for travel at peak times in congested areas. A study conducted by Deakin et al. (1996) estimated that for California, each 10 percent increase in driving costs from a VMT charge would result in a 2 to 2.5 percent decrease in distance driven.

Rodier (2009), in a review of travel model results from 24 metropolitan areas, compared predicted reductions in vehicle kilometers of travel (VKT) or greenhouse gas emissions from business as usual scenarios after 10, 20, 30, and 40 years of sustained policy implementation. Policies were grouped by type; the exact policies varied in the different model applications. The median VKT reduction from VKT pricing was 9.9 percent after ten years and 11.1 percent after 40 years, based on a variety of pricing levels. Combined land use, transit, and VKT pricing policies yielded median VKT reductions of 14.5 percent after ten years and 24.1 percent after forty years.[1] These are simulations from models of varying sophistication, so the magnitudes should not be taken as definitive, but rather are indicative of ballpark estimates and of the varying impact across different groups of policies.

Table 1: Results of Previous Toll Road Studies (Adapted from Odeck and Bråthen (2008))

Study	Study Location	Study Year(s)	Results
Weustefield and Regan (1981)	16 toll facilities in the US	1970s	0.03% to 0.31% traffic reduction per 1% toll increase
Goodwin (1988)	Literature review of previous studies	1980-88	Average traffic reduction of 0.45% per 1% toll increase
Harvey (1994)	Golden Gate Bridge, SF Bay Bridge and Everett Turnpike, New Hampshire	1979-84	Bridges: 0.05% to 0.15% decrease, roads: 0.1% decrease per 1% increase in toll
Wilbur Smith and Associates (1995)	Numerous United States facilities		0.1% to 0.35% reduction per 1% toll increase

[1] All reductions are relative to "business as usual" scenarios – i.e. scenarios that represent a continuation of status quo policies.

Hirschman et al. (1995)	Six bridges and two tunnels in New York City area	1979-90	0.09% to 0.5% decrease per 1% toll increase. Average: 0.25% decrease
UTM (2000)	New Jersey Turnpikes	1999	0.2% decrease in traffic per 1% toll increase
Burris et al. (2001)	Lee County Florida	1999	0.03% to 0.36% decrease per 1% toll increase

Table 2: Summary of Traffic Reductions for Cordon Pricing Projects

Study	Study Location	Study Year(s)	Results	
			Charge Type	Traffic Impact
Olszewski (2007)	Singapore	1975-2006	Variable price 7:30am to 7pm	0.21 to 0.31 percent reduction for every 1% price increase
CURACAO (2009b)	London	2003	Fixed price, 7am to 6:30 pm M-F	16% volume reduction
Eliasson et al. (2009)	Stockholm	2006	Variable price, 6:30 am – 6:30 pm M-F	22% volume reduction
CURACAO (2009b)	Milan	2008	Fixed price, 7am to 7pm	12% volume reduction
CURACAO (2009b)	Bologna	2005	Fixed price, 7am to 8pm	23% volume reduction
CURACAO (2009b)	Rome	2001	Fixed price, time varies by zone	18% volume reduction

DRAFT

Evidence Quality

For the link and cordon charging programs summarized above, reductions in traffic flow were obtained from vehicle counts. Although the exact methodologies in each study vary, factors that were controlled for in these studies included population change, fuel prices, income, number of registered vehicles, transit fares, parking fees, and seasonal variations. By controlling for other factors that could also influence traffic volumes, these studies more effectively isolate the effect of toll prices on traffic volume.

The wide variation in effect size, particularly for toll roads, reflects the impact of local conditions on toll effectiveness. In general, roads that carry less essential trips, have viable untolled alternatives, or lower congestion levels will exhibit higher traffic reductions per toll level increase. For example, a recent Norwegian study found highly variable impacts from link charging. (Odeck and Bråthen, 2008). Traffic reductions ranged from 0.3 to 22.6 percent per 10 percent toll increase on rural highways, with an average of 7.4 percent. On urban arterial roads and motorways, the range of reductions was narrower, but still quite variable: 1.1 to 7.8 percent, with an average of 4.5 percent per 10 percent toll increase. The location-specific nature of link charging makes narrowing the range of possible impacts more difficult.

Evidence quality for distance charging is lower than for other forms of charging, due to the lack of operational programs. The primary goal of the Portland pilot program was to test the feasibility of implementing a distance charge. Some methodological issues, such as the use of a non-random sample and the assignment of certain household types to the control group, limit the generalizability of the study's results. However, the agreement in VMT change between the Portland pilot program and other models indicates that the magnitude of the reduction may be reasonable.

Caveats

With the exception of distance charging, the results of the studies presented here reflect traffic volume reductions rather than VMT effects. The magnitude of VMT reduction depends on a number of factors. Consideration must be given to the proportion of drivers who will forgo trips, carpool, or switch modes compared to those who will avoid the toll by changing route and/or travel time. Evidence on mileage fees, while from models or pilot programs (and hence less generalizable), can speak more directly to the question of VMT reduction, since VMT was typically the variable examined in those studies.

Greenhouse Gas Emissions

A few recent studies have examined the impact of cordon pricing and congestion tolls on greenhouse gas emissions. Beevers and Carslaw (2005) estimated that the London congestion charge resulted in a 19.9 percent reduction in carbon dioxide emissions inside the charging zone, and a 0.6 percent reduction within London's inner ring road. Eliasson et al. (2009) found similar results for the 2006 cordon trial in Stockholm. Their models estimated a 14 percent reduction in vehicle carbon dioxide emissions in the central city, and a 2.7 percent reduction for greater Stockholm.

A study by the International Council on Clean Transportation (ICCT, 2010) estimated that similar impacts could be obtained in Santa Clara County, California. The report states that carbon dioxide emissions could be reduced 17 percent through congestion tolls on freeways and highways in the county. The tolling system assumed in the ICCT model was designed to approximate a distance charge of $0.18 per mile.

Co-benefits

Congestion management would be a possible substantial co-benefit of link and cordon pricing. There is a large body of theory that notes that pricing is one of the best ways to manage induced demand issues. Induced demand occurs when increased road capacity reduces congestion thus increasing travel speeds, which then encourages more traffic on the roadway due to the (post-improvement) lower time cost of travel. Pricing has long been advocated as an effective way to manage urban traffic congestion (e.g. Downs, 1992).

Pricing policies will also generate revenues that can be directed toward road and transit improvements. This can be especially important given the fact that gasoline tax revenues, which help support infrastructure improvements, have not kept pace with driving as vehicle fuel economy improves and infrastructure construction costs increase. In addition, traffic volume reductions from road pricing could lead to reduced air pollution from vehicles.

Examples

California's State Route 91 express lane tolls are an example of variable-rate link charging. The facility, which opened in 1995, was constructed by a private company through a 35-year franchise granted by the state. It includes 10 miles of toll lanes constructed in the median of

DRAFT

the existing state highway. All tolls are collected electronically, and variable tolls are charged based on congestion level. In the year after opening, the toll lanes helped to double travel speeds on the segment. Because the toll lanes were constructed by a private firm under the franchise agreement, all revenues were returned to the company. In 2003 the facility was sold to the Orange County Transit Authority, a public agency.

Perhaps the best-known example of cordon charging is the London Congestion Charge. In effect since 2006, the £8 (approx. $13.50) charge for driving into central London applies from 7 am to 6:30 pm on weekdays. Payments can be made at certain retail outlets, electronically via the internet and mobile phone, and at kiosks located in the charging area. Enforcement is carried out by video cameras that record license plate numbers and match them against the list of vehicles that have paid the charge. Revenue from the London congestion charge is directed entirely toward improving all forms of transportation in the city, with the majority devoted to improving bus service. In the first four years of the London charge, traffic into the charging zone was reduced by 16 percent during the times of day when the charge was in effect.

No examples of distance charging for passenger vehicles currently exist, although the Netherlands plan to implement a national system beginning in 2011. The program will use satellite-based tracking to compute charges based on vehicle type, location and time. Distance charges will largely replace existing car sales tax, road tax, and local taxes, although fuel taxes will remain.

Suggested Further Reading

Beevers, Sean D., and David C. Carslaw. 2009. The Impact of Congestion Charging on Vehicle Emissions in London. Atmospheric Environment 39: 1-5.CURACAO 2009a. “Deliverable D2: State of the Art Review” Project: Coordination of Urban Road User Charging Organisational Issues Sponsored by European Commission under the FP6 Framework. Accessed 30 March 2010 at: http://www.curacaoproject.eu/pdf/CURACAO%20D2%20SoAR%20FINAL%20v1.0.pdf

CURACAO 2009b. “Deliverable D3: Case Study results”, Project: Coordination of Urban Road User Charging Organisational Issues Sponsored by European Commission under the FP6 Framework. Accessed 30 march 2010 at: http://www.curacaoproject.eu/workfiles/files/deliverables/CURACAO%20D3%20Case%20Study%20Results%20FINAL%20v1.0.pdf

Dahlgren, J. 2002. “High-occupancy/toll lanes: where should they be implemented?.” *Transportation Research Part A: Policy and Practice* 36(3): 239-255.

Deakin, E., Harvey, G., Pozdena, R., and Yarema, G., 1996. *Transportation Pricing Strategies for California: An Assessment of Congestion, Emissions, Energy and Equity Impacts.* Final Report. Prepared for California Air Resources Board, Sacramento, CA.

Downs, Anthony. 1992. *Stuck in Traffic*. Washington, D.C.: The Brookings Institution.

DRAFT

Eliasson, Jonas, Lars Hultkrantz, Lena Nerhagen, and Lena Smidfelt Rosqvist 2009. "The Stockholm congestion – charging trial 2006: Overview of effects." *Transportation Research Part A: Policy and Practice* 43(3): 240-250.

Glaister, Stephen, and Daniel J. Graham 2005. "Policy and Practice : An evaluation of national road user charging in England." *Transportation Research Part A* 39(7-9): 632-650.

Hirschman, I, C McKnight, J Pucher, RE Paaswell, and J Berechman 1995. "Bridge and Tunnel Toll Elasticities in New York – Some Recent Evidence." *Transportation* 22(2): 97-113.

International Council on Clean Transportation. 2010. Congestion Charging: Challenges and Opportunities. Available at http://www.theicct.org/climate_change/congestion_charging_paper_. (access May 10, 2010).

Litman, Todd. 2006*. London Congestion Pricing: Implications for Other Cities. Victoria, BC: Victoria Transport Policy Institute.*

Loo, Becky P Y. 2003. "Tunnel traffic and toll elasticities in Hong Kong: some recent evidence for international comparisons." *Environment and Planning A* 35(2): 249-276.

Odeck, J, and S Bråthen 2008. "Travel demand elasticities and users attitudes: A case study of Norwegian toll projects." *Transportation Research Part A: Policy and Practice* 42(1): 77-94.

Olszewski, Piotr. 2007. Singapore Motorisation Restraint and Its Implications on Travel Behaviour and Urban Sustainability. Transportation 34(3): 319–35.

Rodier, Caroline. 2009. A Review of the International Modeling Literature: Transit, Land Use, and Auto Pricing Strategies to Reduce Vehicle Miles Traveled and Greenhouse Gas Emissions. Paper presented at 2009 Transportation Research Board annual meeting. Washington, D.C. January.

Rufolo, Anthony M., and Thomas J. Kimpel 2008. "Responses to Oregon's Experiment in Road Pricing." *Transportation Research Record: Journal of the Transportation Research Board* 2079,1(12): 1-7.

Wachs, Martin. 2009. Financing Infrastructure in California. Testimony before the California Little Hoover Commission. March 26. Available at http://www.rand.org/pubs/testimonies/2009/RAND_CT322.pdf (access Feb. 24, 2010).

Acknowledgments

This document was produced through an interagency agreement with the California Air Resources Board with additional funding provided by the University of California Institute of

DRAFT

Transportation Studies MultiCampus Research Program on Sustainable Transportation and the William and Flora Hewlett Foundation.

DRAFT