Scoping paper:

Increasing physical activity levels through active transport – Congestion pricing

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1. Background to topic

Motorised transportation has increased significantly worldwide over recent decades, in both developed and developing countries. Whereas personal motor vehicles were once considered an expensive luxury, the number of cars worldwide is now estimated at over 1 billion [1] with approximately 13.2 million passenger vehicles currently registered in Australia [2].

Australia has one of the highest private vehicle mode shares in the world [3], with urban environments, culture, access to goods and services, economic growth and mobility inextricably linked with motor vehicle usage [4-7]. Total metropolitan travel (all trips, motorised and non-motorised) in Australian capital cities has grown considerably, from approximately 4 million daily trips in 1900 to approximately 72.5 million daily trips in 2013 [8]. Over this time population growth and urban sprawl has meant that the average length of trips has also grown, leading to increasing car dependence.

Traffic congestion has been recognised as a significant issue in larger Australian capital cities [3, 9-12] and the management of traffic congestion has been identified as a key policy issue in achieving a sustainable Australian population [13]. The social cost of congestion in Australia is projected to reach $20.4 billion by 2020 [14]. The wider economic benefits of efficient transportation systems are well recognised and include productivity and agglomeration benefits [13]. Productivity benefits accrue when transport systems allow for the timely and efficient movement of people and goods using transport networks. Agglomeration benefits accrue when efficient transport systems allow for businesses to gather within a small area without experiencing negative effects, such as the productivity losses associated with road congestion. The positive benefits of agglomeration include the accumulation of human capital, increased specialisation of labour, economies of scale and innovation within competitive markets.

Secondary benefits from efficient transportation systems may include both health and environmental benefits. Congested traffic systems lead to increased rates of pollution and emissions as journey travel times become longer and travel speeds become slower, resulting in greater fuel consumption. If congestion management techniques result in a modal shift to more active forms of transport (i.e. more walking, cycling and use of public transport) benefits may accrue through decreased pollution due to a reduction in fuel consumption. Modal shift to more active transport may also increase rates of physical activity, with the health benefits of physical activity well-established [15, 16].

Pricing factors have been recognised as being very important for reducing congestion and encouraging non-motorised travel [17, 18]. Whilst transport pricing reforms may primarily target congestion or other efficiency measures, they may also have a secondary impact on physical activity levels by discouraging car use [19].

There is currently a lack of adequate price signals in transportation systems, with inadequate demand management and some taxes and subsidies creating incentives for automobile dependence [3, 20, 21]. Motorists do not typically pay the true costs of their transport decisions, with the amount paid not accurately reflecting when, where and how road users travel. Effects on other road users or on the environment are also not fully taken into account, resulting in significant externalities or 'unintended spillover effects' of motor vehicle use [22]. Inefficient market signals and externalities lead to inefficient modal choices and decision-making, contributing to more driving than may otherwise occur [20, 23, 24].

The population's generally skewed perception of the actual costs of driving a motor vehicle compared to the actual costs of more active forms of transport may also play a role in encouraging motor vehicle dependence. Evidence suggests that while the perceived cost of driving a car is lower than the actual cost incurred, the perceived cost of active transport is actually much higher than actual cost (due in large part to misperception about the safety, security and convenience of active transport)[25].

This scoping paper explores the potential impact and effect on modal shift to more active forms of transport of congestion pricing in Australian cities. Economic theory suggests that the way to internalise a negative externality is a Pigouvian tax, with Pigou himself arguing in support of a tax on congestion [26]. Congestion pricing is a form of traffic management demand aimed at reducing the waste and loss of productivity associated with traffic congestion at peak times or on peak routes [27]. Congestion pricing is not about recovering the cost of road infrastructure, but rather setting prices on roads at particular times and places that reflect the impact of the decision to travel on other road users [13].

There are four main types of congestion pricing strategies:

1. Variably priced lanes on toll roads and bridges;
2. Variable tolls on toll roads and bridges;
3. Zone-based or cordon charges to drive within or into a congested area within a city; and
4. Area-wide or system-wide distance charges on roads within congested areas.

2. Intended policy impact

The aim of congestion pricing is generally to alleviate the congestion experienced on city roads, particularly at peak times. Congestion pricing schemes have also been implemented internationally to increase revenue for public transportation systems [28]. An upstream initiative such as congestion pricing may however have an impact on the number of people walking, cycling and using public transport (i.e. engaging in active transport) by increasing the cost to the user of motorised transport. A resultant shift in transport behaviours may have a positive effect on overall physical activity levels, BMI and obesity across populations. Environmental benefits from a potential modal shift to more active forms of transport have also been identified as possible "spill-over effects" [29].

3. Current policy status

a. Australia

Comprehensive road congestion schemes do not currently exist in any Australian capital city, although there has been significant debate surrounding road pricing in Australia in recent years [10, 12, 24, 30]. The Council of Australian Governments (COAG) commissioned a report into urban congestion in 2006, which found that road pricing mechanisms presented a promising means of addressing congestion in capital cities [28]. The Henry Tax Review in 2010 recommended the replacement of state taxes on motor vehicle ownership and use (including vehicle registration fees and transfer duty) with more efficient road user charges [31]. The Harper Competition Review Draft Report in 2014 also recommended cost reflective road pricing, with less use of indirect charges and taxes on road users [32].

A number of single toll routes currently exist (e.g. CityLink in Melbourne and the M5 in Sydney), however most of these are on new routes with the primary function of funding new road infrastructure rather than managing congestion and most are privately owned and funded [28]. Variable tolling on the Sydney Harbour Bridge and Tunnel dependent on time of day was introduced in 2009 to alleviate congestion and represents a tentative first step towards using pricing to manage demand in Australia [10]. The State Government of Victoria introduced an annual 'congestion levy' in the Melbourne CBD in 2005, but applied it to all off-street parking spaces rather than on road usage [33].

Optimal congestion charging would apply to all roads within a network using a more holistic approach to managing congestion, rather than designated toll roads only, which may encourage route substitution rather than behavioural change [30]. Sydney and Melbourne are considered the most viable cities for the introduction of congestion pricing schemes [28]. Recent analyses have suggested that area-wide or system-wide user charges would be most feasible in the Australian context [10, 24]. Whilst cordon charges have been implemented internationally, Australia is considered to be too low density to have significant effect, with decentralised cities and fairly widely dispersed congestion [12, 24, 34]. Technological advancements have meant that road user charges facilitated by GPS, speed sensor vehicle tracking and calculation of prices using sophisticated computerised systems may provide more of a user-pays system in the not too distant future [35].

b. Internationally

Congestion pricing schemes are operating relatively successfully in several cities internationally, including Singapore [36], London [37], Stockholm and Gothenburg [38]. The London congestion scheme imposes charges on cars operating in the central London area. Whilst initially unpopular, the scheme has come to be regarded positively by the public [39]. There has however been some debate as to the economic success of the scheme, with high implementation costs leading to questionable economic benefit [40-42]. The Stockholm congestion charge was introduced in 2006 as a trial but was then publicly accepted as permanent in a subsequent referendum [18]. Whilst also initially publicly unpopular, the fact that the trial exceeded traffic reduction targets and that these effects were maintained contributed to public acceptance [43, 44].

There have also been some examples of unsuccessful experiences with congestion pricing schemes. New York, Edinburgh and Manchester have made unsuccessful attempts at introducing congestion pricing in recent years [18]. In 2008, a congestion scheme in

DRAFT

Manchester was rejected by referendum due to public and political unpopularity. A 2008 proposal to introduce congestion pricing in New York City also failed to proceed due to political unpopularity [46], and therefore the effectiveness of the proposal was unable to be tested. Ogilvie et al [45] were attempting to evaluate the health effects of the Edinburgh congestion pricing scheme at the time that it was also rejected by public referendum and so were unable to proceed with their case study given the scheme did not go ahead.

4. Evidence of efficacy/effectiveness

a. Overview of evidence

Evidence is required in the following areas to model this intervention:

I. Exposure

Determining the affected population for transport interventions is methodologically challenging, given the limitations and difficulties in collecting rigorous evidence for natural experiments [47-49]. Populations may be defined geographically (i.e. by geographical area surrounding the proposed congestion charging area) or by those who participate in the intervention (i.e. by those who travel on the roads), although both methods have limitations [45].

Trip generation data may be estimated by predicting numbers of trips originating or finishing in particular geographical regions based on factors such as population, employment locations, demographics and transport system conditions using transport demand models [50]. Geographically defining the affected population may not however include effects experienced by those who do not live or work within the area but who may be impacted (for instance, occasional travelers).

Cross-sectional comparisons of congestion pricing schemes have analysed the impact on those who have experienced the intervention (i.e those who drove within the congestion pricing area). Defining the exposure as drivers within the congestion pricing zone may not however take into account potential impacts on others (for example the non-driver, who may have changed their transport behaviours as a result of the scheme).

II. Impact

In the absence of comprehensive feasibility studies, the potential impact of congestion pricing schemes in Australia are largely unknown, although a COAG review rated their potential for reducing traffic as high [28]. Significant challenges in collecting rigorous evidence of effectiveness of congestion pricing schemes exist however, including the fact that the impact of the intervention may be difficult to separate from other contextual factors occurring at the same time (for instance if a congestion pricing scheme is introduced alongside other public health or transportation measures) or from the broader set of local and national policies and actions [47].

The review by Elvik & Ramjerdi [51] found that congestion charging may be an effective policy instrument for promoting environmentally sustainable transport, citing negative price elasticities ranging from approximately -3.2 to -0.7 from estimates from the literature assessing the impact of the London, Stockholm and Milan schemes. Price elasticities are commonly used in the transport sector to assess the impact of price on transport demand. Elasticities less than the absolute value of 1 are considered inelastic, with estimates greater than 1 considered to be elastic. Estimates of price elasticities included in the summary for the London congestion scheme ranged from -0.80 to -3.20, however a meta-analysis was not possible due to insufficient reporting of data [51]. This indicates that motor vehicle users in London are relatively sensitive to the increased costs of the congestion pricing scheme, and that implementation of the scheme has resulted in a decrease in demand for motor vehicles in the affected areas.

The Bureau of Infrastructure, Transport and Regional Economics (BITRE) maintains a database of transport elasticities from the literature for use in policy decision-making in Australia [52]. A shortfall of the database however is that it only covers the literature up until 2001 and obviously does not include a price elasticity of congestion pricing specifically (due to there being no scheme in Australia). The demand elasticity of car usage in Australia was estimated as -0.09 to -0.24 in the short run, and -0.22 to -0.31 in the long run [53], demonstrating that the demand for car usage generally is relatively insensitive to price.

To assess congestion pricing from an obesity prevention perspective however we are most interested in the impact of a change in price on travel mode (i.e. modal shift to active transport) or physical activity levels specifically. Data on the price elasticity of demand for the costs associated with driving may not necessarily give a clear picture on the physical activity or modal shift effects of an increase in price. An increase in price may instead lead to changes in trip generation, route, vehicle type or destination rather than to modal shift to more active forms of transport [50].

Relatively limited evidence exists on the impact of financial incentives and disincentives to promote physical activity, and more specifically more active forms of transport [54-56]. The review by Martin et al [54] explored the potential of financial incentives to encourage physical activity by active transport, and found that financial incentives may present an underused but potentially promising method for encouraging active transport but that limited evidence of effectiveness currently exists. The study by Faulkner et al [56] used the Delphi survey method to estimate the likely impact of a range of economic instruments on obesity prevention. The study found that the likely impact on physical activity of a road congestion price was considered to be low, as was the likely impact on obesity. The review by Li and Hensher [57] considered 20 published congestion pricing studies using stated preference or opinion surveys to assess acceptability, likely impact on transport behaviours and subsequent potential for effectiveness. The review found that two included studies suggested that introduction of a congestion pricing scheme may result in modal shift [58, 59].

In order to better inform the evidence of effect, a systematic review has been undertaken of modal shift effects or physical activity effects of congestion pricing schemes that have been implemented in five cities internationally (London, Singapore, Stockholm, Gothenburg and Milan). Table 1 gives an overview of results. Eleven studies were included, with the overall evidence for a physical activity or modal shift effect of congestion pricing considered weak. The quality of the evidence was also considered to be low, as per criteria from a published guidance on the evaluation of natural experiments [60].

DRAFT

Table 1 *Evidence for the impact on modal shift or physical activity of congestion pricing schemes implemented in London, Singapore, Milan[1], Stockholm and Gothenbur*

Study	Study aim	Method for measurement of effect	Reported effect
London			
Nakamura et al (2014) [61]	To examine effect of economic incentive on health behaviours by investigating the impact of the discount for residents of the charging zone.	Boundary discontinuity design, intervention group defined as those living near the border and ineligible for discount, control group defined as those eligible for discount. Regression analysis, using London Travel Demand Survey data.	No evidence that congestion charge increases overall physical activity levels. No health effects found around the border of the congestion zone.
Transport for London (2004) [62]	To describe impact of the London congestion charge.	Part of a 5 year monitoring programme undertaken by Transport for London that used more than 100 specially designed surveys and existing data sources to estimate key transport, business, economic, social and environmental impacts of the scheme.	Estimated that the congestion charge resulted in between 65,000 and 70,000 less car movements in the zone boundary (approximate reduction of 18% of traffic entering the zone in charging hours), with between 35,000-45,000 switching to public transport and between 5,000-10,000 switching to walk, cycle, motorcycle, taxi or car share.
Transport for London (2008) [63]			Approximately 50% of travellers in the Western Extension Zone said the scheme had no impact on their travel behaviours. Increase in "those who ever use" buses of 6%, Underground 4%, walking 4%, cycling 15% and rail 16%.
White (2009) [64]	To examine extent to which regulatory or other measures have contributed to increase in bus patronage in London.	Uses data on bus patronage, fare levels, service levels and demographic data. Most data has been obtained from government sources.	Congestion charge may have contributed up to 6% of increase in observed bus patronage. The impact of the charge has been small in comparison to other factors influencing bus patronage, including fare levels, service levels and relatively stable car ownership rates.

[1] No evidence found for the impact on modal shift to more active forms of transport or physical activity of the congestion pricing schemes in Milan or Gothenburg.

Study	Study aim	Method for measurement of effect	Reported effect
Stockholm			
Bergman et al. (2010) [65]	To examine the potential effect of congestion pricing scheme on physical activity.	Quasi-experimental study (natural experiment). Data on PA was taken from the International PA Prevalence Study, pre-trial and participants were followed up during the congestion charge trial. Participants exposed resided in Stockholm (n=165), and controls resided in either Goteborg or Malmo (n=138).	Study results inconclusive, however at follow-up participants living in Stockholm reported more moderate PA (p=0.036) and less time spent sitting (p=0.009) and an increase in weighted overall PA (p=0.015) compared to baseline measurements. Effect sizes were generally small (r=0.03 for walking and r=0.20 for sitting). No changes in PA levels in controls.
Kaida & Kaida (2014) [29]	To examine effect of congestion charging on motor vehicle use and pro-environmental behaviour.	Survey of those who lived near the boundary specified by the congestion charge scheme (n=291), conducted in 2008 (approx. 2 years after trial and 6 months after implementation). Participants asked their dominant mode of travel pre and post congestion charge implementation.	The number of respondents who use public transport decreased slightly (from 87 to 86). The number of respondents who walked to work increased slightly (from 9 to 17). The number of respondents who cycled to work increased slightly (from 13 to 16).
Karlstrom & Franklin (2009) [66]	To assess equity effects of the congestion charge, in terms of behavioural adjustments (mode choice, departure time) and welfare effects.	Used a subset of the two-wave panel travel survey data collected in September 2004 and March 2006. Restricted data to those who made work trip in both waves to same origin or destination (i.e. hadn't moved or changed jobs) by either car or public transport (walking and cycling were not included due to the problems with seasonality in the dataset). Matched to those not affected by the congestion scheme.	25% of those crossing the toll cordon by car switched to transit (compared to 10% in control group). For those who went by transit pre-charge, 7% of those affected by the congestion scheme switched to car travel (8% in the control group). Most individuals do not change behaviour.

DRAFT

Study	Study aim	Method for measurement of effect	Reported effect
Singapore			
Chin (1996) [67]	To evaluate the reduction in negative externalities as a result of the congestion pricing scheme.	Cites a pre and post survey of car-owning households work travel patterns around the time of the Area Licensing Scheme (1975), however no specific details given.	Modal split pre-charge: 56% car, 33% bus. Modal split post-charge: 46% car, 46% bus, (decrease in car travel by 10%, increase in bus travel by 13%).
Luk (1999) [68]	To give an overview of the development and experience of road pricing in Singapore.	Uses Singapore Home Interview Survey data.	Pre-ALS scheme modal split: 63% car, 33% bus and 4% walk or others (defined as walking, cycling and use of taxis). 1991 modal split: 22% car, 40% bus, 30% rail and 8% others. Cross-price elasticity of bus demand due to congestion pricing estimated as +0.17 at two years (short run) and +0.80 at seven years (long run), over which time the tolls have increased. Price elasticities for car travel due to congestion tolls range from -0.19 to -0.58.
Menon (2000) [69]	To describe the first year of ERP, from September 1998 to August 1999.	Doesn't give details of data source.	After one year the ERP had not resulted in a modal shift from cars to public transport. Results as expected as the ALS preceded the scheme. Short run demand elasticities for car travel between -0.35 to 0.65.
Menon (2006) [70]	To describe the experience of Singapore in implementing and managing congestion pricing.	Doesn't give details of data source.	Modal split of morning work trips in 1975 was 46% bus, 46% car, 6% motorcycle, and other modes 2%. By 1983, bus modal share was 69%, car was 23% and the others remained constant. In 1998, the public transport share (bus and MRT) was 67%.

Initial results of the London congestion pricing scheme suggested that the number of cyclists rose 30% in the first six months after its introduction [62]. By 2006, it was estimated that the number of cyclists crossing into the zone had increased by 49% from 2002 levels [63]. Another analysis estimated that bus travel in London increased by 37% within the first year [71], with most of the effects of the introduction of the charge coming as "one-off shocks" after which no large further changes were observed [72]. However, as other initiatives such as improvements to public transport and the expansion of a bicycle share program were undertaken during implementation of the congestion scheme, causality cannot be established [73].

Bergman et al [65] evaluated the effect of the Stockholm trial on physical activity, and found inconclusive results. Study participants living in the Stockholm region with access to a motor vehicle reported more moderate physical activity ($p=0.036$) and less time spent sitting ($p=0.009$) and an increase in weighted overall physical activity ($p=0.015$) compared to before introduction of the congestion charge. There were however no significant differences in change in physical activity between Stockholm residents exposed to congestion pricing, and residents of a Swedish city not exposed to congestion pricing. The trial period of the Stockholm congestion charge has been associated with a 24% reduction in car commuting trips, with almost all switching to public transport [74]. In a further analysis of the Stockholm congestion charge five years after its introduction, Borjesson et al [44] found that the initial traffic reduction had been maintained or even improved after controlling for population growth and other factors.

Whilst the evidence may be inconclusive or show a low to moderate impact, interventions with small effects may contribute to a reduction in obesity if enough individuals are affected by them [65] or if they form part of a package of interventions with larger population effects. Australian evidence on the likely physical activity related impact of a congestion pricing scheme is limited. The Institute of Transport and Logistics Studies (ITLS) at the University of Sydney found that 13% of peak car driving commuters from their Transport Opinion Survey (TOPS) would switch to public transport use if a charge of 5 cents per kilometre was charged on all major roads during peak periods [75]. A study by Whitehead et al in 2011 [76, 77] modelled the potential introduction of a cordon based scheme in Brisbane central areas, using three hypothetical cordon boundaries. Using the Brisbane Strategic Transport Model, the analysis showed that all three scenarios resulted in a modal shift to either public transport or walking or cycling however no specific detail was given on the magnitude of the modal shifts under each scenario.

The study by O'Fallon et al [58] in NZ found that a fixed kilometre charge on all roads of NZD0.10 per km would result in a 4% shift from motor vehicle to public transport use in Christchurch and 1.3% in Wellington, with a NZD0.30 per km charge resulting in an 8% shift and a 4.1% shift respectively.

DRAFT

III. Impact on industry

The introduction of a congestion pricing scheme would have an impact on industries reliant on road transportation in the affected areas (for example, delivery and postal businesses, some road freight businesses). Congestion pricing schemes that improve travel time and reduce associated costs may however lead to productivity gains, which would benefit business and industry.

Prior to the introduction of the London congestion charge, there was some concern that retail and other businesses within the zone would suffer a negative impact due to the reduced traffic flow. There is conflicting evidence as to the actual impact of the congestion charge on the retail sector. An audit report commissioned by Transport for London found that the introduction of the scheme had a broadly neutral effect on the business economy of the affected zone [78]. The study by Quddus et al [79] analysed the sales data of one store within the zone pre-implementation and at one year post implementation and found that the charge had reduced expected weekly sales by between 5% and 9% dependent on the modeling used. The study by Schmocker et al [80] found that a significant number of respondents to a survey on shopping frequency at one store in the affected zone shopped less often post-charge but did not explore how the effect may have reduced over time post implementation of the charge. A study on the retail effect of the Stockholm congestion charge however found that there was no significant negative effect on 20 shopping malls, of which eight were located within the charging zone [81].

If a congestion pricing scheme led to modal shift there would be an impact on the industries of alternative modes of travel (for instance, the public transport industry, cycling industry, sportswear industry). Efficient public transport systems and comprehensive measures to support walking and cycling, such as bike paths, are a pre-requisite if the desired modal shift to more active forms of transport is to be achieved.

b. Potential to use evidence as a basis for an intervention

Variable	Source	Estimate
Demand elasticity of car usage, Australia	Oum et al 1992[53], as cited by BITRE [52]	Short run -0.09 to -0.24, long run -0.22 to -0.31
Shift from motor vehicle to public transport	Institute of Transport and Logistics Studies [75]	13% of peak hour commuters would shift to public transport given a per-km charge.
Shift from motor vehicle to public transport given NZD$0.10/km charge	O'Fallon et al [58]	4% Christchurch 1.3% Wellington
Shift from motor vehicle to public transport given NZD$0.30/km charge	O'Fallon et al [58]	8% Christchurch 4.1% Wellington
See Table 1		

5. Feasibility of intervention's implementation in Australian context

The momentum for more efficient road pricing strategies has been building for several years in Australia, however such a change is considered politically sensitive [12]. A 2012 study considered congestion charging as the second least acceptable and second most intrusive policy intervention to support active travel, only after regulation that would restrict choice [54]. Negative financial incentives require strong political justification and are a hard political sell [54]. The benefits of such schemes must be convincing to voters, conducive to being "sold" by politicians seeking re-election and acceptable to Treasury and the governmental bottom line [24, 82].

Experience in other countries suggests that whilst acceptability and support for congestion pricing schemes are low prior to implementation, once people experience the scheme they are more accepting [27, 28, 39, 83]. However, several of the unsuccessful congestion pricing initiatives internationally were rejected before their implementation primarily due to the fact that public and political acceptability was never attained [84].

The introduction of a congestion pricing scheme may present as a classic case of a 'stealth' intervention, whereby the impact on physical activity and obesity is a secondary benefit to the purpose of the scheme. In terms of obesity prevention, congestion pricing would need to be network specific (i.e. on a capital city by capital city basis) [28] but comprehensive enough to have a population effect on physical activity levels. A belief in the effectiveness of congestion pricing schemes has been shown to be a key factor in acceptability internationally [85]. From an Australian-wide perspective, it may not be politically feasible to introduce congestion pricing into capital cities that are not experiencing severe enough congestion issues. Whereas Sydney, Melbourne and Brisbane may potentially be considered suitable, implementation in other Australian capital cities may not be realistic for this reason.

Political success of any congestion management scheme in Australia would also likely require broader reform of road pricing strategies, including vehicle registration costs and taxes on motor vehicles and fuel, so as to avoid public perception of "another big new tax" [24]. A recent survey of transport users in Australia found that 60% of Australians would support a scheme based on distance road usage charges (i.e. more of a 'pay for use' system) so long as car registration fees were reduced and provided that overall they would not be out of pocket [86].

Transparency and public approval around the use of congestion revenue streams is also a prerequisite for public acceptability. A report by the Grattan Institute recommended that a significant portion of any revenue from congestion pricing should be reinvested into public transport provision, to improve public acceptability and to address equity concerns [87]. Other studies have also cited the critical importance of the transparent use of revenues in funding public transport, so that alternate modes of transport are efficient and viable [9, 18, 24, 88]. At present, many Australian cities may not be well-placed to provide efficient and comprehensive infrastructure and services to support a modal shift to more active modes of transport [12]. The urban design of most Australian towns and cities is premised on the use of private motor vehicles [13] and therefore significant investment in infrastructure to promote active transport, such as train stations, pathways and trails, would be required. This would require a long term view, with realistic implementation timeframes of at least 5

DRAFT

to 10 years [10, 24]. Acceptability may also require significant investments in educational campaigns designed to encourage modal shift.

Political feasibility may be difficult to achieve given the fact that any reduction in car usage would result in reduced fuel consumption, and therefore the potential reduction of government revenue streams. Federal government revenue is collected from the fuel excise and state governments also receive revenue from the GST that is also applied to fuel. In the analysis of active transport to school interventions, Fishman et al [25] assumed that the money saved by less car use would be spent on other goods and services that also attract GST so that the effect on the states would be limited.

One economic evaluation of congestion pricing schemes incorporating physical activity effects was found in the literature, and reported that hypothetical cordon pricing schemes would be cost-saving (BCRs of 45:1 or 59:1). The study was based on various assumptions and the costs of implementing the hypothetical schemes seem quite low however, potentially affecting results. The study also did not take into account loss of government revenue resulting from the uptake in active transport or other effects.

Physical activity related health effects were incorporated as the number of individuals who became active as a result of the interventions, with health care cost savings of $326 and productivity cost savings of $717 applied for each newly active individual.

6. Economic evaluations incorporating health impacts related to physical activity that exist in the literature

Study	Health valued as	Result/s	Comments
Co S, Vautin D. Benefit-Cost Analysis of Public Health Outcomes in Long Range Transportation Planning in the San Francisco Bay Area. Transportation Research Board 93rd Annual meeting; Washington D.C.2014.	Cost savings through diseases averted. Diseases: CHD, T2DM, some cancers, stroke. Value of each person that became more active was estimated at $326 for health care cost savings.	Cost-benefit ratios of 45:1 for a **hypothetical cordon charge pilot program**, and 59:1 for a **hypothetical cordon charge scheme**.	The study aims to assess the cost-effectiveness of proposed transport projects valued at over $50 million to examine which present the best value in attempting to improve active transport participation. The assessment was undertaken by employees from the US Transport Commission and was found in a search of the grey literature. The study gives very limited information on the interventions themselves, the estimates of effectiveness, the source of the cost data and what exactly is incorporated. Estimates of the health benefits have been taken from the literature. Physical activity related health effects are incorporated as the number of individuals who became active as a result of the interventions, with health care cost savings of $326 and productivity cost savings of $717 applied for each newly active individual. Cost-benefit ratios are high. Costs for each intervention were given as annualised 2035 costs of USD5.1 million and USD1.2 million respectively, which seem low (hence affecting the cost-benefit ratio).

Notes: CHD=Coronary heart disease, T2DM=Type 2 diabetes mellitus.

DRAFT

7. Stakeholders

a. Policy makers/regulators

- Department of Transport
- BITRE
- Local governments

b. Industry

- Australian Transport Council
- Motoring organisations
- RACV and other motoring bodies

c. Academics

- The Institute of Transport and Logistics Studies, University of Sydney.

8. Issues specific to this intervention

a. Modelling

Due to the highly contextual nature of congestion pricing schemes, debate surrounds the transferability of evidence of impact from other cities or countries. Road pricing is normally one part of a multi-component strategy to manage transport behaviour and its success is heavily influenced by other factors, such as the supply of comprehensive and high quality alternate modes, public acceptability and implementation [12, 89]. Even cities within the same country that might appear similar may be subject to confounding trends and policies, with suggestions that transferability of evidence of impact is limited [45].

The study by Borjesson et al [90] however suggested that evidence may be more transferable between locations than previously thought. By investigating the extent to which the impact of the Stockholm congestion charge was context dependent (in regards to transport system features specifically), the authors found that the level of public transport provision, adaptation cost, traffic reduction across the cordon and the share of drivers priced off the road diverted to public transport were all relatively insensitive to the provision of public transport infrastructure. It should be noted however that public transport provision in Stockholm is much more comprehensive than in Australian cities, therefore these results may not be so relevant in the Australian context. The authors state that sprawling cities with dispersed congestion require tailored design of any proposed congestion pricing scheme that takes local context into account. The study found that behavioural responses to congestion charges are relatively less dependent of characteristics such as public transport provision and bypasses than previously thought however initial congestion levels have a considerable effect.

It is also important to note that the impact of congestion pricing is likely to be fairly localised and would not impact on the travel behaviour of the entire Australian population. Congestion pricing schemes in capital cities would not affect those living in regional and rural areas on a daily basis and thus would have limited obesity prevention effect in these areas [51]. As at June 2013, 71% of the Australian population lived in major cities [91] however depending on how the intervention might be specified, not all residents of major cities might be exposed.

b. Other issues (e.g. equity)

Differences in travel behaviour between groups exists and thus transport pricing poses a significant equity issue [3, 17]. Equity considerations are crucial in the evaluation of any proposed congestion charging scheme, in order to examine the distributional effects, compare the magnitude of the net welfare surplus with the distributional effects and to consider the likely impact of different uses of scheme revenue [92].

Conflicting evidence exists on the equity impacts of congestion pricing schemes, with recent analyses suggesting that congestion pricing can be regressive, progressive or neutral depending on contextual factors [57]. Low income groups generally have longer commute distances as they live further from city centres and have less accessibility to efficient and comprehensive public transport systems. This may result in congestion pricing being regressive, whereby those on low incomes bear a greater proportion of the burden than those on higher incomes [66]. Conversely, it has been suggested that high income groups may be more likely to be impacted by the introduction of a congestion pricing scheme as they are more likely to use motorised transport and to live and work in inner areas [92].

In the long run, the introduction of congestion pricing in Australia may in fact improve long term equity outcomes, by improving the accountability of road users for the impacts of their road usage and by providing a revenue stream that could be directed towards improving the provision of alternate transport modes [9, 10]. Overall, the equity effects of congestion pricing schemes are likely to be sensitive to the specification of the individual scheme, taking into account relevant contextual factors [35]. Whilst congestion pricing may encourage a more efficient use of road resources, the equity impacts will be heavily influenced by the ways in which revenue is used to subsidise and cross-subsidise different groups in society [46, 92, 93].

9. Intervention's potential to meet intervention selection criteria

a. Potential impact of addressing the problem of obesity

The study by Faulkner et al [56] used the Delphi survey method to estimate the likely impact of a range of economic instruments on obesity prevention. The study found that the likely impact on physical activity of a road congestion tax was considered to be low, as was the likely impact on obesity. Results from the systematic review of physical activity or modal shift effects suggest that the evidence from the implementation of congestion pricing schemes in five cities internationally is inconclusive and can only be considered weak.

b. Relevance to current policy decision making

Congestion pricing has been discussed at various times within Australia, and several high level reports have been produced as previously discussed.

c. Availability of evidence of efficacy/effectiveness to support the analyses (using a broad definition of evidence)

Limited evidence on modal shift to more active forms of transport or the physical activity related effect of congestion pricing exists, as previously discussed.

10. Intervention specification

Defining the intervention and distinguishing the effects of the intervention from its context may prove difficult [45]. Transport interventions are context specific, and effects may be

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influenced by other factors within the environment that are difficult to separate (for instance, provision of infrastructure, marketing campaigns, and other policies). At best, intervention specification is likely to be somewhat crude and reliant on a number of assumptions.

As previously mentioned, most Australian cities are considered to be too decentralized for effective cordon pricing schemes [12, 24]. Instead there has been growing interest in charging regimes that are based on distance (price per kilometre) across an entire road network [57]. Hensher and Bliemer [94] recommend registration reform to include variable charges based on distance, with a second phase introduction of time dependent charges. It is clear that considerable input from experts in the field would be required to specify this intervention.

11. Feedback from CRE team requested

Significant challenges would need to be overcome to progress this intervention to modeling. Challenges include limited evidence of effect and the difficulties in specifying the intervention. Feedback is requested on ways in which the intervention could potentially be specified or on its overall suitability for modeling.

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