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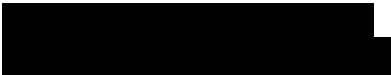
ROAD ACCESS PRICING

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What Type of Road Pricing Scheme might appeal to Politicians?

Gaining the citizen vote by staging reform

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Abstract

The greatest hurdle facing road pricing reform is political commitment. With rare exception, efforts to introduce significant reform in road pricing aimed at raising sufficient revenue to ensure that road investment and ongoing maintenance is secured without an additional impost to users above current outlays, while at the same time reducing traffic congestion, has fallen largely on politically non-supportive ears. The big challenge is to convince politicians (and their advisers) that it is possible to reform road pricing so that users are made better off (at least the great majority) in terms of time spent travelling and monies outlaid, and government coffers secure growing levels of revenue, but with at least some funds being used in supporting vertical equity to improve public transport and the existing road network. This paper identifies the major issues that make much of the academic research into road pricing somewhat pointless in terms of achieving real change. Staging reform is an appealing way forward, but ensuring the order and timing of events to secure progress is the big challenge. We offer some suggestions, including some ideas on new language designed to increase the level of buy in, and recognise that progress through action will require compromises in respect of an 'ideal' economically efficient pricing reform agenda.

Key words: road pricing reform, political process, revenue implications, staging reform, simple solutions, use-related registration fees, time reduction benefit charge, non-choice pricing, choice pricing

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Introduction

“I’m struck by what seems to be a huge disconnect between the systems being modeled by academic economists and the proposals emerging from field tests and demonstrations involving actual motorists.” (Poole 2012)

Road pricing reform is much touted by economists and others who see the current charging instruments inadequate in both delivering efficient outcomes for road use (especially in controlling levels of traffic congestion) as well as raising sufficient revenue to fund new infrastructure as well as much needed maintenance of existing road networks (see Verhoef *et al.* 2008 and Manville and King 2012). It is estimated that traffic congestion in Australia resulted in AU\$9.4 billion of avoidable social costs in 2005, increasing to AU\$20.4 billion by 2020 (BTRE 2007). In the USA, the congestion costs (in constant 2009 dollars) continue to rise from US\$24 billion in 1982 to \$115 billion in 2009; this is associated with 3.9 billion gallons of wasted fuel (equivalent to 130 days of flow in the Alaska pipeline), and a \$US808 cost impost per average commuter in 2009 (Texas Transportation Institute 2011). This results in a predictable 'tragedy of the commons'.

Despite these well known statistics, politicians in the main are not supportive of road pricing reform. An example that is typical of political responses is:

“We will not introduce a congestion tax for motorists ... due to the lacklustre standard of the state’s public transport system. ...The Minister ... has ruled out imposing a tax on motorists entering the CBD similar to a system used in London. There cannot be a congestion toll if there is no public transport, and the one thing that [we] ... have not got is proper public transport,” he says. “It would be so unfair to put a congestion tax on people that have no alternative to using their car.”¹

The greatest challenge is how to gain public acceptance² that is also convincing to politicians. We are of the belief that road pricing reform will entail a slow but progressive set of steps that must comply with the adage “keep it simple and singularly focussed” but do not start with the ultimate journey end pricing solution to reduce traffic congestion, but with some

¹ It is often the case that when politicians refer to public transport they are assuming rail-based solutions, which are not only very expensive, but in the context of road pricing take many years to deliver, making the case for road pricing reform simultaneously accompanied by public transport vexed. If, however, like London, we consider improving public transport by introducing a large increase in the number of buses (designed not to create more havoc on the roads in mixed traffic but to support switching away from the car), then road pricing reform can *simultaneously* be achieved in terms of a timeline with improvement in public transport. A large increase in buses to support greater connectivity and frequency (something not so feasible with single corridor rail projects) can readily be facilitated given the availability of buses of high quality manufactured in countries such as China.

² The experience below typifies public sentiment, albeit misinformed. Setting: ABC Radio 702 Tuesday 4 Oct 2011 8.30-8.55am. Hensher discusses the merits of Road Pricing Reform (after stating clearly that it is more than a congestion tax, and to please stop using the emotive language of a congestion TAX). Conversation proceeds and calls are invited. A plumber calls in. He says (paraphrase): “...I spend up to 5 hours on the roads every day between jobs and now you are telling me I have to pay a congestion tax on top of all of my existing costs for the 5 hours. What is he thinking (the Professor needs to get real)... I do not earn enough income now as it is.” Hensher’s response (paraphrased): “...I made it very clear I thought that the aim is to reform the entire set of charges (including registration fees) and to set the kilometre based charges to reflect the traffic conditions with the aim of not only enabling you to save time (which is money as well) but to give you realistic options on levels of charge and time of day to travel. It is expected that you will spend less time travelling and can convert such saved time into more productive income earning time.” This is the buy in challenge – how to convince voters that there are benefits to them.

initiative that has an easier staged sell. Crucially the focus of the reform process must be on asking ‘are travellers paying for the right things’ and not ‘are they already paying enough’? This also translates into a request to stop being obsessed with the question of how much car users pay *on average*, for congestion is not caused by “...the fact that the tax on a car trip is 50p on average: it is caused by the fact that *the next trip is always [perceived as] free.*” (Harford 2006).

Policy Objectives that Require Addressing

Introducing road pricing is a delicate task as there are many and diverse interests at stake. In general, travellers would like to have a fair system and typically do not like paying more than they currently do. Public acceptability is often regarded as a prerequisite for introducing road pricing. If the public acceptability is not there, politicians typically find the topic too controversial. On the other hand, governments face the issue of raising sufficient revenues for building new roads and maintaining existing roads, while at the same time they are held responsible for solving any congestion problems. What is often not realised by the public is that building new infrastructure is extremely expensive and will generally not ‘solve’ congestion problems. Congestion typically appears during the morning and evening peaks, typically about five to seven hours a day³. At other times there is an oversupply of infrastructure and the roads are under-utilised. Many, but by no means not all, people may have already adapted their departure times to avoid some or most of the delays in travel time by leaving earlier or later to work. Building extra roads would mean that some travellers would shift back to their preferred departure time, and that others will change mode to car use, so because of this, congestion would again appear and may even end being worse than prior to the road improvement. Hence, in the best of cases it may provide comfort to car drivers not to get up so early, but would not decrease their travel time much and it would come at a large expense in infrastructure investment.

The main question is: is it possible to find a road pricing strategy that (i) is acceptable and well-understood by the community, (ii) raises sufficient revenues for infrastructure investment and maintenance, (iii) is revenue neutral or better to satisfy Treasury, (iv) would alleviate congestion, (v) would be technically simple (meaning less risk) and inexpensive, and (vi) addresses adequately the vertical equity concerns?

If all six points could be ticked, it would be a big sell for road pricing. However, this is not trivial, as some of the objectives are not in line with each other (Joksimovic *et al.* 2006). For example, for raising revenues, the optimal strategy would be to price everyone and not offer any alternatives. A fixed annual fee is an example of this strategy, where the only alternative to not paying is to sell the car. In contrast, for the objective of alleviating congestion, the optimal strategy is to offer many alternatives (i.e., offer plenty of relevant choices) such that there may be fewer car trips, and the remaining trips would be distributed better over time and space. A space and time dependent kilometre charge is an example of this strategy, where

³ There is a view amongst specialists in traffic management that it only takes about a six percent reduction in the number of trips in the peak period to reduce the worst of the congestion.

the road pricing fee can be avoided by not driving, driving at a different time period, driving on another route, or switching to another mode. A fixed annual fee is a much simpler strategy to implement, while a space and time dependent kilometre charging strategy likely relies on installing GPS devices in vehicles. Privacy issues are often mentioned when using GPS devices, but these issues can be and have been largely resolved⁴.

We could argue that offering travellers alternatives that would avoid paying any tolls, taxes, or prices would be of interest to the traveller, and therefore could provide a means to increase acceptance. We argue that offering such choices is relevant in pricing strategies, and we come back to this point later. Furthermore, total revenues could be kept the same (revenue neutral for Treasury), but rather have frequent car drivers who travel many kilometres each year, especially in the peak periods, pay more than less frequent drivers, which would be fair.

The next sections describe how road pricing could be sold and how a transition could take place from the current status quo.

A Starting Position: What do Voters think about Reform Options?

In recent research by Hensher *et al.* (2012), a model of choice between the current situation and a number of reform packages, suggested, *ex ante*, that over 62 per cent of participants would vote for a cordon-based payment of \$8 to enter the crowded Sydney CBD in peak periods and \$3 outside of peak periods, respondents would also be prepared to pay the charge on top of existing annual registration fees (ARFs) and fuel costs so long as 100 percent of the revenue was used to improve public transport. This reduces to 60.9 per cent when the revenue is allocated 50:50 to public transport and road improvements. Distance-based charging is clearly less popular if there is no reduction of the ARF and no hypothecation of revenue to uses supported by voters, with the highest percentage voting for a scheme, where the charge is 3c/km in the peak only, being 32.2 per cent. A particularly important finding is that when the revenue allocation is recognised in conjunction with distance-based charging, the support increases from 17.6 percent (under 5c/km) to between 25.5 and 27.12 percent (depending on the revenue allocation plan). If however, we eliminated the annual registration fee in the presence of a peak charge of 3c/km, and hypothecated all the revenue to public transport improvements, over 51 percent would vote for the scheme, enough to ensure a positive outcome. The evidence reinforces the view in the growing literature, in the absence of a trial that delivers real time savings, that how the revenue is allocated is critical to obtaining buy in to road pricing proposals (see Hensher and Li 2012)⁵.

⁴ Instead of letting the GPS device send the complete GPS trail of locations of an individual car driver, the information can be transformed or aggregated in such a way that, for example, only the charge to be paid is sent, or only the distance travelled in certain areas or certain road types at certain time intervals, etc. As a result, the exact locations of each driver cannot be traced.

⁵ If a pilot program was introduced that showed real time benefits, as in Stockholm, then the requirement to ensure revenue hypothecation might be less relevant.

A cordon-based charging scheme in a specific location such as the CBD may be a good starting scheme as long as it can demonstrate real time benefits⁶; however this is something that is by no means clear in many cities (and hence a real risk of failure). Such an initiative should be seen as a pilot scheme, as in Stockholm, that is then subject to a referendum so that it is carried forward with community support in contrast to a government imposed scheme. It is not however a ‘solution’ to improving the efficiency of the entire network in a metropolitan area, recognising that much of the traffic congestion is often on roads far away from a CBD. The challenge then is to find a way of beginning the pricing reform journey that can deliver widespread benefits to the entire transport network. The remaining sections of the paper focus on this agenda, but we start with a plea for a new language to assist the debate on road pricing reform.

Language Support: Switch from No-Choice Pricing to Choice Pricing

ARFs and fuel excise are unrelated to *specific* kilometres travelled and *specific* travel time outlaid in terms of a charging mechanism that can be used to discriminate between travel at specific locations and times of day. To emphasise the need for alternatives, and to give users more choices in a use-related pricing reform scheme, a critical (albeit intuitively useful) distinction in the selling of road pricing reform in language that can be understood by the population of travellers affected by pricing reform, is what we call *no choice pricing* vs. *choice pricing*. This distinction offers a powerful marketing language designed to suggest some flexibility in the amount you pay to travel.

No choice pricing (NCP) is what we have currently with ARFs (for a given class of vehicle) and fuel excise charges. For a given class of vehicle, there is a fixed non-negotiable annual fee which is not linked to use of the road network; and fuel excise is a sum per litre of fuel that is essentially independent⁷ of the *specific* kilometres of travel. The idea of *specific* kilometres (and its link to locations and times of the day) is critical to the distinction between NCP and choice pricing, and is focussed on relating travel to sources and magnitudes of externalities such as traffic congestion and emissions. NCP instruments are essentially invisible charges at the time of *specific* trip activity, and are unrelated to the prices of alternatives.

In contrast, choice pricing (CP) offers individuals a very visible choice to pay to use a particular road at a particular location and time of day, with different prices charged according to location and time of day, so that individuals have a real choice of paying or avoiding to pay a specific sum for specific kilometres. We believe that the population of voters would prefer a suite of CP instruments than the NCP instruments, especially if the choice pricing instruments can offer the opportunity to both save travel time and reduce the overall cost of motoring while exercising the right to avoid such a charge by switching out of

⁶ There will be some spill-over benefits from a CBD treatment, but they unlikely to be sufficient to make a big difference to the performance of the network as a whole.

⁷ Although we acknowledge that there is a link between variations in fuel consumed per kilometre and specific kilometres.

the peak (by undertaking off peak car travel) or use public transport. We believe this is possible.

We would encourage the marketing of road pricing reform to stop using language like a *congestion tax* imposed on top of existing charges, and to start referring to *no choice and choice pricing* with reference to specific kilometres, or travel at specific times of the day and locations, and to talk about *travel time benefits* or *annual registration fee discounts* instead of reference to the emotional and misunderstood language associated with a congestion charge.

Beginning the Sell: Registration-Usage Reform

Focus on Cost Reductions

Let us begin with what is in place at present and see how that might be modified in line with a longer term objective. While we may wish, in time, to have a true distance-based or travel time related charging regime in which the charge varies by time of day and road type, it may be sensible for community buy in to see if we can modify the current mix of registration and fuel excise charges to signal real opportunities for individuals to reduce their road use cost outlays, even if the resulting level of traffic congestion does not deliver improvements in travel time (although such gains would be a real bonus). This focuses on what is seen by many, informed or otherwise, as the first blockage in gaining public acceptance. It is astounding how few individuals, when exposed to the idea of a congestion charge, relate it to time savings; the overwhelming response is: ‘why are we being sluggish again given how bad the traffic is?’ (see footnote 2). This disconnect is frightening, but may be the fault of those promoting the debate on road pricing reform via a reference to reducing congestion. It is not long after that the media pronounces that a congestion ‘tax’ is being proposed.

The reform must emphasise a package of pricing reforms, which include current fees. Let us consider ARFs. These are typically imposed and collected by State governments (at least in the USA and Australia, for example) and vary in most cases by the class of vehicle, and certainly not by the amount of usage. It is assumed that usage is covered by fuel excise, which has been argued to be an inappropriate way of charging for usage in *specific* traffic settings. But what if we could redefine a transitional role for the ARF? In particular, why not introduce a baseline (or flag fall) fixed fee (which is significantly less than the current ARF) defined to support a minimum amount of annual usage, regardless of whether peak or off peak kilometres, this minimum based on a percentage (say 75 percent) of an estimate of the previous two years of kilometres driven, much like what the taxation office does in a number of countries (e.g., Australia) with a “pay as you go” (PAYG) quarterly or annual up front estimate of tax obligations. The sum tailored to the recent historical evidence of each vehicle can be promoted as a use-related ARF designed to have individuals ‘*paying for what you do and not what you own*’.

This could be also calculated in accordance with the overall amount of revenue currently raised from this source (in the previous two years) to ensure that government (Treasury in particular) is no worse off. This is a very simple way of beginning the usage journey to

achieving “those who benefit also pay”, even if we are not yet ready to have different charges by time of day and location. An adjustment would be made at the end of the year at an annual vehicle inspection (or other check point) as a refund or additional charge, depending on usage relative to the agreed baseline as proposed above⁸. People like refunds, so if the levels can encourage this, then it is a psychological win⁹. This then defines the baseline charge for the next period. The level could also be calculated so that there could be a reduction in fuel excise (or any cost component that can reasonably be adjusted¹⁰) which will send another positive message about reforms that can appeal to the public, although this requirement is not critical.

If this stage one initiative ensures that Treasury is no worse off (and it can be adjusted to ensure this), and the public is happy with this reform, since it offers an incentive to reduce costs, then this is real progress. What we would have achieved is the beginning of a commitment to the notion of ‘user pays’ but without any additional financial impost on users or government. The real test of acceptance must come from a population-level poll on whether people think this is fair.

The baseline fixed fee could be further reduced each year, while increasing the avoidable kilometre-linked cost component. Keeping the average costs of car users the same, this will be revenue neutral to Treasury, but at the same time provide scope for more discounts to car users that choose to drive less than the average annual number of kilometres (over all car users). In general, even assuming that no one would change their driving behaviour, the majority of the car drivers will be better off and pay less, while a smaller proportion of the population will pay more. This results from the fact that a small number of car users is responsible for a significant proportion of the total number of travelled kilometres, while many car drivers use their car relatively little. From percentiles of total kilometres travelled obtained from the Australian Bureau of Statistics (ABS 2010b), for example, approximately 62 per cent of the car drivers in the state of New South Wales (NSW) would receive discounts on their current ARFs.

Another way to start offering car drivers the option to save on their costs is *voluntary* participation in an ARF discount plan, in which they will guaranteed to never pay more than their current annual fee. If they drive less than the average annual number of kilometres (in NSW about 14,250 kilometres per year, ABS 2010b), they receive a proportional discount on their ARF. Again, the majority of the car drivers would benefit by entering such a plan. In order to keep it revenue neutral to Treasury, car drivers who do not participate will have to pay a fixed ARF that is determined yearly by the average annual kilometres driven by non-participants. In particular car drivers who drive significantly less than average would choose

⁸ This reformed registration two-tier charge has a sunk cost component and an avoidable cost component, the latter referring to the kilometre-linked charge that could be avoided.

⁹ It is well known that if you start with a somewhat undesirable proposition and then offer something that you really want that is indeed ‘better’, then the chances of support increase.

¹⁰ In Australia, there is a problem in reducing fuel excise since it is collected by the Federal government and not the States; however a road pricing use-related charge would most likely be collected by the State government. Possible fees that could be adjusted (apart from annual vehicle registration) that are State related are driver licences, stamp duty of vehicle registration and fuel franchise taxes and/or fees.

to participate and save money. As more car drivers participate, the ARFs of non-participants will slowly increase reflecting their higher average usage of the infrastructure. Such a scheme could be easily communicated as the choice between (i) a fixed ARF that gradually increases over the years, and (ii) participating in an ARF discount plan in which you will never pay more than the fixed ARF. This interesting voluntary discounted ARF concept, which we call ‘saving per automatically registered kilometre’ (SPARK), would likely be acceptable by the public (as it is opt-in and the majority saves money), could remain revenue neutral to Treasury, and does not require expensive technology besides periodically (e.g., annually) monitoring the already automatically registered kilometres as shown in any car.

Targeting specific kilometres

There may be other, possibly more attractive, registration-usage reform scenarios worth considering which start targeting the *specific* peak vs. off peak kilometres (see Hensher and Mulley 2012 for further details). For example, we might begin by assuming that all annual kilometres are peak kilometres. If the driver wants to have a subset of kilometres recognised as off peak (including peak shoulder) kilometres, they must purchase a small on-board unit (OBU) (approximately \$Aud100 once off cost) that will record the kilometres by time of day. The off peak kilometres are not charged, but peak kilometres will be charged at either an agreed cents/km¹¹ or a fixed peak surcharge for bands of annual peak kilometres (the choice of charging regime must be cognizant of which will offer the least resistance in the initial phase of reform). Note that if an OBU is not installed, all kilometres will be charged as peak kilometres, giving an incentive to install a meter, just like households have had with off peak electricity meters or with water meters when they were first introduced.

This regime can, and ideally should, be related to the ARF, with the idea that the latter is adjusted from the full amount to close to zero¹² depending on the amount of kilometres travelled per annum in the peak, and the number of kilometres that have switched out of the peak in the previous year¹³ (regardless of whether the reduced peak kilometres are now converted to off-peak kilometres, public transport trips, or eliminated travel). Although we recognise the possibility of complaints of unfairness (and political concerns) from those who claim they cannot switch some amount of kilometres out of the peak, we counter this by the argument that maintained peak kilometres are a contribution to peak congestion and are not currently being fully paid for; and that a significant number of road users (enough to make a difference to peak traffic congestion) do actually have a choice of time of day to travel¹⁴. Car drivers that cannot switch, however, are likely rewarded with lower travel times due to fewer

¹¹ There can be a graduated set of peak charges to reflect the degree of peakiness in the traffic throughout the declared peak hours.

¹² Zero registration would not work because registration is the process where documentation is checked and so there should always be a minimum fee e.g., \$50 to both cover the administrative fee and to maintain the process where insurance and roadworthiness is checked.

¹³ For newly acquired cars which have no previous year kilometre history we would have to assume the kilometres of the previous vehicle which should be recorded by the regulatory inspection organisation. Individuals who have just received a driver’s licence will be ineligible for any registration exemptions for one year until they have a baseline annual kilometres. If a household tries to evade the system by selling their cars to another member of the household every year to avoid any history of use, we would have to impose an estimate associated with the average annual kilometres for a vehicle in a particular geographic jurisdiction. Such data is readily available in cities in Australia.

¹⁴ We recommend a research study to establish the ability to time of day switch.

travellers in the peak period. We propose to reward the amount of switching out of the peak through a noticeable discount on the ARF, calculated in such a way that the revenue raised for the Treasury is not disadvantaged. The charge per peak kilometre or new peak annual surcharge is one way of securing revenue neutrality (even in the absence of politically problematic c/km peak usage charge), which we believe is likely to be necessary to incentivise some amount of temporal switching if the ARF is too price inelastic to have any significant effect.

The challenge is to identify an appropriate adjustment quantum in the ARF. It should be calculated on the basis of the reduction in the amount of annual peak kilometres. Herein lies the (perceived) vertical equity debate¹⁵ about fairness, which can work against both high and low annual peak kilometres if not carefully defined. One way forward might be to adopt a simple discount rule which amounts to a flat reduction in the ARF linked to the acquisition of the OBU, even if a differential amount for further reductions is offered. Given the problems with absolute and percentage reductions in peak kilometres as the entitlement for an ARF adjustment, we suggest an incentive based on free peak kilometres for 50 per cent of peak kilometres if an OBU is purchased and a charge per additional peak kilometre or an annual peak surcharge linked to bands of additional peak kilometres for the balance of peak kilometres¹⁶, which begins the move to a distance-based charge, *together with* a 50 percent reduction in the ARF.

An Illustrative example

Hensher and Mulley (2012) are undertaking detailed assessment of the likely impact of registration-usage reform using data at the postcode (or suburb) level for the Sydney Metropolitan Area. The evidence is not yet available; however we provide an example below of the types of information and responses that we need to measure to establish the financial implication on classes of users. In our example, we do not account for vertical equity impacts that are being identified by Hensher and Mulley (2012).

Let us begin by assuming that total annual kilometres are 15,000, all initially assumed to be peak kilometres. A motorist purchases an OBU, which means that only peak kilometres are then subject to a new charge, which we will define as a surcharge based on kilometre bands (in contrast to a cost per kilometre). We have arbitrarily defined five charge bands: <2,500 km; 2,500-5,000 km; 5,000-7,500 km; 7,500-10,000 km, and >10,000 km per annum. A charge of \$100 applies for band 1, with \$100 increments as the band increases.

If peak kilometres are switched to off peak kilometres, the proposal is to reduce the ARF, which we will assume is currently \$500. The reduction in fee will be \$100 per move to a lower adjacent band plus a 25 per cent reduction in the ARF. The surcharge for remaining peak kilometres will be imposed.

¹⁵ If one believes equity balance is appropriate, in the sense of being equitable for people who have made a location decision which is difficult to reverse, and in that sense is politically sensitive.

¹⁶ In this regime you could ignore new cars and new ownership by saying that x,000 km (worked on the average of the previous year national or local statistics of usage) is the allocation of peak kilometres. This is the most appealing pricing regime if it can be linked to reducing peak kilometres.

We assume that the initial peak kilometres are 8,000 (Band 4) and that the motorist has managed to reduce peak kilometres by 1,500, moving the peak kilometres to Band 3. Their costs comprise the Peak km surcharge of \$300, a \$100 reduction in the annual kilometre charge (Band 4 to Band 3) plus a 25 per cent discount on the ARF (for moving to Band 3) = $0.25 \times \$500 = \125 . The ARF now drops from \$500 to \$375. This driver saves \$225 in total.

The focus is on cost adjustments, but there will also be time benefits for both peak and off peak kilometres *ex post*, due to the individual switching and adjustments associated with traffic levels. If there is no switching, then the ARF remains at \$500 and the annual peak charge is \$400. The net impact to the user is \$900 ($\$500 + \400) – \$675 ($\$375 + \300) = \$225 plus time savings. Treasury is currently receiving only \$500 and no system time benefits but will *ex post* receive \$675 (i.e., \$375 ARF + \$300 peak surcharge). Hypothecation of the \$175 might be a politically worthwhile strategy to signal recognition of how the community would like to see road pricing revenue spent.

In summary, a user in the absence of the reform package, will outlay \$500 ARF and Treasury will receive the full amount. After the reform package is implemented, the user incurs a net increase of \$175 per annum, which is the full net gain to Treasury. Importantly, this financial outlay is accompanied by travel time savings, associated with 1,500 reduced kilometres in the peak. Although the actual time savings will be dependent on the aggregate response by all drivers, if we assume that the value of travel time savings is \$16 per person hour, then \$175 of cost outlay is equivalent, on average, to 10.93 hours of time outlaid. If the users can reduce their travel time by at least 10.93 hours as a result of the reduction in peak kilometres, then they will be better off, and the traffic system will also benefit by reduced congestion. Assuming 10 trips per week in the peak, spread over 48 weeks per annum, the average time that would have to be saved to be no worse off (in generalised cost terms) is 1.4 minutes per trip. Given that the percentage reduction in peak kilometres for this user is 18.75 per cent (i.e., $1500/8000$), one might reasonably expect a time savings better than 1.4 minutes on average. The final outcome will be dependent on how the reform package is responded to by the population of motorists; however our knowledge of elasticities suggests that the gains are likely to exist.

Continuing the Sell: A Time Reduction Benefit Charge

So far we have stayed away for the sensitive (emotional) and badly appreciated idea of explicitly paying to reduce congestion *and* gain travel time benefits, although some element of this clearly exists in the proposition outlined above. The next step, possibly after a two to three year implementation of proven registration-usage reform, with or without some element of fuel excise adjustment, is to think through ways of linking the charging reform to ways of saving people (passenger and freight vehicle) time, much like tolling of specific roads is designed to achieve, while still retaining the principles in place for a use-related registration fee. The next stage will be heavily influenced by the extent to which peak travel times are reduced as a result of the use-related registration fee reform.

Let us assume that the main objective of stage 2 is to improve travel times in the peaks, which may be a better way of describing the task than reducing traffic congestion, given that the latter is only worthwhile if travel time is reduced. Government might consider a pilot test in a small geographical area (that has a few well delineated entry and exit locations) in which on-board computers linked to satellite-based GPS are used to monitor the travel times (and speeds) at various times of the day (and day of the week) on all roads in the selected jurisdiction. It may be feasible to use smart phones to capture relevant information. Ideally all vehicles should participate if they enter the area otherwise it could fail as a real evidence-based pilot.

An alternative, less demanding pilot plan would be to relax the need that each vehicle entering the area participates, regardless of whether a cordon or distance-based charging regime is introduced. As long as the size of this volunteering population is large enough, there will be time benefits. In the Netherlands, rewarding schemes (see below) each had between 2,000 and 4,000 participants on concentrated roads (half of the projects using smartphones, and half with in-vehicle GPS). Provided that removing a few hundred cars from these roads has travel time impacts we do not require all vehicles to participate. The critical issue is to demonstrate real time benefits. The demonstration project in Stockholm showed that road pricing can have benefits regardless of how the revenue is spent, supporting a view that revenue allocation may not be necessary to gain support in the presence of a successful demonstration project.

Drivers should be told that they will be charged for time reductions (or improvements) that guarantee elimination¹⁷ of delays due to traffic congestion. Initially we might not be in a position to strike an advance notice charge per km; but it is essential that motorists know that the charge is designed to ensure that they are not (unnecessarily) delayed in the traffic, and that at the end of each month drivers will be told how much they have to pay in return for delivering maximum travel times. If travel times exceed the government backed travel times, then the payment charge will be discounted by some formula based on each additional excess travel time minute. The first two months of the pilot should involve no charge (and maybe a small financial reward) in order for most users to get used to the plan. The charge should not be called a congestion charge (or tax) but a ‘time reduction benefit charge’ (TRBC).

Do we have to charge for peak use when we might consider the alternative of rewarding off-peak travel that has moved out of the designated peak periods?

Rewarding vs. Charging

Linked to the TRBC might be a financial reward that is netted off of the TRBC when motorists switch travel to pre-designated (entry) times of day that are mandated as times of day that contribute to reducing traffic in peak hours. We would not want to guarantee that there will be no congestion at these times of day, since that may not be true; but what is being done here is to take pressure off of the really serious peak times when delays are at their

¹⁷ We must be very careful with the language here. A very specific adjustment must be unambiguous, since free flow may not be guaranteed, but a significant improvement in travel time may be.

worst. Trips that are eligible to receive this trip time reduction benefit must have been undertaken previously in the defined periods in which the TRBC is applicable. Funds to support this time of day switch would need to be derived from the TRBC source.

Such charging schemes (which are in effect rewards for ‘good community behaviour’) have been successfully implemented at several locations in the Netherlands with a pool of voluntary participants since 2008, in which 15 to 44 per cent of the car drivers opted for a different departure time (usually earlier), about one to six per cent chose to work from home, five to 14 per cent chose public transport, and depending on available route alternatives, up to 28 per cent chose a different route (see Bliemer *et al.* 2009). This confirms the argument that monetary incentives can have a huge impact on the travel choices, with more than half of the participating car drivers able to avoid paying any charges by changing their travel behaviour.

A Taxi Tariff as a way of being Aware of the Charge in Real Time: *It is time we want to save, not kilometres*

A simple pricing strategy that would not involve new technology, but would be related to a TRBC, is applying the taxi tariff methodology. Taxi meters around the world are often distance and time based. Distance based charging has been proposed in several countries, often so-called kilometre charging schemes; however, time based charging has been proposed less frequent. The rationale behind it is simple. During peak hours, the travel times are longer than the travel times during off-peak periods.

Hence, paying per minute (like in a taxi) essentially means that one has to pay more during the peak periods than off-peak. Cars currently only register the total distance travelled, but could potentially also register the total time travelled without any significant technological adaptations. The charges could be based on these two numbers on an annual basis, and can be adjusted to reflect the impact on trip time reduction benefit and government revenue requirements.

There may be some issues that need to be resolved, for instance what will happen when a major incident increases the travel time for car drivers, but the concept is interesting.

Vertical Equity Considerations

Regardless of the merits of each reform package in terms of the impact on levels of traffic congestion and hence time reduction benefits, there are very strong arguments opposing any reform if it discriminates between individuals on vertical equity grounds (i.e. the impact on individuals in different personal income groups). There is a large literature on the topic (e.g., Ison 1998, King *et al.*, 2007, Levinson 2010 and Peters and Kramer 2012). Despite the recognition that revenue allocation¹⁸ can be a major lever to gain community support for road pricing reform, there is also a view and evidence that revenue redistribution cannot resolve all

¹⁸ Manville and King (2012) also raise the concern about credible commitment from government in using the revenue in line with community supports for reform. The Sydney study by Hensher (see Hensher *et al.* 2012) found only 22 percent confidence that government would allocate revenue the way they would like it allocated.

equity and fairness concerns. Initial travel patterns also matter (Eliasson and Mattsson 2006), especially the concern that individuals undertaking most of the trips will be the ones most affected by any change, even if the impact is higher levels of time benefits. Let us have a closer look at mandatory trips that people cannot avoid, i.e., work, business, and education trips.

People who have a long commute to work will end up paying more. Therefore, the road pricing reform should not be an abrupt but rather be a gradual process (e.g., several years) in which people are given the opportunity to re-evaluate their mobility choices, including changing jobs and/or residential relocation. The road pricing reform should by no means force people to move or change jobs, but rather when people are making the decision to move or change jobs, that they take the commuting distance more into account. Even without any road pricing reforms, the majority of the working population will likely be moving at least once within the next five years for various reasons¹⁹. Although less frequent, people also regularly change jobs in their lifetime. Hence, road pricing reform should not be a push factor that pushes people away from their current residential and employment location, but rather a pull factor (after they have chosen for other reasons to change the residential and/or employment location) that pulls people towards more attractive locations from a mobility and cost perspective. At the same time, employers should be stimulated to offer alternatives such as flexible working hours and working from home; there has been limited effort by employers to provide incentives for some occupations where working from home makes eminent sense (as shown by Brewer and Hensher 1998, 2000). There may still be a number of people who cannot avoid the long commute, e.g., a low income family with limited employment possibilities and a restricted relocation budget. Additional compensation would be required to avoid equity loss for these people.

People who travel a lot by car for business purposes will also have to pay more. Additional costs of company car drivers or lease car drivers will likely be compensated by their employers. People who have their own business (e.g., plumbers, landscapers) will probably charge their clients, which is reasonable since all costs have to be considered when pricing a product or service. Fortunately, this increase can be assumed to be small (e.g., \$1) compared to the fixed call out charge (e.g., \$80) that is often asked. Any improvements to the travel times due to the road pricing reform would of course be a great benefit to people with their own businesses, as clearly time is money for them (see footnote 2).

The number of people who have to travel far by car for education purposes is expected to be fairly small. Full time students often use public transport or live close to the school or university. With a gradual road pricing reform process, current students will not be affected much, and future students can take the extra cost of a long trip to school into account. Again, there may be people that need extra support from the government (e.g., parents who have to drop off their child to a special school).

¹⁹ In Australia (ABS 2010a), in the past five years, 90 per cent of young households (aged 35 or younger) without children have moved at least once, 45 per cent of parents in couple families with dependent children have moved at least once, and 59 per cent of lone parents with dependent children have moved at least once. In comparison, only 17 per cent of the older households (aged 65 or older) have moved at least once within the past five years.

King *et al.* (2007) recommend redistribution efforts that concentrate the benefits and create “strong advocates” for a proposal, and contend that congestion pricing schemes with concentrated benefits and widely-dispersed costs are more likely to succeed. Achieving this outcome is essentially empirical and requires knowing what behavioural responses individuals on different incomes would have and how this translates into winners and losers on costs and benefits. King *et al.* (2007) and Peters and Kramer (2012) summarise gainers and losers as follows:

Net beneficiaries associated with improved traffic flow:

1. Drivers whose time saved is worth more than the fees/charges they pay.
2. People who already use public transport and will not pay road pricing reform charges but will travel faster (i.e., buses in mixed traffic).

Road pricing reform will create a net loss for:

3. Drivers whose time saved is worth less than the charges they pay.
4. Drivers who switch to a less convenient route to avoid the charges.
5. People on non-priced routes whose traffic increases when drivers from Group 4 switch to their roads.

Hensher and Mulley (2012) offer some evidence in the Sydney (Australia) context of reforms proposed above, ranging from use-related registration fee reforms, a cordon-based scheme in the CBD and a widespread distance-based charging regime. They find that although individuals on lower incomes tend to be more reliant on car use (in part linked to relatively inadequate public transport), they do have the opportunity to reduce kilometres since a higher proportion are discretionary and are very local, and also the average trip length is much shorter. With an appropriate compensation package (including kilometre saving credits), it is possible to make all income groups winners.

Conclusions

Progress takes time when politicians are involved²⁰, except if there is a champion for the cause, yet we cannot avoid them. Short of a bipartisan commitment to road pricing reform (not in spirit, but in action), we are left with no recourse but a drip feeding and dragging along of the public (see also Ortúzar and Hensher 2012). While the Stockholm congestion charging scheme in the CBD is our best success to date in a democratic society, highlighting the essential ingredient of a trial *ex ante* prior to a referendum, it is very much a leap of faith in most societies that this experience can be duplicated, especially when the more serious endeavour of system-wide reform is proposed.

A CBD cordon-based congestion charging scheme is unlikely to deliver significant benefits to a city wide transport network. The findings in Hensher *et al.* (2012) suggest that a wise transition strategy is to reform registration charges as suggested above, making the annual registration fee variable as step 1, followed later by step 2 to make it time dependent. In step

²⁰ Including obtaining community buy in, and especially when the community is uninformed.

1 people get used to decreases in cost relative to their usage, and in step 2 people will actually experience time savings as well.

Coming back to our main question, whether it is possible to find a road pricing strategy that satisfies the six properties that we defined earlier, we conclude we believe it is possible to have an strategy that (i) is acceptable as it offers discounts on the annual registration fee to the majority of car drivers, which is also transparent and easy to communicate and could even be voluntary, plus a gradual reform process can prepare people for upcoming changes, (ii) can raise sufficient revenues for infrastructure and maintenance, (iii) is revenue neutral to Treasury, (iv) will alleviate congestion and offer travel time benefits using time differentiated charges or rewards, (v) does not require any complicated technology besides annual registrations of total travelled kilometres, possibly differentiated in peak and off-peak kilometres, and (vi) with appropriate compensation packages can avoid vertical equity concerns.

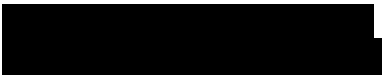
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Complementing Distance based Charges with Discounted Registration Fees in the Reform of Road User Charges: the Impact for Motorists and Government Revenue.

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Abstract

The call for a congestion charge is getting louder and more frequent in many countries as major metropolitan areas experience increasing levels of road congestion. This is often accompanied by a recognition that governments need to find new sources of revenue to maintain existing road networks and to invest in new transport infrastructure. Although reform of road pricing is almost certain to occur at some time in the future in a number of countries, a key challenge is in selling the idea to the community of road users as well as a whole raft of interest groups that influence the views of society and politicians. Simply announcing a need for a congestion charge (often misleadingly called a tax) does little to progress the reform agenda. What is required is a carefully structured demonstration of what might be done to progressively introduce adjustments in road user charges that are seen as reducing the costs to motorists while ensuring no loss of revenue to government. In this paper we show, the context of Sydney (Australia) that this can be achieved by the reform of registration fees in the presence of a distance-based charging regime (either for the peak or all day), that can deliver financial gains to motorists with prospects of revenue growth to the State Treasury. The reform package assessed is predicted to result in changes to total annual kilometres of travel (especially in the peak) and flow through gains in travel time that deliver reductions in traffic congestion. We see this as an essential first stage in gaining community support for road pricing reform – proof of cost reductions associated with improvements in traffic congestion can then be used to continue the reform process.

Key words: road pricing reform, political process, revenue implications, staging reform, appealing solutions, use-related registration fees, distance-based charging, implementation costs

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Introduction

Road pricing reform is much touted by economists and others who see the current charging instruments inadequate in both delivering efficient outcomes for road use (especially in controlling levels of traffic congestion) as well as raising sufficient revenue to fund new infrastructure and much needed maintenance of existing road networks (see Verhoef *et al.* 2008, Manville and King 2012, and Small 1992).

The greatest challenge in reforming road user charges is how to devise a scheme which gains public acceptance, which means convincing voters that there are benefits to them, is also convincing to politicians who will be concerned about their electoral future (see Marcucci *et al.* 2005, Goodwin 1989, Hensher and Bliemer 2012, Bliemer *et al.* 2009, Hensher *et al.* 2012) and satisfies Treasury. The public sentiment, albeit often misinformed, is well illustrated by the following summary of a recent radio conversation.

Setting: ABC Sydney Radio 702 Tuesday 4 Oct 2011 8.30-8.55am.

Hensher discusses the merits of Road Pricing Reform (after stating clearly that it is more than a congestion tax, and to please stop using the emotive language of a congestion TAX). Calls are invited from the public.

A plumber calls and says (paraphrase): "...I spend up to 5 hours on the roads every day between jobs and now you are telling me I have to pay a congestion tax on top of all of my existing costs for the 5 hours. What is he thinking (the Professor needs to get real)... I do not earn enough income now as it is."

Hensher's response (paraphrased): "...I made it very clear I thought that the aim is to reform the entire set of charges (including registration fees) and to set the kilometre based charges to reflect the traffic conditions with the aim of not only enabling you to save time (which is money as well) but to give you realistic options on levels of charge and time of day to travel. It is expected that you will spend less time travelling and can convert such saved time into more productive income earning time."

This paper promotes the belief that road pricing reform will be achieved only by a slow but progressive set of steps in situations where a 'trial' is not put in place that allows motorists to see its merits (Schuitema *et al.* 2010). The predominant interest of car drivers when first asked about congestion charges is what it will mean financially to them (with rare reference to its value in improving travel times) as evidenced by referendums in the UK which failed to support congestion pricing packages (Gaunt *et al.* 2007, De Borger and Proost 2012). Indeed, in identifying congestion charging schemes that voters would opt for, the literature identifies that support is influenced by the perception of societal benefits but the impact of personal well-being is stronger (Jaensirisak *et al.* 2003, Eliasson and Jonsson 2011). The paper is therefore predicated on the idea that reform must start some initiative that has an easier staged sell in respect of the "hip pocket" rather than with the explicit end objective to reduce traffic congestion if it is to achieve acceptance and buy-in.

The paper is organised as follows. We begin with a discussion of how registration fees can be packaged with peak¹ distance-based charges to obtain financial gains to key stakeholders. This is followed by an explanation of the method we have adopted, together with the data we have used from the Sydney Household Travel Survey data (expanded to the population), to undertake scenario analysis in determining the financial and usage implications of varying registration fees and distance-based charges in the peak. We then present compelling evidence to show how road pricing reform can make both drivers and government better off financially, although we recognise that the need for some upfront investment in the data capture technology may involve a significant outlay by government. The conclusions summarise the main policy implications and topics requiring further research.

Registration-Usage Pricing Reform

Whether any proposed road pricing reform begins with a driver-wide compulsory application or a voluntary opt in and opt out plan is secondary to establishing if there is financial merit in a scheme in terms of its impact on drivers. In addition to motorists, government, and especially Treasuries also have a keen concern for the revenue implications of road pricing reform. The approach we propose in this paper is to start with a budgetary constraint that represents the need for Treasury to be financially no worse off (and possibly better off) while establishing a charging regime that will also make drivers, on average, financially no worse off (and possibly better off). The Treasury of interest is a State organisation which does not collect fuel excise (a federal tax) but collects registration fees. We recognise that in some countries such as the UK, the collection agency is at the National level, whereas in Australia and the USA, for example, there is the distinction between State and Federal agencies. There will be implications for fuel excise which is a Federal responsibility in Australia. The implications for fuel excise revenue is not central to this paper, lying as it does outside the reforms proposed, but could easily be included in this framework if a national agency perspective is sought.

The reform framework we adopt, as proposed in Hensher and Bliemer (2012) that has these desired attributes involves the introduction of a distance-based charging regime in return for a discount on the current annual registration fee, in full or in part. Although governments often raise the prospect of increasing the annual registration fee to raise revenue (a recent example being the release in September 2012 of the NSW Long Term Transport Master Plan draft (TfNSW 2012)), we would argue that discounting of the registration fee can be used as part of a carrot and stick initiative to move to use-related charging to relieve a cost burden on motorists, at least in the initial phase of securing buy in to road pricing reform. To be able to

¹ We also investigated all day distance-based charging, and while there may be some merits for this, including the view that the perception of an all day charge might look better as it is less (3) cents per km, on balance we believe that it will be more difficult to sell this as the first step, and so we have focussed on peak period only distance-based charging.

say that a reform strategy will not make drivers worse off financially² will be a major step forward in dulling the immediate critical response from motoring organisations and politicians! A resulting bonus of this reform plan, which is not available under a registration fee only regime, given the disconnection with kilometres travelled, is drivers enjoy the resulting travel time savings. The reduction in kilometres travelled, especially during peak periods, need not be radical in order to make enough of a difference in traffic congestion. The best evidence of this is the difference between peak period travel times on roads during school holidays and during normal times of the year, typically associated in Sydney with up to 5 percent less traffic (or 1 in 20 vehicles) as a conservative estimate³.

Sourcing Data to Quantify the Potential Cost and Revenue Impacts of the Reform Plan

The primary data on car driver trip activity and cost outlays is sourced from the Sydney Household Travel Survey (HTS), the largest and most comprehensive source of personal travel data for the Sydney Greater Metropolitan Area. The HTS was first conducted in 1997/98 and has been running continuously since then. About 5,000 randomly selected households are approached each year to participate in the survey⁴. The sample of the continuous HTS is designed on a three-yearly cycle so that the pooling of three years of data gives a sample size similar to that achieved in the traditional once in 10 years metropolitan household interview survey.

We have used pooled data of residents of occupied private dwellings in the Sydney Metropolitan Area from five waves, June 2007 to October 2011, weighted to June 30 2010 population. Population weights are based on the estimated resident population as at 30 June

² The issue of vertical equity is discussed in detail in Mulley and Hensher (2012), since some individuals may be (slightly) worse off financially even though most will be better off. Some form of a compensation package may have merit in such circumstances, with monies coming from the additional revenue gain beyond the revenue neutral outcome for Treasury. See also Levinson (2010).

³ Based on data from the Sydney annual Household Travel Survey and

http://www.rta.nsw.gov.au/publicationsstatisticsforms/downloads/travelspeeds_sydney_metro_area.html

During school holidays, traffic lightens by about 7 to 10 percent outside school drop off hours, yet the influence that this has on traffic flow is immense. (See <http://www.privatefleet.com.au/congestion/>). The National Road and Motorists Association (NRMA) of Australia uses a rule of thumb that when traffic on congested roads falls by 5 per cent, speeds increase about 50 per cent (though this might only mean an average speed increase from 20 km/h to 30 km/h). See <http://smh.drive.com.au/roads-and-traffic/how-do-you-spell-the-end-of-the-school-holidays-gridlock-20120715-224ag.html>. We calculated a 4.77 percent drop in traffic volumes during school holidays in Sydney in 2005 on all the major arterial roads, freeways and tollroads (sourced from http://www.rta.nsw.gov.au/trafficinformation/downloads/aadtdata_dl1.html.)

⁴ The HTS consists of a face-to-face interview survey carried out every day from July to June of each financial year. This collection method ensures high data quality and maximises response rates. A simple travel diary is used by each householder to record the details of all travel undertaken for their nominated 24-hour period. An interviewer then interviews each householder to collect the details of each trip. The interviewer records the mode of travel, trip purpose, start and end location, and time of departure and arrival. Vehicle occupancy, toll roads used and parking are recorded for private vehicle trips and fare type and cost for public transport trips. The HTS sampling method was designed for BTS by the Statistical Consultancy section of the Australian Bureau of Statistics (ABS) such that the relative standard error (RSE) decreases and the statistical reliability increases as more waves of data are pooled.

2010. The data is based on an average day and is scaled up to the full year. We have undertaken all of the analysis at the geographical level of the Sydney Statistical Division (SSD)⁵. There are 14 SSD's in Sydney; however we excluded the Statistical Division of Gosford Wyong which is unlikely to be exposed directly to road pricing reform⁶ (see Figure 1).

In designing a scenario-based application framework, we need to identify the 'before' or status quo financial outlays and kilometres travelled by drivers in the peak and off-peak periods. Some costs are use-related such as fuel costs (distinguishing the fuel excise from the other fuel costs passed to motorists), and tolls, while the registration fees are annual fixed charges unrelated to usage. We also need to calculate the revenue obtained by State Treasury under the status quo situation. In this study we are interested in the revenue implications for the State (of NSW) Treasury who collect registration fees only, and who will under a distance-based charging regime also collect the use-related revenue. Fuel excise is collected by the Federal government and is disbursed as they see fit, with some of the funds returning to the States in many forms. Tolls are collected by the tollroad operators and are retained as part of the public-private partnership concession arrangements and are not available to State Treasuries. The tollroad network in Sydney is extensive by the standards of most cities (see Li and Hensher 2010).

⁵ We have data at the postcode level which is at a greater level of spatial disaggregation; and while it is useful for studying sources of systematic variation that influence total kilometres travelled per driver, there are sample reliability concerns for the analysis undertaken herein. We use SSDs but undertake some additional scenario analysis to assess the range of annual kilometres of drivers from each SSD.

⁶ There may be implications for residents of Gosford-Wyong who commute to the other Sydney SSDs; however this can, in future analysis, be included if required.

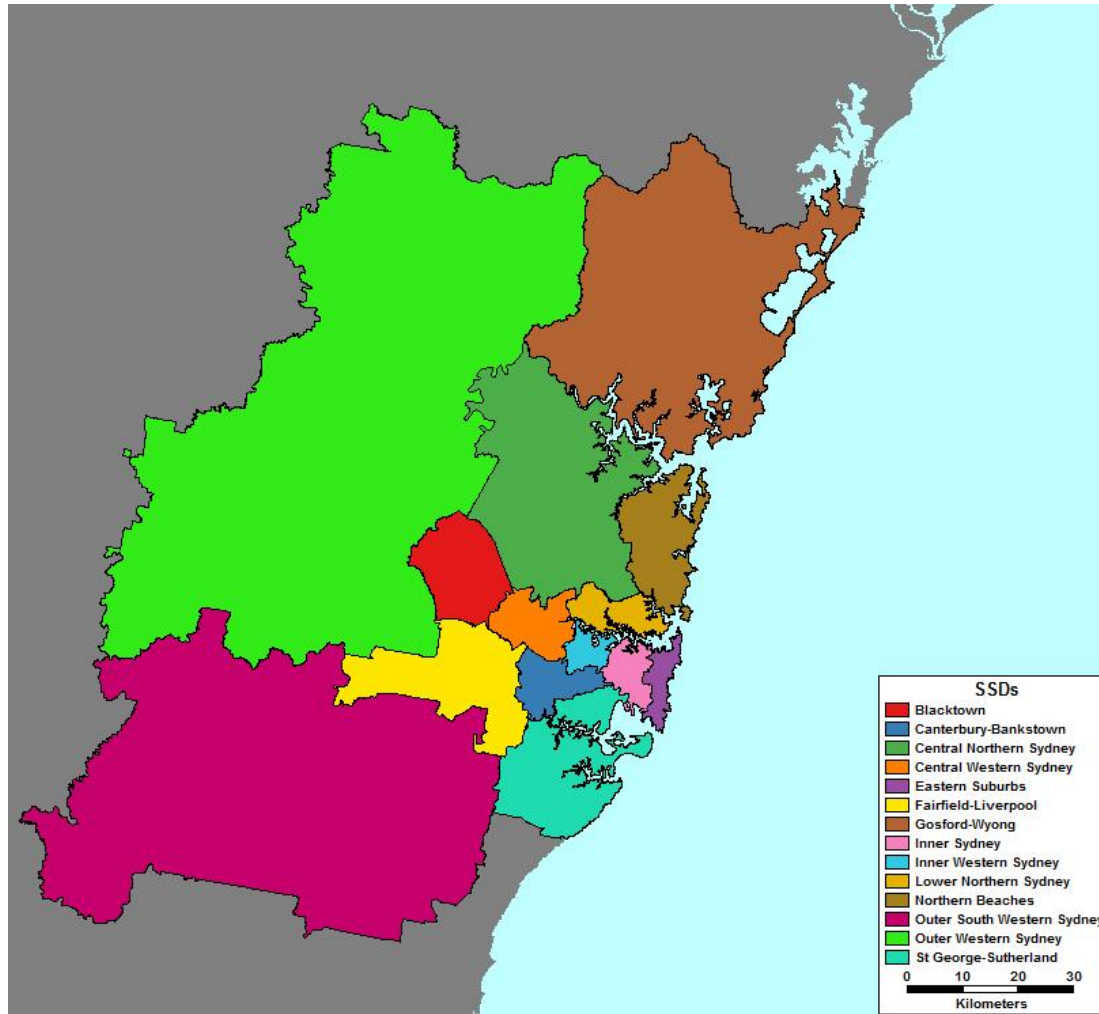


Figure 1 The location of the 14 SSD's in Sydney

To determine the behavioural response of car drivers, expressed in terms of changes in peak and off peak kilometres, to the introduction of peak period distance-based charges (DBC), we need to assume a DBC elasticity of kilometres travelled, *ceteris paribus*. Li and Hensher (2012) provides one review of the evidence, although they find that the focus of most road pricing studies that have reported elasticity estimates has not been in terms of changes in kilometres travelled. Hensher *et al.* (1992), in a longitudinal study of household demand for automobile by type and kilometres travelled in Sydney, obtained static and dynamic short run and long price elasticities for fuel and registration charges in the context of annual kilometres travelled. We have drawn on this study to select price arc elasticities of -0.25 and -0.35 respectively for peak and off-peak kilometres, which we suggest are generally in line with expert opinion. Sensitivity testing around these mean estimates enables us to determine the influence these estimates have on the change in kilometres travelled. These elasticities are applied to the fuel and toll costs⁷ together with a peak period distance-based charge,

⁷ In Sydney, all tolled roads are cashless with electronic tags (ETAGS). ETAGS tend to make payment seamless and change the perception of toll payments since the driver is not having to be reminded in the same way as having to find cash and stop. This tends to reduce the price sensitivity and brings it closer to the fuel cost response.

assuming no change in total *status quo* kilometres. Formulae were developed to calculate the peak and off peak kilometres under a peak only DBC:

$$\begin{aligned} &\text{Peak Kms}^{\text{After}} \text{ Elasticity Application} \\ &= \text{PKM}^{\text{Before}} * \{ [1 - ((\text{TC}^{\text{A}} | \text{TotalKM}^{\text{Before}} - \text{Regn}^{\text{After}}) - (\text{TC}^{\text{SQ}} - \text{Regn}^{\text{SQ}})) / (\text{TC}^{\text{SQ}} - \text{Regn}^{\text{SQ}}))] * \text{Abs Elas} \} \text{Off Peak Kms}^{\text{After}} \\ &\text{Elasticity Application} = \text{Total KM}^{\text{Before}} * (1 - \text{Proportion PKM}), \end{aligned}$$

where PKM = annual peak kilometres, Regn = annual registration fee, TC^{SQ} = total costs before (i.e., status quo) reforms, $\text{TotalKM}^{\text{Before}}$ = total annual kilometres after DBC but holding kilometres to SQ levels, and Abs Elas = the direct elasticity without sign.

Table 1 summarises the kilometre activity of motorists resident in each SSD together with the mean personal income as background to the setting where the extent of changes in annual kilometres in the peak and off peak periods change in the presence of reforms to the cost of owning and user cars is to be identified. As might be expected, the quantum of kilometres of residents of each SSD varies significantly and in large measure is due to location relative to the Sydney Central Business District, reflecting the radial-centric nature of Sydney. The data has an implied direct elasticity of daily kilometres per driver with respect to distance from the CBD of 0.21 (obtained from a linear regression model in which distance to the CBD was statistically significant with a t-value of 3.64 and in which the overall explanation of variation (adjusted R^2) is 51 percent); hence a 10 percent increase in the average distance to the CBD increases average daily kilometres per driver by 2.10 percent, *ceteris paribus*. Interestingly, when we add in personal income, retaining distance to the CBD, we find that the parameter associated with the natural logarithm of income is not statistically significant (t-value of 1.29) but with an implied mean direct elasticity of daily kilometres per driver with respect to mean personal income per SSD that is very close to unity (1.03). If distance to the CBD is removed from the model, the personal income parameter is negative (-0.85) and highly non-significant (t-value of -0.95). At the mean, therefore, there appears to be no statistically significant relationship between average daily kilometres per driver and income.

When we use equivalent data at the postcode level, the overall fit of the model is poor, (adjusted R^2 of 0.027), although both distance from the CBD and personal income as the only variables in the model, are statistically significant with respective t-values of 12.76 and 11.79. The implied direct elasticity of daily kilometres per driver with respect to distance from the CBD is 0.27, not dissimilar to the SSD level evidence of 0.21, and with respect to personal income it is 0.15.

Mulley and Hensher (2012) investigate in detail the vertical equity implications of the pricing reform evidence in this paper. In this paper we now take a closer look at the combinations of a distance-based charge and discounted registration fees that satisfy the budget neutral (or better) requirement of State Treasury, and which also deliver no financial impost on drivers overall.

Table 1 Descriptive Profile of SSD level Data

SSD	Mean Personal Income (\$'000s)	StdDev Income	Mean Kms per day per driver	StDev KmDay perDrv
Inner Sydney	62.89	41.07	13.97	21.45
Eastern Suburbs	63.38	43.73	17.14	21.75
Inner West	56.42	40.86	16.22	22.64
Lower Nth Sydney	62.22	44.03	19.5	23.64
Central Nth Sydney	59.96	43.24	26.43	31.09
Northern Beaches	61.04	43.27	20.5	24.72
Central West Sydney	57.28	42.52	22.75	29.03
Canterbury-Bankstown	49.66	36.54	17.85	22.91
Blacktown	53.43	37.22	28.18	32.59
Fairfield-Liverpool	51.42	37.68	25.68	30.25
Outer South West	52.87	38.94	18.24	39.63
St George Sutherland	57.18	39.56	24.16	28.72
Outer West	56.65	39.23	32.86	37.82
SSD	Drivers	Total kms per day per all drivers	Population	Total Licence Holders
Inner Sydney	113,525	1,585,942	362,074	178,624
Eastern Suburbs	103,756	1,778,382	261,089	173,161
Inner West	79,607	1,291,231	195,230	127,167
Lower Nth Sydney	136,065	2,653,274	321,383	194,170
Central Nth Sydney	186,687	4,934,141	463,330	146,962
Northern Beaches	118,165	2,422,390	250,506	211,984
Central West Sydney	180,976	4,117,210	360,720	291,151
Canterbury-Bankstown	131,798	2,352,592	338,390	212,523
Blacktown	129,705	3,655,082	313,057	188,005
Fairfield-Liverpool	161,531	4,148,128	386,326	130,943
Outer South West	116,234	2,120,108	257,647	171,410
St George Sutherland	216,495	5,230,509	465,594	325,089
Outer West	161,735	5,314,614	330,454	104,697
All SSDs	1,836,280	41,603,603	4,305,800	2,455,886

Identifying the Preferred Mix of a Peak Period Distance-based Charge and Discounted Annual Registration Fee

To establish the financial implications of alternative combinations of a peak period DBC and discounted annual registration fees, we built a scenario decision support system (in excel). The key inputs, for each SSD and status quo (i.e., before) situation, are the mean annual kilometres, the proportion of kilometres in the peak periods (AM and PM)⁸, the average daily cost per driver (comprising fuel and tolls, distinguished by peak and off peak periods), annual registration fees, and mean direct elasticities of peak and off peak kilometres with respect to usage costs. In addition, for the reform scenarios, we considered a DBC varying from 2c/km to 10c/km in the peak, and allowed annual registration fees to vary from 30 to 75 percent of the status quo annual fee. These ranges were determined from an initial assessment of likely adjustments that would satisfy the binding constraints to be neutral to government revenue and driver cost outlays. As part of scenario definition, given the absence of any evidence on cross elasticities of kilometre switching by time of day under a move from a fixed annual registration fee to a DBC use-related charge, we have assumed that all kilometres that have

⁸ The peak is defined as 6.31am to 9.30 am and 3.01pm to 6pm Monday to Friday.

moved from the peak period do not move to the off-peak⁹. This is a limiting assumption, with an expectation that we have under-predicted the change in off-peak kilometres (Bliemer *et al.* 2009). Since the off-peak kilometres do not have a DBC cost element, the impact on State Treasury is zero; although there is a reduction in Federal fuel excise.

The decision support system calculates the status quo total costs and kilometres for all drivers and revenue to State Treasury, distinguishing outlays and receipts for the peak and off peak periods. We then introduce the range of peak-period DBCs and discounted registration fees and calculate the combination of these two cost outlays for motorists of each SSD that results in *both* a reduced mean cost outlay to motorists and no loss in revenue to State Treasury. At the SSD level, we expect to obtain different DBC levels for a given discount on the registration fee, and indeed that is what was obtained. The range is three to eight cents/km. as shown in Figure 2. Taking the lowest value would ensure net gains to each SSD motorist, but would result in the loss of neutrality (or better) to Treasury revenue. Placing different charges on motorists over the metropolitan area would raise clear concerns from many perspectives including the political ramifications.

A preferred solution is to take a system wide approach (essentially a weighted averaging of the SSD data), and to identify a single DBC, given a discounted registration fee, that achieves the required financial outcomes for drivers and State Treasury. Table 2 summarise the findings in which the selected peak period DBC is 5c/km with a discounted registration fee of \$185, slightly greater than a 50 percent reduction. On average, a driver saves \$9 per annum and Treasury gains \$32 per driver per annum. These are extremely low amounts per driver, but they translate into sizeable financial gains to all drivers (Figure 3) and State Treasury (Figure 4 and Table 3). Figure 3 highlight the total mean differences in cost outlays for drivers resident in each of the SSDs, with eight SSDs having positive gains and five SSD's with negative gains. There is a total cost gain of \$43.6m and a total cost loss of \$28.8m. When converted to an additional cost outlay per driver per km the amount for the five affected SSDs is 0.34 cents/km, contrasted with 0.65 cents/km gain for the eight SSDs.

In exploring the financial implications on drivers of moving away from an SSD-specific DBC solution, Table 4 is particularly informative in that it identifies the average gains or losses in cost outlays *per driver per annum* in each SSD. The blue shaded cells represent the preferred outcome when each SSD is assessed independently; and this is contrasted with the light beige shaded cells based on the system wide 5 cents/km solution. The light green shading for SSD's 5 and 12 represents the situation where the SSD-specific and system wide DBC charge is the same. The evidence in Table 4 suggests that, on average, car drivers are better off under the system wide DBC than under the SSD-specific solution for SSDs 1-4, 6-8, and SSD 11, but Treasury is worse off; and worse off for SSDs 9 and 10, with Treasury better off. The average annual financial gains and losses per driver at 5 cents/km are relatively small, ranging from \$91 for SSD1 to -\$40 for SSD9. Of the SSDs located the furthest distance from the CBD

⁹ When we introduced an all day DBC, we would also get a change in off-peak kilometres but that scenario is not considered in this paper.

(notably SSDs 9-13), drivers are better off under the 5 c/km DBC in SSD8 and SSD11, whereas in the other SSDs drivers are worse off, with annual cost outlay increases varying from a high of \$84 (SSD13 - Outer West) to a low of \$3 (SSD12 – St George Sutherland). These are still, however, very small financial imposts on drivers. Importantly, however, as shown above, there appears to be no evidence of an income effect as a consequence of moving from SSD-specific DBCs to a system wide DBC.

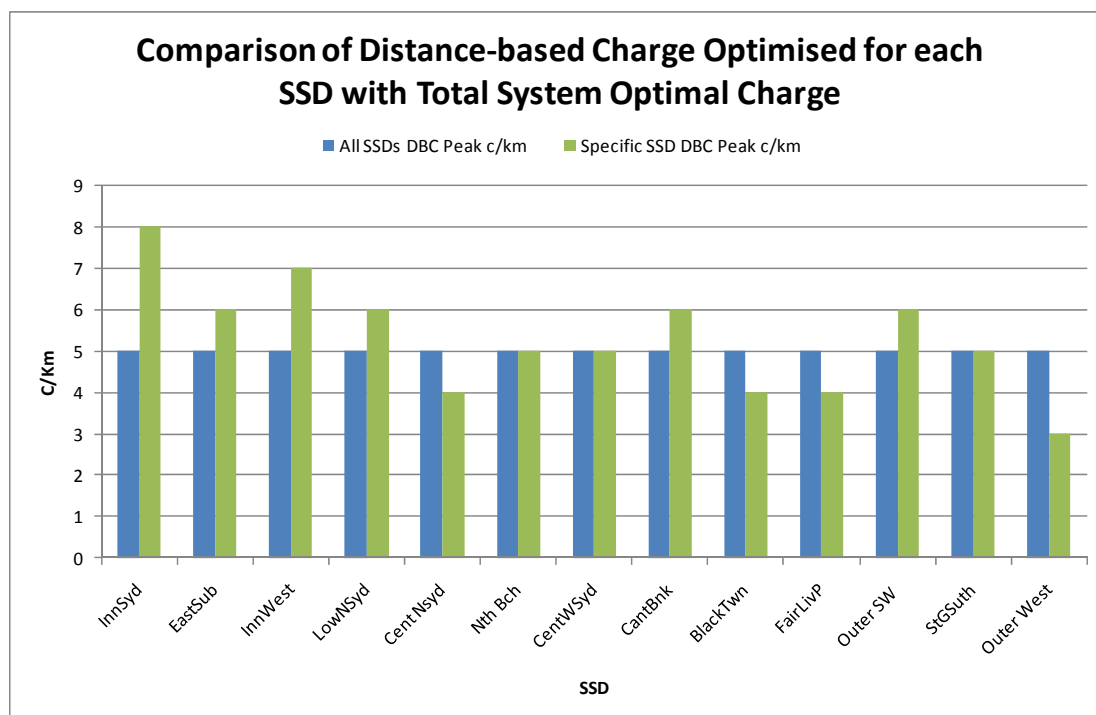


Figure 2 A Comparison of the System wide DBC versus SSD Specific Pricing

Table 2 Identifying a DBC and Discounted Registration Fee that makes Motorists and Treasury Financially No Worse Off

		ALL SSDs		
		Positive = gain, negative = loss		
		Car driver	Treasury	change in peak km
Regn fees halved and DBC for peak kms only C/km	2	130	-113	-102
	3	88	-64	-154
	4	48	-16	-205
	5	9	32	-256
	6	-29	78	-307
	7	-66	123	-358
	8	-102	167	-409
	9	-137	210	-461
	10	-171	252	-512

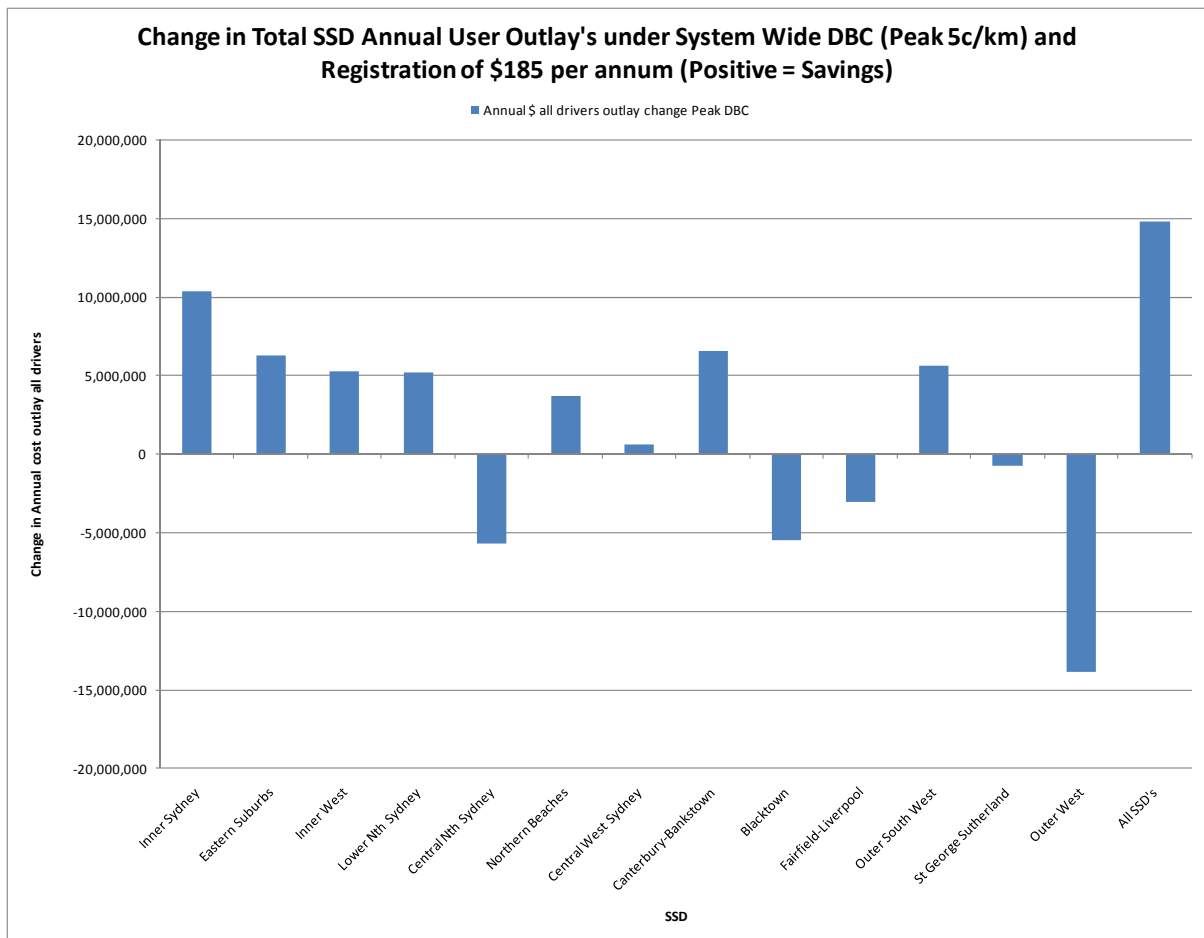


Figure 3 Impact of Pricing Reform on Annual Costs of Driver per SSD

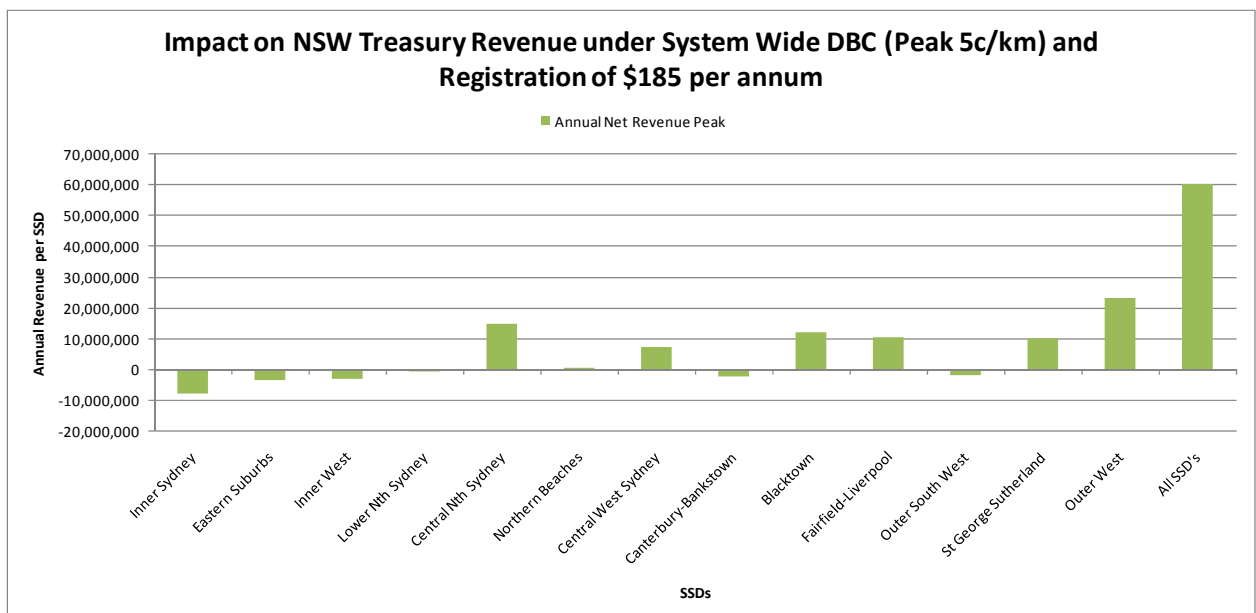


Figure 4 Impact of Pricing Reform on Treasury Revenue

Table 3 Impact of Pricing Reform on Treasury Revenue per Driver and for all Drivers

SSD	Treasury Impact Peak PA	Annual Net Revenue Peak
Inner Sydney	-68	-7,690,883
Eastern Suburbs	-31	-3,184,248
Inner West	-36	-2,885,496
Lower Nth Sydney	-3	-428,670
Central Nth Sydney	80	15,002,723
Northern Beaches	3	412,293
Central West Sydney	40	7,202,676
Canterbury-Bankstown	-16	-2,157,321
Blacktown	93	12,001,333
Fairfield-Liverpool	65	10,432,742
Outer South West	-16	-1,851,350
St George Sutherland	46	10,043,318
Outer West	145	23,453,308
All SSD's	302	60,350,423

Table 4 Summary of SSD-Specific Optimal DBC compared to the Systemwide 5c/km Impact

	SSD1 InnSyd			SSD2 Eastern Suburbs			SSD3 Inner West			SSD4 Lower Nth Sydney		
Pos =gain, neg= loss												
DBC for peak kms only	Car driver	Treasury	change in peak km	Car driver	Treasury	change in peak km	Car driver	Treasury	change in peak km	Car driver	Treasury	change in peak km
2	164	-154	-56	151	-139	-72	153	-141	-75	141	-128	-83
3	139	-125	-84	120	-102	-108	124	-106	-113	106	-85	-125
4	115	-96	-113	90	-66	-144	95	-71	-151	71	-43	-167
5	91	-68	-141	60	-30	-180	66	-36	-188	37	-3	-208
6	68	-40	-169	32	4	-215	39	-3	-226	4	37	-250
7	45	-13	-197	3	38	-251	12	30	-264	-28	77	-292
8	23	14	-225	-24	72	-287	-14	62	-301	-59	115	-333
9	2	40	-253	-50	104	-323	-39	93	-339	-90	152	-375
10	-19	66	-281	-76	136	-359	-64	123	-377	-119	189	-416
Pos =gain, neg= loss												
DBC for peak kms only	SSD5 Central Nth Sydney			SSD6 Northern Beaches			SSD7 Central West Sydney					
2	Car driver	Treasury	change in peak km	Car driver	Treasury	change in peak km	Car driver	Treasury	change in peak km			
3	113	-93	-124	139	-125	-88	127	-110	-113			
4	64	-34	-186	103	-82	-133	85	-60	-170			
5	17	23	-248	67	-39	-177	45	-10	-227			
6	-30	80	-311	32	3	-221	5	38	-283			
7	-75	135	-373	-2	43	-265	-34	86	-340			
8	-119	189	-435	-35	83	-310	-71	132	-397			
9	-162	242	-497	-67	123	-354	-108	177	-453			
10	-204	293	-559	-98	161	-398	-143	221	-510			
	SSD8 Canterbury-Bankstown			SSD9 Bankstown			SSD10 Fairfield-Liverpool					
DBC for peak kms only	Car driver	Treasury	change in peak km	Car driver	Treasury	change in peak km	Car driver	Treasury	change in peak km			
2	147	-133	-86	109	-89	-125	118	-100	-118			
3	114	-94	-128	58	-28	-188	72	-44	-177			
4	82	-55	-171	8	32	-251	26	10	-236			
5	51	-18	-214	-40	90	-313	-18	64	-295			
6	21	19	-257	-88	148	-376	-61	116	-353			
7	-9	55	-300	-134	204	-439	-103	167	-412			
8	-37	91	-342	-179	259	-501	-143	217	-471			
9	-65	125	-385	-222	312	-564	-183	265	-530			
10	-92	158	-428	-264	365	-627	-221	313	-589			
	SSD11 Outer South West			SSD12 St George Sutherland			SSD13 Outer West					
DBC for peak kms only	Car driver	Treasury	change in peak km	Car driver	Treasury	change in peak km	Car driver	Treasury	change in peak km			
2	146	-133	-80	124	-107	-113	91	-67	-152			
3	113	-94	-120	81	-55	-169	31	5	-228			
4	81	-55	-161	38	-4	-225	-27	75	-304			
5	49	-17	-201	-3	46	-281	-84	143	-380			
6	19	21	-241	-43	95	-338	-139	211	-456			
7	-11	57	-281	-82	143	-394	-193	276	-532			
8	-41	93	-321	-120	189	-450	-245	340	-608			
9	-69	128	-361	-157	235	-507	-296	403	-684			
10	-96	162	-402	-193	279	-563	-345	464	-760			

Importantly the new reform package results in a 4.7 percent reduction in total annual peak period kilometres and a 2.96 percent reduction in all kilometres¹⁰ (given in Table 5 and Figure 5 for each SSD and overall for all SSDs). This percentage change of close to 5 percent in the peak is in line with evidence on what it takes to get a noticeable improvement in levels of traffic congestion, which are often associated with the reduced traffic during school holidays (see footnote 2 which reports a 4.77 percent drop in traffic volumes during school holidays in Sydney in 2005). Hence if the reform package of a combination of a peak period DBC of 5c/km is combined with a discounted registration fee of \$185 on average, we can expect noticeable improvements in traffic congestion without cost hit to motorists or revenue loss to State Treasury. There will however be an overall 2.96 percent loss in fuel excise to the Federal government.

Table 5 Impact of Pricing Reform on Annual Kilometres

SSD	Total Daily Peak Kms Before	Total Daily Peak Kms - Peak DBC, 50%Rego	Total Daily Off peak Kms Before	OffPk Kms - Peak DBC, 50%Rego	Total Daily Kms Before	Tot Daily Kms - Peak DBC, 50%Rego
Inner Sydney	960,137	915,997	625,805	625,805	1,585,942	1,541,802
Eastern Suburbs	1,100,758	1,047,854	677,624	677,624	1,778,382	1,725,478
Inner West	819,932	779,731	471,299	471,299	1,291,231	1,251,030
Lower Nth Sydney	1,661,215	1,579,473	992,059	992,059	2,653,274	2,571,532
Central Nth Sydney	3,175,539	3,021,395	1,758,602	1,758,602	4,934,141	4,779,997
Northern Beaches	1,480,543	1,414,676	941,847	941,847	2,422,390	2,356,523
Central West Sydney	2,653,106	2,526,716	1,464,105	1,464,105	4,117,210	3,990,821
Canterbury-Bankstown	1,502,772	1,434,478	849,820	849,820	2,352,592	2,284,298
Blacktown	2,282,529	2,185,637	1,372,553	1,372,553	3,655,082	3,558,189
Fairfield-Liverpool	2,596,794	2,474,630	1,551,333	1,551,333	4,148,128	4,025,964
Outer South West	1,327,221	1,267,888	792,886	792,886	2,120,108	2,060,774
St George Sutherland	3,263,618	3,100,803	1,966,891	1,966,891	5,230,509	5,067,694
Outer West	3,345,305	3,190,485	1,969,309	1,969,309	5,314,614	5,159,794
All SSD's	26,169,470	24,939,764	15,434,133	15,434,133	41,603,603	40,373,897
Percent Change		-4.70%				-2.96%

¹⁰ We recognise that this will likely be smaller when trips moving to off-peak periods are considered.

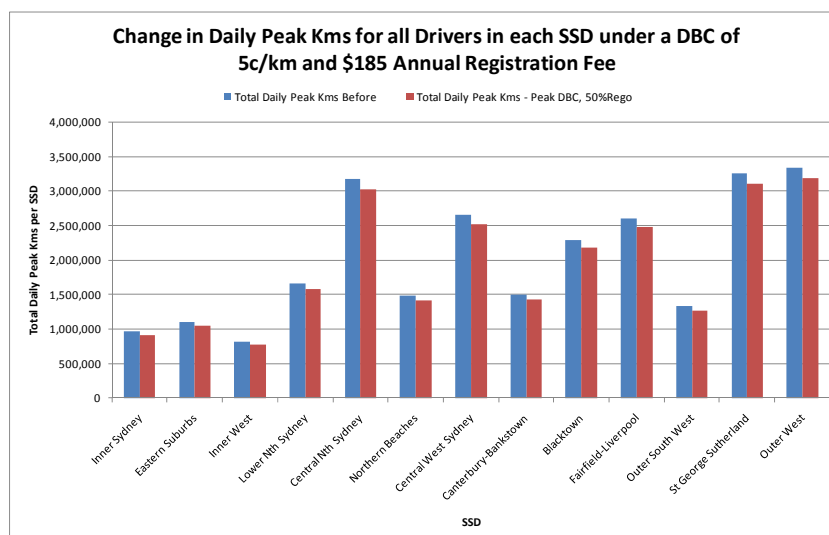


Figure 5 Impact of Pricing Reform on Total Driver Kilometres per SSD

The analysis reported so far has been based on the average driver in each SSD. To investigate the likely implications on cost outlays and revenue raised of deviations around the mean, we have taken the two extremes of all drivers in each SSD having high and low kilometres. The relevant levels for each SSD are given in Table 6 and range from a high of 75 kilometres per driver per day to a low of 8 kilometres per driver per day, both in the Outer West. Under these kilometre assumptions, we find that the peak period DBC is reduced to 2c/km for the high kilometres and increased to 10c/km for the low kilometres, given the same discounted registration fee of \$185. If all drivers were at the high or low kilometre level, State Treasury is financially much better off than under the 5c/km DBC, due to either the greater number of kilometres in the peak periods, or the higher DBC. Drivers however are worse off if they all operated at the high kilometres, while substantially better off at the low kilometres. Clearly this evidence is not what will occur in reality because of a distribution of annual kilometres across all drivers. Even with a user loss of \$14.076m, that is equivalent to only 2.01 cents per day per driver, hardly noticeable!

Table 6 Implications of High and Low Annual Kilometres in each SSD

Peak period DBC = 2c/km for high kms and 10c/km for low kms

Annual registration fee is held at the discounted fee of \$185

Positive = savings

SSD	Annual Kilometres per driver per day		Change in Driver Costs \$ per annum per SSD		Change in Treasury Revenue \$ per annum per SSD	
	Low	High	Low Kms	High Kms	Low Kms	High Kms
Inner Sydney	10	40	5,296,833	7,775,340	-1,500,051	-4,737,915
Eastern Suburbs	12	45	1,000,505	4,901,139	3,352,227	-1,636,590
Inner West	12	45	642,193	3,497,667	2,872,721	-861,481
Lower Nth Sydney	15	65	-5,896,785	-4,007,725	13,197,394	10,334,920
Central Nth Sydney	12	65	685,461	-6,488,833	7,781,749	15,661,644
Northern Beaches	10	55	5,420,140	1,430,670	-1,392,256	3,000,003
Central West Sydney	10	55	7,455,849	649,823	-598,481	6,893,282
Canterbury-Bankstown	10	50	5,518,786	3,174,935	-611,578	1,732,272
Blacktown	15	70	-5,537,584	-6,185,996	12,460,972	12,647,825
Fairfield-Liverpool	12	65	1,488,862	-4,737,450	5,442,874	12,246,831
Outer South West	9	50	6,902,847	3,137,157	-3,161,920	1,019,429
St George Sutherland	12	65	2,375,002	-6,199,179	6,854,364	16,197,659
Outer West	8	75	12,161,459	-11,024,484	-7,483,515	19,795,630
All SSDs	10	55	37,513,570	-14,076,936	37,214,501	92,293,510

Another way of considering variations in total peak and off peak kilometres is to stay with the DBC of 5c/km and to calculate the impost on drivers with high and low kilometres (Table 7). Although State Treasury is significantly better off under both low and high kilometres, drivers are much better off under low kilometres, but substantially worse off under high kilometres, as might be expected. It is clear that if say, 20 percent of all drivers have peak kilometres much greater than the weighted average for all SSDs, then some adjustment down in DBC will be required or a further discount of the registration fee. The ‘optimal’ DBC of 5c/km is the lowest we can obtain if State Treasury is to be no worse off (see Table 2); however if we reduce the registration fee we may be able to establish a possible ‘solution’. A zero registration fee does not work at all for Treasury; a \$150 registration fee will satisfy the Treasury budget constraint at 5c/km (gaining \$11 instead of \$32 per driver per annum) while making drivers better off (gaining \$32 compared to \$9 per annum), but only at a very slightly higher kilometres than the average kilometres.

Table 7 Implications of High and Low Annual Kilometres in each SSD

Peak period DBC = 5c/km for high and low kms

Annual registration fee is held at the discounted fee of \$185

Positive = savings

SSD	Annual Kilometres per driver per day		Change in Driver Costs \$ per annum per SSD		Change in Treasury Revenue \$ per annum per SSD	
	Low	High	Low Kms	High Kms	Low Kms	High Kms
Inner Sydney	10	40	14,307,805	-15,677,906	-12,409,414	23,271,470
Eastern Suburbs	12	45	11,036,737	-19,611,823	-8,860,372	27,773,194
Inner West	12	45	8,340,664	-15,609,974	-6,583,207	22,200,438
Lower Nth Sydney	15	65	10,631,043	-50,773,151	-6,980,738	66,591,138
Central Nth Sydney	12	65	19,235,148	-71,886,155	-15,001,543	94,818,182
Northern Beaches	10	55	14,825,949	-32,313,832	-12,812,007	43,390,513
Central West Sydney	10	55	22,119,151	-52,916,193	-18,690,467	71,773,956
Canterbury-Bankstown	10	50	16,176,667	-32,091,947	-13,723,064	44,359,965
Blacktown	15	70	10,174,725	-54,085,857	-6,713,031	70,240,430
Fairfield-Liverpool	12	65	17,079,316	-60,165,202	-13,613,448	78,938,656
Outer South West	9	50	15,427,902	-27,582,892	-13,557,438	37,974,358
St George Sutherland	12	65	23,019,199	-80,243,178	-18,404,516	105,239,380
Outer West	8	75	22,857,881	-75,335,331	-20,518,909	97,263,195
All SSDs	10	55	205,232,187	-588,293,441	-167,868,152	783,834,875

What is emerging from this analysis is that if we can increase the net revenue to Treasury substantially, while not making users worse off on average, then we can use the net Treasury gains to compensate drivers who have kilometres in excess of the average, possibly limiting this to 25 percent or more above the average. As the annual savings are very small per driver for users and Treasury (shown in Table 3), an increase in cost, say of \$100 per year, amounts to a minimal amount per trip. For example, in Table 2, if we had a peak DBC of 10c/km, the average cost increase per driver per day would be 46 cents on average or 2 cents per kilometre over all kilometres. The resulting increase in net revenue to State Treasury can then be available to compensate high peak kilometre drivers¹¹, and based on the evidence in

¹¹ This will need very careful consideration. It should be fair as well. If high peak km drivers get a lot of compensation, they pay much less per km than people that drive below average kms. So this would more or less mean that the first kms are charged at a higher rate, while the rate diminishes. Does this have the desired effect? In the end, high peak km drivers may have less and less incentive to decrease their kilometres driven.

Tables 2 and 3 this could amount to over \$60m per annum available for disbursement. A user loss of \$588.29m is equivalent to 89 cents per day per driver (or \$324 per annum), or 3.8 cents per kilometre, which again is very small! We might suggest, given these very small numbers, that a case can be made for a higher DBC above 5c/km as a way of ensuring sufficient additional funds to compensate high peak kilometre drivers.

Conclusions

The road pricing reform proposal developed in this paper is designed to provide a pathway to gaining buy in from the community that is essential to securing the support of the political process. With demonstrated evidence in the initial phase of reform that the majority of drivers and the State government will not be worse off financially, it is easier to obtain buy in, regardless of the implications for reduced traffic congestion and faster trips. The real bonus and effective selling point will occur when drivers see real time savings and motoring associations finally are convinced that their members do gain from such pricing reform. We see no reason to suggest that the results for Sydney do not translate to other cities and countries.

This is the first study that we are aware of that has systematically investigated a reform package that can appeal to key stakeholders and that places quantitative evidence on the table for an entire Metropolitan area. The great majority of well articulated academic and consultancy research has failed in this endeavour. Indeed a recent comment by Poole (2012) best summarises this position: “I’m struck by what seems to be a huge disconnect between the systems being modeled by academic economists and the proposals emerging from field tests and demonstrations involving actual motorists.” (Poole 2012). There are, however, some excellent exceptions, but they relate to cordon-based charging as in Stockholm (Eliasson *et al.* 2009) or have an environmental focus (Parry 2012).

This road pricing reform plan would require drivers to purchase an on-board unit (OBU) (approximately \$50 once off cost¹²) that will record the kilometres by time of day. The off peak kilometres are not charged, but peak kilometres will be charged at the agreed cents/km. This scenario implies that if an OBU is not installed, all kilometres will be charged as peak kilometres, giving an incentive to install a meter (with the expectation that all motorists will do so), just like households have had with off peak electricity meters or with water meters when they were first introduced. Indeed, linking this to the availability of ‘Pay As You Go’ insurance could provide additional benefits to users (Greaves and Fifer 2010, Parry 2012). There could be considerable implementation, operating and enforcement costs of a metropolitan wide (i.e., all roads) charging system for the state if a state of the art system was put in place. This would upset the revenue/cost balance (and which may require a variation in the ‘optimal’ DBC) unless the costs of such implementation can be spread over other reforms such as insurance reform. We believe that an additional cent per km may be all that is

¹² Based on the expected volume of installations.

required, at least initially or a smaller amount of the investment is amortised over say a 10 year period. This would increase the net revenue to \$70m per annum or at least \$800m to \$1bn over 10 years, excluding adjustments for inflation but factoring in growth in car use. In the Sydney context, there is already a system in place to capture data on the tollroads using ETAGS which have the capability of capturing time of day kilometres (indeed distance-based time of day charging already exists on one of the longer tollroads in Sydney). Technology experts advise us that conversion to GPS capture is feasible if required.

In ongoing research using the same data and analysis framework, Mulley and Hensher (2012) investigate the vertical equity implications of the road pricing reform scheme proposed in the current paper. Vertical equity requires that revenues benefit low-income drivers as a class at least as much as the costs they bear, and that disadvantaged residents (including non-drivers) benefit overall. A popular view is that revenues must be dedicated to transport improvements to be politically feasible, but some analyses indicate that alternative distributions that include broad tax reductions or financial rebates benefit the largest number of citizens and therefore may be more politically popular (Littman 1996, Hensher and Li 2012, King et al. 2007, Levinson 2010).

In the current paper we have focussed on a peak DBC; however we have also considered the possibility of an all day DBC, which will be lower than the 5c/km peak charge, optimised at 3c/km. There are arguments for and against peak versus all day charging. For example, charging only in the peak may make some people worse off, especially those that cannot avoid the peak period because of fixed working hours in comparison to others that have flexible working hours, although the higher DBC in the peak with a no off peak charge may result in them being no worse off given the percentage of all kilometres that are in the peak. Clearly this effect may be increased, subject to the relativity of a peak only and an all day DBC, because all revenues need to come from peak hours, such that the peak rate needs to be higher, but for Sydney the difference is only 2c/km. As part of the paper on vertical equity (Mulley and Hensher 2012) we are exploring the possibility that, although on average, drivers are no worse off financially under a peak DBC, a peak rate only scheme might lead to large differences, where many will be much worse off, and many will be much better off. Having an off-peak rate might spread the financial impact much more, and hence does not create such huge equity issues.

Finally, this paper has focussed on motorists resident in Sydney and is designed to move to a more efficient use of roads by using the price signal to underpin motorist's travel behaviour. However, there is a good case to extend the reform package to all vehicles, freight and passenger, as well as all jurisdictions under the control of a single government (in our case it would be New South Wales). In doing this, vehicles would be more closely paying for the damage done to roads. However, a charge related to damage is likely to be a lower all day DBC than is suggested by this paper and would be similarly replacing an element of registration charge when implementing the scheme outside of capital cities where traffic congestion is not an issue. When initial reform is bedded down and accepted, a case for increasing the DBC may be considered, as a way of raising much need funding for future

investment in public transport and roads as a consequence of the diminishing revenue base from traditional and more inefficient sources.

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