"Trying to Put the 'Full' in the Full Costs of Transportation"

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Developing measures of the full costs of transportation for various modes and services is an important policy research item in Europe, North America and several other countries. It is one of the major long-term research issues for Transport Canada.

The present paper looks beyond the challenging immediate issues in developing estimates of the full costs of transportation, to identify some of the subsequent issues we expect will arise once reliable measures of full costs are obtained. This is necessarily a speculative paper, posing questions and teasing out some implications more than answering them, but it is important that some of these broader and/or longer term issues begin to be addressed.

This paper only briefly addresses the challenges of assembling the financial costs associated with transportation. We focus on the problem of externalities or circumstances where prices and costs diverge in the economy, and consider the implications for the application and implementation of full cost pricing of transport infrastructure and services.

The paper first addresses a few issues concerning the financial costs of transportation, in particular the relationship between full cost pricing and full cost recovery. A related issue is how to treat costs

borne directly by users (such as travel and waiting time costs) in comparison with the financial costs. Turning to the challenges of incorporating externality costs such as congestion and environmental externalities, the paper considers what categories of externalities are to be included, whether marginal or average costs are being estimated, and what to do about the inevitably wide range of estimates of environmental costs. This leads to some issues of organisation and governance: what issues need to be addressed and what mechanisms or organisations are needed to implement full cost pricing of transport including externalities. For some modes or infrastructure, the market power of operators can affect the level of congestion charges and revenues collected. Still another issue is under the heading of second best policies: the optimality of full cost pricing policies presumes that prices and costs are equal in other sectors of the economy. But usually this is not true. How are efficient prices modified in such circumstances and how will this relate to full cost pricing of transportation?

Measuring the Full Costs of Transportation

The underlying purpose of full cost estimates is to provide directional guidance for policies to promote efficiency in the utilisation and mix of transportation modes. This reflects the basic microeconomic prescription of linking prices to social (marginal) costs to obtain the most efficient allocation of resources. Modes of transport and their use have evolved over time with mixes of public and private involvement, and with some differences in levels of taxation and subsidies. This has caused distortions within modes as well as distortions between modes. The first step is to develop accurate and comparable measures of the full costs of the various modes, i.e., not distorted by differences in taxes or subsidies. This gives rise to many specific issues such as measuring and valuing capital inputs in infrastructure, comparing expenditures at different points in time, etc. Transport Canada (and many previous authors) have addressed these topics, which are not covered in this paper.

To jump ahead a step: measuring the full costs is preliminary to pursuing pricing policies to better reflect the real costs of alternate

modes. This raises an issue of the link between full cost prices and cost recovery. One interpretation of full costs is the average full cost calculated by measuring the total costs associated with a mode divided by traffic volumes. This may be useful for descriptive purposes but it is not necessarily useful as a pricing guideline. If there are decreasing average costs through scale economies then optimal pricing at marginal costs would not result in cost recovery. Given Canada's large geographic area with modest population hence modest traffic volumes in many areas, it is very likely that large portions of the Canadian transportation system would not recover costs under an efficient (marginal cost) pricing regime. On the other hand, where there are rising costs of transportation use (decreasing economies), such as in congested urban areas and high density corridors, it is very possible that marginal cost pricing would generate revenues in excess of transportation outlays in those regions.

The foregoing suggests a research agenda of examining the cost/demand characteristics of various sub-networks, regions or markets in Canada to assess the financial implications of introducing marginal cost pricing policies. Furthermore, it identifies a critical problem in identifying what is the appropriate geostatistical unit for the application of pricing and indeed for the calculation of social costs; is it link, sub-network, urban plus near urban? The choice of where to apply pricing may exacerbate or even solve the under-recovery financial problem. Given the dividing lines of jurisdictional authority for different modes and components of the networks, it also reinforces the necessity for policy analysis of alternative means of implementing and coordinating efficient pricing practices – including for example reform as radical as the proposals by the Canada Transportation Act Review for self-funding agencies for roads and urban transit (CTAR 2001).

Another issue in measuring the full costs of transportation is recognising that some – potentially substantial – costs are borne directly by transportation users and do not involve financial transactions. The obvious example concerns the time costs borne directly by users, whether passengers or freight. In some markets

(urban auto use for example) the monetary equivalent of time costs borne by users may exceed the resources provided through financial transactions. Also important, the size of user-borne costs relative to financial costs will differ across modes and markets. Hence a comparison of the full financial costs associated with the different transport modes and markets would not be revealing the true full costs across the modes and markets. But to do the latter requires measuring the monetary magnitudes of user-borne costs. This is done in some contexts, especially for evaluation of specific infrastructure investments, but it is not necessarily pursued in discussions of optimal pricing policies. It is generally (implicitly) assumed that the marketplace reflects this as differences in qualities of service associated with different modes or markets. This assumption is not correct in congested operations where users impose externality delay costs on one another. Hence researchers do attempt to measure these user-borne costs to be included as an externality cost of transportation (see Boardman, Gillen, Waters and Zhang, 2005).

Incorporating Externality Costs in Full Cost Estimates of Transportation

There has been considerable research to identify and estimate the magnitudes of externality costs of transportation (for example, see. Zhang et al., 2005; ECMT, 1998; and Nash, 2005 who draws on the very large scale European research effort including "UNITE" and "INFRAS"). A concise summary of estimates (in Canadian dollars) and issues was presented at CTRF last year (Boardman, et al., 2005). This paper builds on these previous works – not to update estimates but rather to think ahead on how to make use of such estimates in moving forward on pricing reform for transportation.

Categories of Transport Externalities

There are potentially many categories of externality costs. Most research concentrates on the few largest categories such as congestion delays, vehicle crash externalities, noise, air pollution and greenhouse gases. Zhang et al. (2005) and Boardman, et al. (2005) reviewed cost estimates for the latter major externality categories but also identified (but did not review cost estimates for): water pollution, vibration,

visual intrusion, 'barrier effects', security risks, as well as situations where market prices in other sectors of the economy do not reflect their underlying full marginal costs and transport activities could exacerbate these economic distortions, i.e., 'second-best' issues.

No doubt research will continue in order to refine estimates of the magnitudes of the major externality categories. But there is also the long run issue about what to do about the other, lesser, externality categories. Most likely they can be important in particular contexts or localities, e.g., the impact of vibrations from heavy vehicles, or the community disruption from expansion of infrastructure capacity through established local communities. Can one contemplate imposing Pigouvian taxes say along specific corridors to incorporate externalities of local importance? Presumably yes but this gives rise to a research need to explore various externality categories, estimates of their costs and factors affecting them, and the need for ideas about what mechanisms and/or formulae would be used to specify such taxes.

Alternatives of regulation and pricing

An alternative to Pigovian taxes in those conditions might be a regulation restricting traffic to the optimum. That is in practice often the solution chosen by governments, and indeed there is a large body of rules and regulations on land use practices and traffic control, which are practical solutions to the implementation of expressed collective or community opinions. In concept, such rules and regulations could be based on the same economic reasoning as is marginal social cost pricing. If it is possible to recognise the community's monetary valuation of the harmful external effects of traffic, and also to predict the costs of measures to restrict traffic, restrictions could be imposed up to the point at which the marginal benefit just exceeds the marginal cost; the use of standards rather than effluent charges to control water pollution is a good example of this point. This presupposes a knowledge and foresight of the valuations and cost conditions that is very unlikely in practice (though those same valuations and cost conditions would have to be known to set Pigouvian prices). But even approximate cost-benefit analysis might

still be able to show with confidence that some forms of land-use or traffic regulations are justified on grounds of reducing externalities – just as the marginal social cost pricing rules are justified. And such regulations would be compatible with pricing remaining externalities. Indeed, it is the case that transport externalities of all kinds are regulated substantially at present – as well as land-use and traffic rules, regulation of vehicles and operators is common for safety, emissions and noise – and any proposed marginal cost pricing rule would in fact be pricing the remaining externality costs, after the regulations have had their effects. Whether existing regulations are efficient alternatives to pricing is a subject for discussion and research, and reconsideration of the government processes for assessing proposed regulations.

Issues in Determining Externality Tax Levels

Looking at implementation issues, one challenge to be faced is how to arrive at specific proposals for environmental taxes to be levied to make various transport modes and services better reflect true marginal social costs. While we hope that accuracy of cost estimates will improve with time, it is very likely that there will continue to be potentially large differences in estimates of various externality costs. The question arises: what would be an appropriate level of a Pigouvian tax when there is substantial uncertainty about the magnitude of the externality cost? And how might we resolve such an issue?

Faced with a wide range of estimates from different research studies of an externality cost category, what specific value should be chosen to adjust transport prices? A mean or median valuation is a candidate, but note that these will change as research continues and additional estimates are always forthcoming. In calculating a mean, would one give equal weight to all research studies or put higher weight on those deemed to be more reliable? Also, there might be an upward bias in the average as the number of studies increase. Estimates of environmental costs have a higher upside than downside. More studies may produce both higher and lower new estimates, but being unbounded in an upward direction will tend to raise the

calculated average. Perhaps some measure below the mean might be advocated, especially since one would be introducing a charge where none exists at present. Is it appropriate to error in a downward direction in imposing a new tax? This would be a cautious approach, although it ignores the question of how much below a mean estimate one should adopt. It does draw attention to the importance of understanding the sources of error. Differences in the estimates occur for a number of reasons and we need to better understand the source of much of the variation using, for example, a meta-analysis. The problem also is that the estimates are not estimates of the same things, but differ in specifications, and may also differ fundamentally in methodologies. One example is that stated preference (SP) estimates have been shown to be systematically higher than revealed preference (RP) estimates. Nonetheless, we are accepting more and more SP studies into valuation studies as they are so much easier to carry out and they provide estimates of issues that are not available via RP data. A real problem is the difficulty of discriminating between valid and invalid studies. And even if this is solved, while we have methods to combine results of the same thing statistically, combining estimates of different things and/or estimates using different methods is difficult, requiring some basis for weighting the various studies. Finally, the relative modal price level and mix is of great importance since it matters how sensitive the marketplace is to any new tax.

Organizational and Financial Issues with Externality Taxes

What mechanisms or organisational structures might help resolve these questions? Are they to be purely an outcome of a political process? At present it will most likely be a recommendation forthcoming by a government department such as Transport Canada to the Government of the day (or the provincial equivalent). A more neutral organisational structure might be an independent commission who would compile and review evidence, and bring for recommendations for Parliament or provincial legislatures. Such a commission could be headed either by appointed experts or more or less random appointments of citizens to reflect diverse backgrounds of citizens. As scientist it is our job to identify trade-offs and costs and benefits but these costs and benefits are not purely objective;

communities can decide what they deem as an acceptable level of pollution or congestion, as an example, the value of Canada's Kyoto target is not a product of scientific inquiry.

Another set of issues concern the financial implications of the introduction of externality-based Pigouvian taxes? The economic rationale for externality-based taxes is to improve efficiency in resource use within transportation as well as by transportation users. That is, behavioural responses are the goal. But introduction of such taxes will be accompanied by tax revenues. In principle, such taxes are not necessarily intended to produce a financial windfall to the government overseeing the environmental charges. Indeed, people can be highly suspicious that such efficient pricing proposals are really pursued as a "tax grab." In some cases this might be deliberate, but it is possible that there would be far less resistance to externality taxes if they were to be implemented in a revenue-neutral fashion, i.e., their introduction would be accompanied by reductions in other taxes to result in no net change in overall government revenues. For example, implementation of road pricing could be accompanied by reduction or even elimination of fuel taxes. Air pollution taxes might be accompanied by reductions in income and/or property taxes. Hence, an important research agenda is to explore revenue-neutral tax adjustments to accompany proposals to implement transport externality taxes. An obvious complication here is that existing and prospective charges could be associated with different levels of government. Congestion taxes would be levied in an urban region, but the fuel taxes are collected by the Province *and* the Federal Government. This raises numerous complications of jurisdiction and governance structures.

There is the slightly broader issue of how to combine and coordinate new charges for the marginal costs of infrastructure (e.g. axle-weight-distance charges) with those for externalities. Presumably the former should go to infrastructure construction and expansion. The congestion externality components might be used for infrastructure expansion so as to reduce users' congestion costs as well, but rising marginal congestion costs might result in revenues in excess of

investment requirements. In that case, base-level infrastructure charge might be reduced so that it is coordinated with the congestion tolls. And the emission, noise, accident externality components might legitimately be used to compensate those affected, or just used for anything else, if the affected population is indistinguishable from the whole population. In brief, there are financial accounting issues in addition to the behavioural modification and efficiency goals associated with full marginal social cost pricing.

Full Cost Pricing and Full Cost Recovery when Carriers have Market Power

The economic literature has advocated congestion pricing because it will make the use of scarce resources at a congested transport infrastructure (road, airport, port, etc.) socially efficient, in the sense that the user will pay the full cost of his consumption of the services provided by the infrastructure. The resulting congestion toll would thus curtail demand and help relieve congestion.

However, if the infrastructure is used by only one carrier or a few oligopolistic carriers, although the additional delay costs imposed by one vehicle/flight are external to that vehicle/flight, these costs would become internal to the company if other vehicles/flights also belong to the same carrier. If so, the carrier will internalize these costs and raise prices to reflect the congestion costs. Concerning airports, several papers have recently considered whether airlines with large shares of airport traffic face incentives to internalize congestion costs (e.g., Daniel 1995, Brueckner 2002, Pels and Verhoef 2004, Basso 2005). Brueckner (2002) showed that the standard rule of congestion pricing only applies to an airport servicing competitive (atomistic) carriers and that there is no room left for the airport to levy congestion tolls if all the flights belong to a single carrier (the monopolist), or only partial room if some flights belong to the same carrier (the oligopolists). This implies that carriers themselves will be effective in curtailing excess demand by making their passengers pay the social congestion cost, fully so for a monopolist and partially so for oligopolists.

These studies on airport pricing and congestion with non-atomistic carriers have also raised a new issue regarding capacity financing at airports. Apart from demand management, congestion tolls may also serve a second purpose, namely providing funds to finance capacity expansion by an airport. Literature on congestion pricing and airport capacity financing is extensive. However, almost all of the existing literature assumes, explicitly or implicitly, that the airport is served by competitive (atomistic) carriers. If carriers have market power at a congested airport and therefore are able to internalize congestion costs, the airport may lose all or part of congestion tolls to the airlines and hence the funds to finance its capacity expansion. Zhang and Zhang (2006) investigate the relation between the optimal transport infrastructure cost and the revenues from optimal congestion pricing, recognizing that transportation carriers may have market power and therefore internalize part of the congestion externality. The self-internalization of congestion costs calls for a downward adjustment of the airport congestion charge compared to the conventional "full cost" charge based on marginal external congestion costs. Under atomistic competition, revenues from the conventional congestion charge – under certain conditions – would exactly cover the capacity cost at the optimal level of capacity (see, e.g., Mohring and Harwitz 1962, Mohring 1970, 1976, Morrison 1983). However, airport congestion charging under imperfect competition yields revenues that fall short of the optimal capacity cost, and thus resulting in a *financial deficit* for the public infrastructure (Brueckner 2002, Zhang and Zhang 2006).

Second Best Pricing Policies

A persistent nagging issue in applying welfare economic principles is the problem of 'second best.' One of the basic tenets of microeconomic policy is the importance of prices reflecting costs to foster an efficient allocation of resources. This recommendation is derived from a model that assumes that elsewhere in the economy there is efficient (marginal cost) pricing.

But what if prices do not equal costs in many sectors of an economy? Do the policy principles of marginal cost pricing still apply where it is possible to do so? To be more specific, is full-cost pricing of

transport services the optimal policy in a world with various price/cost distortions?

Lipsey and Lancaster (1956) formally investigated the second best problem. Mathematically, in an idealized competitive market economy, they introduce a constraint to set one or more prices to deviate from marginal costs and then solve for the optimal conditions for prices. It turns out that marginal cost pricing is not necessarily the optimal policy. Unfortunately, the optimizing conditions are complex, requiring extensive knowledge of all the relevant costs and elasticities.

There are some pragmatic although complex guidelines for optimal second best pricing (e.g., Turvey, 1974). The optimal deviation of a particular sector's price from its marginal costs depends on (1) the size and direction of price/cost divergences in other sectors of the economy, and (2) the cross-elasticity of demand between the sector being priced and the other sectors of the economy. For example, if a substitute sector has a price below costs, the second best policy calls for price to be set below marginal costs although the exact divergence of price from marginal costs depends on the aggregate of price/cost divergences and cross-elasticities of all interrelated sectors. A potential example is the common practice of subsidizing public transit to combat peak auto travel. The first best policy would be to introduce congestion pricing on auto use. But given the inability or unwillingness of governments to impose unpopular congestion taxes, a second best policy is to subsidize urban transit to at least partially counter the effect of an uneconomically low price of auto use.

Another example is the subsidization of public airports when there is market power at the airline level. The first best policy would be to make the airline market competitive and then impose the social marginal cost charge. Given the presence of market power by carriers, however, the monopolistic mark-up calls for a downward adjustment of the second-best charge, compared to the conventional social marginal cost charge. The latter charge would be 'third-best' under conditions of market power.

There are troublesome features of second best policies. The complexity of accurate calculations is one. Another is that it involves accepting the other distortions from first-best policies rather than working to correct them. Third, second best pricing is a piecemeal approach, pricing one sector given the price structure of other sectors. But over time many sectors could be evaluated and reformed. This raises how to coordinate a sequence of second best pricing policies.

In sum, recognising the second best problem weakens the rationale for full cost pricing in transport, although more accurately, it calls for a more complex calculation of optimal prices taking explicitly into account the price/cost relationships and substitutability for other modes as well as other sectors of the economy. Second but related: in additional to identifying the extent to which environmental concerns result in market prices not reflecting true costs, we also have to also investigate the extent to which there are any manners of price/cost divergences in various sectors of the economy, not just those associated with externalities. An already formidable task is made all the more ambitious and difficult.

Conclusion

It is easy to be overwhelmed with the many complications and challenges in developing measures of the full costs of transport and how they would influence transport pricing. First of all are the financial and accounting issues in determining the relevant measure of the financial outlays associated with infrastructure costs including measuring capital costs and cost assignment among multiple users. Then there are the even more tenuous estimates of environmental and other externality costs and how to interpret them: are they marginal or average cost estimates, do they vary substantially from place to place, which level of government would implement them and rebalance overall tax revenues?

There are important conclusions that transcend the myriad of difficulties of measurement and implementation. The key point is that full cost measurement is a needed and crucial first step. The

external costs of transport are real, even if difficult to measure. And they likely differ among modes and regions. "Making the best use of all modes of transport at lowest total costs…" should include externality costs it also implies the resultant charges emerge from an optimization model.

Measures of externality costs do exist and have been reviewed by various groups. Considerable uncertainty remains, but there are sufficient estimates to be exploring the next step of what type and level of charges (or regulations) would be appropriate to improve efficiency both within and among the transport modes. These explorations need to be accompanied by studies of the implications for overall tax revenues and sharing among levels of government, including governance and accountability structures. Finally, progress can be made on second best implications. It is possible to identify price/cost differences among modes and the sectors that are substitutes or complements to the various modes. This would shed light on the extent to which full cost pricing is appropriate given the constellation of price/cost differences that exist in the economy.

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