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Broadening the Debate on Road Pricing

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Abstract:

There is increasing awareness of the role of road pricing in influencing travel demand, improving economic efficiency, reducing environmental costs, and meeting the cost of providing roads. Particular attention has been given in recent years to the concept of congestion pricing. While congestion pricing will ensure economic efficiency, the financial and political cost of implementing it are likely to be considerable. Given this, the debate on road pricing appears to have been too narrowly focused on congestion pricing. Within this context, this paper has two main themes. First, it considers the effect of misperception of the cost of travel by road users, an aspect of road pricing that has been largely neglected to date. The paper demonstrates that user misperception can have a significant impact on the economic analysis of road pricing. Second, the paper identifies a broader range of road pricing options which could improve welfare outcomes, but at lower cost than congestion pricing.

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Introduction

There has been considerable interest in road pricing amongst transport professionals for years. Economists in particular have long argued the theoretical merits of road pricing as the best tool for achieving efficient levels of road use. Its use as a policy tool in practice has however lagged well behind the theoretical arguments.

Interest in road pricing was initially aroused by the introduction of area licensing in Singapore in 1975. Relatively little happened elsewhere in subsequent years however, with governments preferring to initially pursue policies of encouraging a shift from cars to public transport, and then the broader paradigm of demand management, as tools for controlling the growing problem of road congestion.

Consideration of demand management measures, and developments in technology, has led to renewed interest in road pricing. This has seen the implementation of a number of toll rings schemes, including Bergen in 1986, Oslo in 1990, Trondheim in 1991 and Stockholm in 1993. The role of these schemes was however more as financing systems than to regulate traffic (Hervik and Braathen 1994:23). Electronic congestion pricing was also trialed in Hong Kong in the mid-1980s.

The growing recent worldwide interest in road pricing, particularly congestion pricing, is illustrated by recent reports such as Transportation Research Board (1994) on the USA, MVA Consultancy (1995) on the United Kingdom, National Cooperative Highway Research Program (1994) on Singapore, Hong Kong, Scandinavia and the Netherlands, and Commission of the European Communities (1995) on the European Union.

In Australia, the Industry Commission (1994) noted the importance of pricing to achieve effective use of both roads and public transport. Since then, Luk and Hepburn (1995) and Bureau of Transport and Communications Economics (1996a) have made important contributions to the debate. Road pricing is also receiving attention via inter-government processes, through which the research reported here has been undertaken.

The driving force in this paper is a concern that current research and debate in Australia may be too narrowly focused on one form of road pricing, ie congestion pricing (pricing which varies by time and location to reflect variations in congestion levels). Although congestion pricing is worthy of research, it is likely to be expensive to implement, and has well documented political and equity difficulties. The paper presents some preliminary considerations and results of research currently in progress addressing the above concern. The paper considers two main themes: the effect of misperception by motorists of their private car use costs; and the need to assess a broader range of road pricing options than congestion pricing alone.

The costs of road use

Three cost concepts are used in this paper. Economic welfare analysis is based on *resource* costs, equilibrium analysis on *financial* costs (or behavioural costs in the case of travel time), while *perceived* costs (on which travel decisions are based) comprise part or all of financial costs.

An economic optimum requires that marginal benefit equal short run marginal social cost (ie costs which vary with level of road use). These costs are now considered.

Travel time costs

The work of Akcelik (1991) has formed the basis of time cost functions used in recent road pricing research in Australia (Luk and Hepburn 1995; BTCE 1996a), and is used here. Travel time is given by the expression (BTCE 1996a:79):

$$t_a = t_o\left[1 + a\left\{(x-1) + \sqrt{(x-1)^2 + bx}\right\}\right] \tag{1}$$

where t_a is average travel time per km, t_o is free speed travel time per km, $x = q/Q$ is the volume/capacity ratio (or degree of saturation), an indicator of congestion level, q is traffic volume (vehicle-km/hr), Q is road capacity (vehicle-km/hr), and a and b are constants. With $T = qt_a(q)$, marginal travel time is given by:

$$t_m = \frac{dT}{dq} = q\frac{dt_a}{dq} + t_a \quad \text{, where} \quad \frac{dt_a}{dq} = \frac{t_o a}{Q}\left[1 + \frac{(x-1) + b/2}{\sqrt{(x-1) + bx}}\right] \tag{2}$$

Luk and Hepburn (1995:7) provide a useful approximation for constants a and b based on the speed (v) when $x = 0$ and 1 (denoted v_o and v_1 respectively), ie:

$$a = 0.25v_o \text{ and } b = 16(1/v_1 - 1/v_o)^2, \text{ where } v = 1/t_a \tag{3}$$

BTCE (1996a:Table III.2) reports values for v_o, v_1, a and b for Australian cities for various road types. Considerations here are limited to arterial roads for which $v_o = 58$ kph, $v_1 = 38$ kph, $a = 14.5$, and $b = 0.001318$.

As congestion increases, each additional road user imposes additional travel time on all other road users. Thus t_m rises more rapidly than t_a, and so t_m is greater than t_a.

Travel times were converted to travel time costs by factoring by the value of travel time savings (VTTS). BTCE (1996a:90) reports VTTS values for non-local roads of \$12/vehicle-hour for peak periods and \$16/vehicle-hour for the inter-peak period. The analysis here assumes a uniform \$12/vehicle-hour throughout.

Other (non-time) costs

Other road use costs are:

- vehicle related resources which are consumed in the course of travel;
- road costs resulting from use of roads by vehicles;
- accidents; and
- damage caused to the environment.

The marginal cost of some non-time components may rise as congestion increases, eg fuel consumption (and therefore air emissions). The converse may also occur, eg with accident costs if lower speeds result in less severe (though possibly more frequent) accidents. Luk and Thoresen (1996:12) report some data on average and marginal costs for non-time components. However the database was limited, and no firm conclusions could be drawn on the marginal to average cost relationship. Any divergence between marginal and average cost for non-time components is expected to be considerably lower than for time costs. As a result, the current analysis assumes that, on balance, non-time marginal cost equals non-time average cost (which implies that both are constant).

A summary of adopted values for marginal non-time cost (*MNTC*) components is presented in Table 1. For environmental costs, both best and upper estimates are reported to reflect variation in available estimates.

Table 1 Marginal non-time costs of car use

Component	Marginal Cost (cents/vehicle-km, 1996 prices)(1)		
	Financial Cost	Resource Costs	
		Best Estimate	Upper Estimate
Vehicle Costs:			
• Fuel	8.9	3.8	3.8
• Tyres	1.0	0.9	0.9
• Maintenance	7.3	6.6	6.6
• Depreciation and Capital	4.8	4.2	4.2
Subtotal (Vehicle Costs)	22.0	15.5	15.5
Road Costs		3.1	3.1
Accident Costs		5.0	5.0
Environmental Costs			
• Noise		0.3	0.5
• Greenhouse Gas		2.0	2.9
• Local Air Pollution		2.0	3.6
• Water Pollution		0.2	0.3
Subtotal (Environmental Costs)		4.5	7.3
Marginal Non-Time Cost		28.1	30.9

(1) Marginal costs are assumed to equal average costs for all components

Source: Appendix A.

Perceived costs

An important issue that has received limited attention is the extent to which motorists perceive the cost of their travel when making travel decisions. Economics generally assumes that consumers have full information and perception of costs when making decisions. However, it is commonly conjectured that motorists do not perceive all of their private travel costs (ie a market failure occurs), eg this may be due to the time lag between incurring some vehicle expenditures and making travel decisions. As early as 1971, Neuberger noted *"car drivers tend not to take full account of running costs in estimating the cost of making a trip"*. Suggestions on the extent of perception include:

- Button (1993:117) suggests that car users may perceive as little as their time costs;
- Luk and Hepburn (1995:5) suggest that motorists may perceive only the cost of fuel and their time costs;
- McIntosh and Quarmby (1970) suggest time, fuel and all or a part of parking costs;
- Luk and Thoresen (1996:3) include time and fuel costs, plus parking costs;
- BTCE (1996a:23) includes time costs and vehicle operating costs (fuel and maintenance); and
- Ker (1989:671) noted that the ratio of perceived to resource costs differed between private and various categories of business and commercial vehicle, and changed marginally over time.

Thus all these observers agree that private travel time costs are perceived, and most feel that the cost of fuel is also perceived. Opinions differ on other costs. There appears to be a general lack of quantitative evidence on the extent of under-perception to substantiate these conjectures (although travel demand analyses could provide an initial guide).

Given the lack of evidence, the analysis here assesses three misperception scenarios:

(a) $T+F$: time cost (T) and all fuel cost (F) are perceived;
(b) $T+0.5F$: time cost and half of fuel cost are perceived; and
(c) $T+F+OVC$: all time, fuel, and other vehicle costs (OVC) are perceived.

Welfare implications of cost misperception

What are the welfare implications of a misperception of costs by motorists? We are unaware of any previous formal analysis of this issue. Button (1993:117), however, notes that user misperception could lead to underestimation of the marginal cost of road use. A more complete welfare analysis of user misperception follows.

Analytical cases

A total of five cases were considered, based on combinations of the above three misperception scenarios with two environmental cost estimates. The cases are described in Table 2. Cases 2 to 4 use best estimate environmental costs, and test variation in levels of private cost perception. Case 1 is considered as a base case in the following sense. Conventional discussions of road pricing often implicitly assume that there is no misperception, and sometimes exclude environmental costs from their analyses. This is particularly true of textbook presentations of road pricing upon which the knowledge of road pricing of some people is likely to be based. Finally, Case 5 tests the impact of using the upper estimate of environmental costs.

Welfare framework

The welfare outcomes under the different analytical cases can be assessed with the aid of Figure 1. The analysis is presented as a function of volume/capacity ratio (x), making it a general analysis applicable to a range of congestion situations.

Table 2 Summary of analytical cases

Case	Denoted	Perceived Private Costs	Environment Costs[1]
1	T+F+OVC, Env=0	Travel time cost, all fuel and other vehicle costs	Zero
2	T+F+OVC, Env=B	As for Case 1	Best estimate
3	T+F, Env=B	Travel time cost and all fuel cost	Best estimate
4	T+0.5F, Env=B	Travel time cost, and half of fuel cost	Best estimate
5	T+F, Env=H	As for Case 3	Upper estimate

(1) Other non-time costs (road damage and accidents) are the same in each case.

There are three relevant curves in the analysis. First, the marginal social (resource) cost of road use is represented by the *MSC* curve, with the subscript $_0$ or $_B$ corresponding to the use of zero and best estimate marginal environmental cost respectively. Marginal social cost consists of the sum of all the non-time cost components in Table 1, plus marginal time cost given by expression (2), all expressed in resource cost terms.

Secondly, there is a set of perceived marginal private cost (*PMPC*) curves. Three curves are illustrated in Figure 1, corresponding with the three user cost perception scenarios described earlier. Each *PMPC* curve consists of the average travel time cost based on expression (1), plus the vehicle cost components from Table 1 relevant to each perception scenario being considered. All the *PMPC* (and *D* curves - see below) are based on costs inclusive of existing taxes (denoted by t_0).

The third curve is the demand, or marginal benefit, curve (*D*). The demand curve must pass through the point representing current user behaviour, ie the point which coincides with the actual perceived cost and the actual level of congestion (x_u in uncongested conditions and x_c in congested conditions). For example, for the *T+F* scenario under congested conditions, the demand curve must pass through point *h* on the $PMPC(T+F,t_0)$ curve in Figure 1, and hence the demand curve is $D(T+F,t_0)$. Alternatively, for a different perception scenario, the demand curve will be in another position. For example, for the *T+F+OVC* scenario, the demand curve will pass through point *a* in Figure 1, and the demand curve is $D(T+F+OVC,t_0)$. It is important to note that multiple demand curves do not exist concurrently. In any given situation, there can be only one demand curve, and it will be that which matches the actual level of perception of costs and the actual level of congestion.

To undertake an accurate welfare economic analysis, an analyst therefore requires information of the actual level of user perception of costs in order to locate the position of the demand curve. However, if the analyst misunderstands the level of misperception (which is conceivable given the lack of quantitative information available), they will mislocate the demand curve (ie use an incorrect demand curve) in their assessment. In turn, as the analysis below indicates, this will lead to an incorrect estimation of the welfare outcomes of alternative levels of road use.

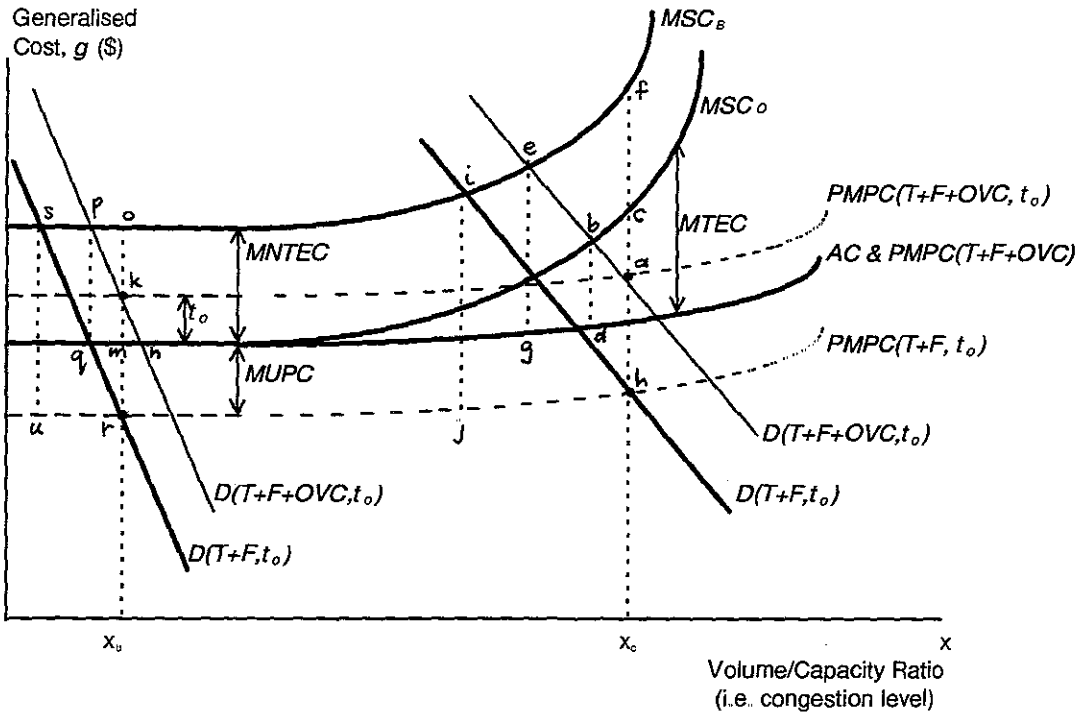

Figure 1 Welfare analysis framework

Table 3 Equilibrium and welfare outcomes

	Case 1 *T+F+OVC* *Env=0*	Case 2 *T+F+OVC* *Env=B*	Case 3 *T+F* *Env=B*
Demand Curve:	*D(T+F+OVC, t_0)*	*D(T+F+OVC, t_0)*	*D(T+F, t_0)*
Average Cost Curve:	*PMPC(T+F+OVC, t_0)*	*PMPC(T+F+OVC, t_0)*	*PMPC(T+F, t_0)*
Marginal Cost Curve:	*MSCo*	*MSC_B*	*MSC_B*
Congested Condition:			
• Equilibrium Point	a	a	h
• Equilibrium Divergence	ac	af	hf
• Optimum Point	b	e	i
• Efficiency Loss	abc	aef	hif
• Optimal charge	bd	eg	ij
Uncongested Condition:			
• Equilibrium Point	k	k	r
• Equilibrium Divergence	km	ko	ro
• Optimum Point	n	p	s
• Efficiency Loss	kmn	kpo	rso
• Optimal charge	zero	pq	su

Qualitative welfare results

To illustrate the welfare analysis, Figure 1 presents equilibrium and welfare outcomes for analytical Cases 1, 2 and 3 for both congested and uncongested conditions. The relevant curves and outcomes for each case are summarised in Table 3. In each case, revealed equilibrium is determined by the intersection of corresponding *D* and the *PMPC* curves, whilst the economically optimal position is determined by the intersection of the pertinent *D* (=*MB*) and *MSC* curves. In order to reach the optimal outcome, an additional charge (ie in addition to the existing fuel tax) equal to the gap between the current *PMPC* and *MSC* at the optimal level of congestion is required (assuming that motorists fully perceive the additional charge). The total optimal charge to be imposed on motorists is therefore the sum of current fuel tax and this additional charge.

The optimal charge comprises up to three components:

(a) *MNTEC*: the marginal non-time external cost. These are non-time costs which are not incurred by individual motorists when making travel decisions, ie road, accident and environmental costs.

(b) *MTEC*: the marginal time external cost. These are the travel time delay costs imposed by individual motorists on all other motorists. This is zero for uncongested conditions, and grows with the level of congestion.

(c) *MUPC*: the marginal unperceived cost. These are those private costs which motorists fail to perceive when making travel decisions. These are zero for Cases 1 and 2, *OVC* for Case 3 and 5, and *0.5F+OVC* for Case 4.

This approach is consistent with Small (1992:108) who identified the optimal charge as comprising two components: (i) a *non-time externality charge*; and (ii) a *congestion externality charge*. Item (i) is the equivalent of (a), while (ii) is identical to (b). Component (c) is a further element, one which does not appear to have been previously addressed in the literature, and reflects the need to correct for the under-perception of private costs: it is denoted here as a *misperception charge*. It is important to note that the size of the required misperception charge can be reduced by, for example, improved information to motorists through education (see later discussion).

Several observations can be made about the results in Table 3 and Figure 1:

- Case 1 produces the usual textbook result: an optimal charge equal to *MTEC* is required in congested conditions.
- The introduction of *MNTEC* and *MUPC* both result in an increase in equilibrium divergence, efficiency loss, and the required optimal charge.
- Interestingly, with either non-time external costs and/or under-perception of costs, an optimal charge is required even in uncongested conditions.

The results also indicate that there are potentially significant differences in the welfare outcomes between the analytical cases considered. The next section quantifies the magnitude of these differences.

Quantitative welfare results

Quantification of the results in Table 3 were based on the following assumptions:

- A fuel price elasticity of -0.13. This lies towards the lower end of observed Australian elasticities (Luk and Hepburn (1993) report a range of -0.1 to -0.26). The corresponding generalised cost elasticity (based on Adelaide conditions) is -0.5 and -0.8 for user perception cases $T+F$ and $T+0.5F$ respectively. These are broadly consistent with those reported in BTCE (1996a:42, 91).
- A constant elasticity demand functional form was adopted for the $T+F$ perception case. The demand curves for each of the other two perception scenarios were derived by undertaking parallel shifts of $D(T+F,t_0)$. All demand curves were calibrated under current conditions, including the presence of current fuel taxes.
- Welfare results were determined for an indicative lane-km of road with capacity (Q) of 1,200 vehicles per hour.

The quantitative results are presented in Figures 2 and 3, which report the two key welfare analysis outcomes: welfare (efficiency) loss, and the optimal charge required to achieve optimal congestion. The x-axis of both Figures 2 and 3 is denoted x(base). That is, the x values (paired with current perceived generalised cost) through which a series of demand curves were scaled to give a coverage of demand (and congestion) conditions. x(base) is therefore an indicator of the position of the demand curve, and thus the level of demand and congestion.

There are two main results in Figure 2. First, as one would expect, as the level of demand grows (for a given capacity), congestion increases and welfare losses rise. Second, and more importantly, the relative position of the curves in Figure 2 indicates the degree of error which the analyst would make from incorrectly interpreting the level of user misperception of costs. At higher levels of congestion, the error is of moderate size only because the analysis is swamped by time congestion effects. However, at lower and medium levels of congestion, the percentage error can be more significant. Overall, correct interpretation of the level of misperception is therefore important in the welfare analysis of road use.

Now consider Figure 3. In Case 1, as congestion increases, the optimal charge increases consistent with textbook results. For the other cases, Figure 3 confirms that increasingly larger optimal charges are required in uncongested conditions as the extent of misperception and non-time external cost grows, and thus the *non-time externality charge* and the *misperception charge* play a relatively greater role. In all cases, as demand grows and saturation conditions are approached, optimal charges grow more rapidly.

Figure 3 also shows that as the level of misperception and non-time external costs grow, the smaller is the ratio of optimal charges in congested versus uncongested conditions (due to the increased dominance of the *non-time externality charge* and *misperception charge* over the *congestion externality charge*). This suggests that as the level of misperception and non-time external costs grow, the efficiency gain from adopting pricing which varies with the level of congestion rather than uniform charging (as through fuel taxes) diminishes, making the need for variable pricing less critical. This observation is further reinforced by the fact that the difference between peak and inter-peak levels of congestion is becoming less pronounced (due in part to the relatively greater growth in social and recreational travel vis a vis journey to work), thus further reducing the gap between optimal peak and inter-peak charges.

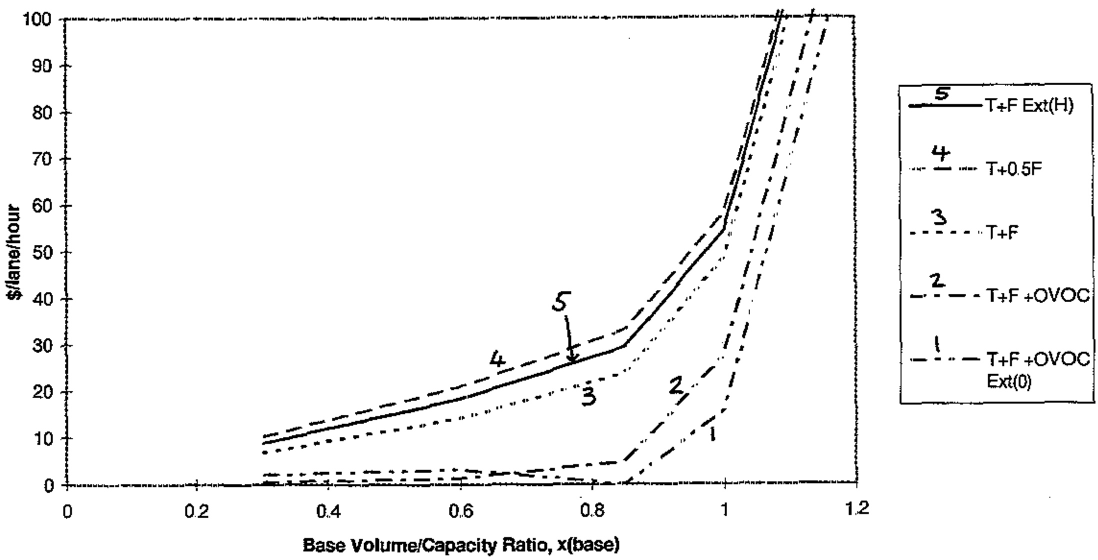

Figure 2 Efficiency loss

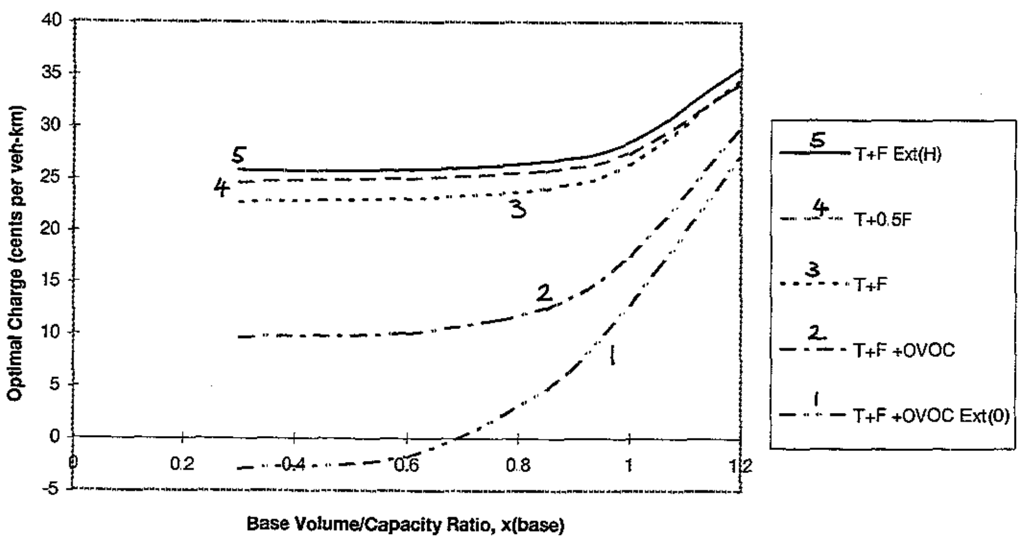

Figure 3 Optimal charge

The overall conclusion that one can draw from the results in this section is that recognition of non-time externalities and introduction of private cost misperception into the analysis can have a substantial impact on both welfare losses and the optimal charges required to attain efficient road use outcomes. Further research is considered justified, particularly to estimate the actual level of misperception of costs and to test the assumption of constant marginal non-time external costs. In addition, there is a need for further sensitivity testing of input variables. For example, preliminary analysis indicates that variation in the elasticity value used has some impact on the results. A higher elasticity results in greater welfare losses and smaller optimal charges which are even more uniform across congestion levels. The analysis also needs to be applied to other road conditions, especially CBD roads.

Policy issues

The above analysis has examined the optimal level of road use. A range of alternative road pricing approaches can be used to move towards this optimum.

Alternative approaches to road pricing

As the marginal social cost of travel varies according to traffic conditions, the optimal outcome requires that the price for use of the road system must vary according to the time and location of travel. This feature is the defining characteristic of congestion pricing.

In its purest form, congestion pricing will result in prices which are continuously variable by time and location. Emerging technology will make it feasible to implement such a pricing system. In practice, however, a pricing system which has continuously variable prices would be complex by comparison with current pricing systems, and could be expected to face consumer resistance if only because of this complexity. Motorists may also be expected to react to the moral hazard inherent in congestion pricing, ie that under-investment in roads increases congestion and hence increases the revenue collected by governments from motorists (Evans 1992).

The application of congestion pricing can be simplified, for example using a charge which is uniform within time periods, and locations, where traffic conditions are relatively similar. Such a pricing system might still need to be electronically-based, but would be both easier to implement and easier for motorists to understand.

Congestion pricing can be further simplified by making the locations and time periods even coarser, eg using area pricing and toll rings. Increasing the coarseness with which congestion pricing is applied will, however, diminish its effectiveness, and will result in a loss of welfare by comparison with its ideal form. Problems will also arise from time and location-related boundary conditions.

The alternative to congestion pricing is uniform pricing across time periods and locations. This is similar to the current pricing "system" that is, at least within metropolitan areas, uniform (other than to the extent that fuel consumption is higher during slow peak traffic, and hence vehicle operating costs are marginally higher). Two possible bases could be used to set such uniform prices:

(i) the price that minimises welfare loss (which recognises that a uniform charge can, at best, undercharge (below *MSC*) in highly congested conditions, and overcharge (above *MSC*) in less congested conditions); or

(ii) the price that generates sufficient revenue to meet the actual financial cost of providing roads and 'compensate' the community at large for the externalities imposed on them by motorists, on the basis that recovery of such costs is more likely to be considered 'fair' by the community, and will provide the necessary funds for development, maintenance and operation of the road system.

Such uniform prices would make the current road pricing system more explicit, and would also move us towards a more efficient outcome, ie reduced road use and welfare loss (although to a lesser extent than congestion pricing). Five broad developments to the current pricing system, through the use of uniform pricing, are described below. While each option could be implemented in isolation, the options can also be considered as a hierarchy in which each successive option is likely to result in an increasingly less sub-optimal outcome. The options are:

(a) *Improved awareness of prices:* Increasing motorists' perception of the actual cost of using their vehicles, eg through advertising and education, may improve their decision-making by encouraging them to consider all costs when making transport decisions.

(b) *Shift from fixed to variable charges:* Periodic government charges such as vehicle registration have no effect on decisions regarding vehicle use. Such fixed charges could be converted to a variable charge, eg a tax on fuel. This would have a more direct effect on travel decisions.

(c) *Full recovery of average transport costs through increased fuel taxes:* The revenue that car users pay to governments at present is not explicitly linked to the cost of providing roads and the externalities that motorists impose on the community at large. It is practicable to determine these costs, and thus to establish the fuel taxes that would ensure that motorists pay all pertinent costs. This option, and the options that follow, would require explicit identification of the proportion of current fuel taxes that are imposed for general taxation purposes.

(d) *Full recovery of average transport costs through direct charges:* The current practice of users incurring all charges periodically (eg annually with registration charges and weekly or similar for fuel taxes) dilutes their effect on travel decisions. By comparison, it may be postulated that direct charges (eg through tolls or electronic road pricing) have a relatively greater effect on motorists perception of the charges, and hence on their travel behaviour. A direct charging system could also be used by others, eg by insurance companies to collect premiums (on the basis that these, too, vary with the amount of travel undertaken).

(e) *Optimal uniform charges:* Charges based on the average cost of providing roads and the cost imposed by motorists on the community at large (options (c) and (d) above) exclude marginal travel time cost externalities imposed by motorists on other motorists. A uniform charge could be set at a level that minimises welfare loss, ie with the price related to the marginal social cost of travel (rather than the average cost), but set at the level where the total welfare loss that results from undercharging for travel in congested conditions, and overcharging in uncongested conditions, is minimised.

Such pricing could be imposed through indirect means such as fuel taxes, but would be more effective if collected through a direct means such as in-vehicle charging as the perception of costs is likely to be greater. An interesting observation then follows. Assume there was a substitution of fuel tax by in-vehicle charging. If a revenue neutral switching between charging instruments occurred, an instant reduction in congestion would occur given the greater response to in-vehicle charges compared with current indirect charges. For the same revenue take, welfare losses would be reduced. Alternatively, a limited reduction in the revenue take is likely to still deliver reductions in the level of road use and welfare losses. It is therefore feasible to obtain a win-win outcome, with both road users as "taxpayers", and the community as bearers of the welfare losses of excessive road use, being better off.

Evaluating alternative approaches to road pricing

The benefit of improving the current pricing system is a reduction in welfare loss. We have initiated work to quantify these savings for the pricing strategies described above. In principle, the options (a) to (e), and forms of congestion pricing, each bring the level of road use closer to the optimal level, and hence has a benefit relative to the current pricing system. The greatest benefit can be achieved by implementing congestion pricing in its purest form.

If the cost of implementing each of the pricing options was zero, pure congestion pricing would be the preferred solution as it would have the greatest net benefit. In practice, costs will be incurred in implementing the options, and the costs will vary between them. The costs will include financial expenditure to establish and operate the new pricing regimes, and a political cost that reflects expectations of the public's confidence in the credibility and acceptability of the proposals.

A comparison of the costs and benefits of alternative pricing proposals relative to the Base Case (ie the present pricing system) will indicate the most effective solution. In this manner, it is possible that one of the "second best" options discussed above may have the highest net benefit, and hence be preferable to theoretically ideal congestion pricing.

Summary and conclusions

The aim of the paper has been to initiate a broadening of the road pricing debate in Australia. We believe this is necessary because the current debate appears to be too narrowly focused on one version of road pricing, ie congestion pricing. Whilst in theory, congestion pricing is the ideal approach to road pricing from an economic efficiency perspective, there are a range of reasons why congestion pricing can be questioned. Accordingly, a broader range of road pricing options are worthy of consideration.

A number of conclusions can be drawn from this paper. First, pricing is important in the matter of the level of road use. If pricing is sub-optimal, as it currently is, overuse of roads occurs and results in significant welfare losses to the community.

Second, the level of perception by road users of their private costs appears to be an important determinant of welfare outcomes. While the concept of under-perception of private costs is commonly acknowledged, there appears to be little evidence on the extent of the misperception. The results of the quantitative analysis undertaken here has shown that analysts can make significant errors when estimating welfare outcomes of road use if they misunderstand the level of private cost misperception. Overall, over[under]-estimating the level of perception leads to under[over]-reporting of the welfare losses of underpriced (and overused) roads.

Third, as the level of misperception of costs and the level of non-time external costs grows, the relative need for congestion pricing rather than a more practical form of road pricing such as uniform road user charges to reduce welfare losses diminishes. This is due to the fact that misperception and non-time externality effects start to swamp time externality effects.

Fourth, recent road pricing analysis in Australia has been focused primarily on congestion pricing. Yet the cost of implementing congestion pricing is likely to be relatively high, from both financial and political perspectives. Other pricing options are available, and may be able to close the welfare loss gap at a lower overall cost, and are therefore worthy of closer analysis.

Further research will quantify the aggregate welfare results for a number of Australian cities, and determine the incremental net benefits (including recognition of implementation costs) of the various policy options discussed above.

The overall conclusion drawn is that the analysis of road pricing in Australia has been too narrow and could be improved in a number of ways. The effects of user misperception should be more explicitly recognised, with research required to better understand the actual level of misperception which occurs. Whilst congestion pricing is an important policy option, a broader range of pricing options should also be assessed. Finally, in assessing policy options, considerations of welfare losses should be complemented by other important factors such as the cost of implementation, and political and equity considerations. Broadening the road pricing debate would lead to a better understanding of the costs of road congestion, and the relative merits of the various options available for tackling this increasingly significant urban problem.

Appendix A: Road transport costs

This appendix describes estimates of the marginal social cost of car travel. We consider cars as they make the greatest contribution to traffic congestion. Costs are expressed in 1996 Australian dollars unless otherwise noted.

Vehicle costs

Fuel: Typical retail price of regular unleaded petrol in Adelaide is 77 cents/litre (c/l). Subtracting the Federal excise (34.56 c/l) and the State fuel franchise fee (9.77 c/l) yields a resource cost 32.7 c/l. Using average car fuel consumption of 11.5 litres/100 km, the financial and resource costs of fuel are 8.9 and 3.8 c/veh-km.

Tyres: The resource price of tyres for a car is $95 per tyre in 1995 prices (Thoresen 1996:8). For an average life of 45,000 kilometres, average resource cost is 0.9 c/veh-km. The financial cost of tyres is estimated at 1.0 c/veh-km.

Maintenance costs: Financial maintenance cost is 7.3 c/veh-km (Bray 1995: App. A), comprising routine servicing and other intermittent maintenance and repairs. The resource cost is 14 percent less, ie 6.6 c/veh-km (using Thoresen 1996:7).

Vehicle depreciation and opportunity cost of capital: Vehicle depreciation is, in part, a function of distance travelled. Assuming (a) 30% of car depreciation is attributable to use (Bennett et al, 1990:20); (b) financial and resource costs of new cars of $26,239 and $23,700 respectively (derived from Thoresen 1996:7); (c) average vehicle life of 20 years (double the average age of registered vehicles – ABS - 9311.0); (d) average annual distance travelled of 16,000 kilometres (ABS 9202.0); and (e) a real opportunity cost of capital of 7 percent; yields depreciation and cost of capital of 4.8 c/veh-km (financial cost) and 4.2 c/veh-km (resource cost).

Road costs

The damage to urban roads caused by the passage of each car is very small, at 0.19 c/veh-km (Meyrick 1994, in Cox 1994:304), or 0.2c/veh-km in 1996 prices. Recognition was made, however, of the need for regular ongoing expenditures for periodic maintenance, reconstruction, and the operation of the traffic signal and traffic management systems in order to accommodate ongoing traffic. These ongoing costs are a function of the amount of traffic that uses the road system. Luk and Thoresen (1996:12) estimate an average cost of providing roads of 1.7-4.4 c/car-km (although it is not clear what components of infrastructure costs are included in these estimates). The midpoint estimate of 3.1 c/car-km is used here. Bray (1995) derived a similar estimate of 3.3 c/car-km (excluding sunk costs of land, service relocation and road base and road network expansion expenditures) averaged across all road vehicles. It should be noted that there is debate, however, over the inclusion of these ongoing costs in short run marginal cost estimates.

Accident costs

The cost of accidents includes vehicle repair, social, health and other economic costs. While motorists pay for some of the cost of accidents indirectly through insurance (including some part of social costs that are awarded through claims on third party insurance), not all costs are covered. Insurance premiums are about $550 per year, ie 3.5 c/car-km. Accident costs which are not covered by insurance considered by Meyrick (1994, in Cox 1994:304) include some hospital costs, the cost of police and emergency services, costs imposed on non-motorists, and uncompensated costs incurred by motorists. These additional costs are 1.25 c/veh-km in urban areas, giving an overall marginal cost of accidents of 4.75 c/veh-km. Given other estimates of similar magnitude (BTCE 1996b:461 and Luk et al, 1994:213), a value of 5.0 c/veh-km is used in the current analysis.

Environmental costs

Given the considerable body of literature on, and variation in estimates of, the value of environmental externalities of transport, the current study has generally adopted typical or average values. Particular use was made of two recent Australasian reviews (Luk and Thoresen 1996, and Ministry of Transport 1996).

Noise: Luk and Thoresen (1996:12) report a range of estimates of the cost of car noise in Australia. A mid-point value of 0.3 c/veh-km was used as the best estimate, with an upper estimate of 0.5 c/veh-km.

Greenhouse gas emissions: Few estimates of the economic cost of greenhouse gas emissions exist. Small and Kazimi (1995:28), using work by Manne and Richels (1992), estimate the marginal cost at US$0.67 per gallon (1992 prices), or 2.9 c/veh-km (1996 prices). Ministry of Transport (1996:72) estimate the greenhouse damage cost of road transport in NZ as NZ$25-580 million (1993 prices), ie 0.1-1.9 (average 1.0) c/veh-km (1996 prices). 2.0 c/veh-km, the approximate average of these estimates, was used as the best estimate, and 2.9 c/veh-km as the upper estimate.

Local air pollution: Local and regional air pollutants include hydrocarbons, nitrogen oxides, carbon monoxide, volatile organic compounds, sulphur dioxide, and particulate matter. Luk and Thoresen (1996:12) report a range of cost estimates with a midpoint of 2.1 c/veh-km. NZ Ministry of Transport (1996:xvi) report a best estimate 140% greater than the cost of greenhouse gas emission, ie 2.4 c/veh-km. A value of 2.0 c/veh-km was used. An upper estimate of 3.6 c/veh-km was based on the Luk and Thoresen range.

Water pollution: Luk and Thoresen (1996:12) report the cost of water pollution as 0.15 c/veh-km. The best estimate in MOT (1996:xxiii) is 0.3 c/veh-km. The former value is used as the best estimate, and the latter as the upper estimate.

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