ADDRESSING ALLOCATION ISSUES IN THE FULL-COST INVESTIGATION (FCI) OF TRANSPORTATION

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INTRODUCTION

Transport Canada has launched a project aimed at producing estimates of the "full costs" of transportation in Canada. It is a three-year project steered by a federal-provincial Task Force. "Full costs" include 'financial' and 'social' costs. By the end of 2006, estimates of both financial and social costs will have been produced for transportation infrastructures and activities for all modes within the borders of Canada in the year 2000. This information could constitute a powerful analytical tool for policy makers and transportation analysts, in particular in comparing modes.

The cost estimates will differentiate between freight and passenger transportation. Because these two activities often share the same infrastructures and sometimes the same vehicles, this raises the need for allocating common costs[2]. Allocating common costs has particular importance in the FCI because of the large share of common costs in transportation. This paper presents potential allocation methods for each mode and their rationale in the context of the FCI[3].

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[1] Views expressed in this paper benefited from numerous exchanges between the author and the Transport Canada FCI team and the provincial FCI Task Force members. However, these views do not necessarily reflect those of either Transport Canada or the FCI Task Force.
[2] For an overview of the economics of common costs see Kahn [1993]
[3] Some aggregated statistics have to be allocated by components and these allocations are also mentioned in this paper

FCI FIVE PHASES

The FCI has five phases[4] and allocation issues appear in each of them.

Phase 1: Financial costs and revenues for infrastructures and operators are estimated at the national level for the four major modes (road, rail, air and marine)

Phase 2: Financial costs and revenues for infrastructures and operators are estimated at the provincial and territorial level for the four major modes

Phase 3: Allocating infrastructure costs which have factored in network characteristics of each mode by vehicle/craft, passenger/freight and network characteristics

Phase 4: Estimating, valuing in money terms, and allocating the social costs generated by transportation activities

Phase 5: Allocating and comparing marginal costs of representative modal transportation freight and passenger activities

APPLICATION COUNTS

The first element that influences the choice of an allocating methodology is the final application of the costs allocation. A review of applied methodologies helped to identify three types of application that impact that choice:

1. Allocating for actual pricing to fund current and future supply often considers past costs as sunk and ignores them and rather focuses on balancing future revenues with costs[5]
2. Allocating costs for actual pricing to manage demand often focuses on marginal costs (including social), especially

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[4] See Transport Canada [2005] on www.tc.gc.ca/pol

[5] See US FHWA Office of Transportation Policy Studies [1997] or Australian NTA [2005]

congestion and air quality, to improve transportation efficiency, including modal choice[6]
3. Full-cost investigation should allocate all costs, even some past costs, to year 2000 users

When cost allocation leads to actual pricing, the pricing process has to factor in demand-price elasticities in order to forecast costs and revenues realistically. This is not required for the FCI.

THREE PRINCIPLES

The choice of the allocation methodologies for the FCI should be based on principles, which enhance their acceptability. Three principles appear to be important.

Equity

Some common costs are variable. Others are fixed costs but they could be linked to a sub-set of users. Both of these costs are attributable costs and have to be allocated to what cause the costs. This should be based on well-documented causal functions with measurable allocation factors to respect the first principle: equity.

The residual costs that are not attributable have to be allocated with fairness. In such a case, the method could use a more general allocation factor. In any case, there will be a degree of arbitrariness in the choice of allocation methodology of the non-attributable costs.

Efficiency

Economists support pricing at a level equal to marginal cost in order to maximize economic efficiency. The price paid by a user for an additional unit should be equal to the cost of supplying it. To achieve this when fixed and non-attributable costs are important, as well as ensuring a balance between costs and revenues, it is appropriate to apply a two-part tariff with a variable component equals to marginal cost and a fixed component to balance total revenue and total cost. Since the allocation for the FCI does not aim at pricing, this should not

[6] See Sansom *et al.* [2000] on European UNITE project

be an important consideration.

The element of efficiency that is more relevant is to ensure that measurement, administrative, and implementation costs of the allocation are reasonable. Since excessive precision could be expensive, the choice of methodology has to take into account data availability on cost details and allocation factors, or data gathering costs if data are not yet available.

Even if it is not required for the FCI, considering of the demand price-elasticity by using Ramsey pricing[7], for instance, is acceptable, especially when allocating costs is actually applied to pricing. This could be the case at the last phase of the FCI when specific shipments by competitive modes would be compared in phase 5 of the FCI.

Applicability

The third principle is essential to the success of implementing the allocation methodology: applicability. The causal links between activity and costs that are driven by the equity principle have to be measurable. In order words, before finalizing the choice of a methodology, one has to ensure that relevant data on costs, as well as on activities, are available at the right level of detail to be able to implement the methodology chosen.

PROPOSED GENERAL APPROACH

For each mode and each element of common costs, the assessment of attributable share, the definition of the causal link and the identification of an available and relevant activity measure for allocating attributable costs would have to be completed. In case of uncertainty regarding causal links, assessment could be completed by sensitivity analyses[8].

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[7] The Ramsey pricing takes into account the demand price elasticities to reduce the impact of pricing on quantity demanded when economy of scale or economy of scope are present and justify such an approach

[8] One option could be applying a Monte Carlo technique to reduce the range of results

The non-attributable share of costs (the residual costs) could be allocated based on a more general measure of activity or capacity. Since they are not part of the marginal costs, they could be ignored in some pricing applications, but they have to be allocated for the FCI.

If allocation were needed at further degrees of detail, by commodity for instance, it would be possible to use other allocation methods such as Ramsey pricing, especially if it is an actual practice by the industry.

A fictional example could help to understand how this would work. Let us assume that the assessment is for the cost of road wear on a coarse grain soil freeway in a specific region. According to Doré *et al.* [2005], traffic is responsible for 80% of the damage on that class of road and thus of tied traffic related costs of road maintenance and rehabilitation. An allocation factor for traffic damage costs is the Equivalent Standard Axial Load (ESAL[9]) –km. Activity data shows that trucking represents X% of ESAL-km in a specific region, buses Y% and cars Z% on this class of road. The share of non-attributable costs is thus 20% of the damage and they are not linked to traffic *per se* (they are "residual"). Let us further assuming that the Passenger Car Equivalent (PCE)[10]-km is an appropriate general measure of activity for road and that activity data shows that trucking represents A% of PCE-km in that specific region on this class of road, buses B% and cars C%. Therefore trucking's share of road wear costs on a coarse grain soil freeway in that region = (0.8 × X% + 0.2 × A%) × cost of freeway wearing in that specific region.

This allocation process would have to be applied for each cost element estimated to complete the allocation in phase 3 of the FCI.

[9] The ESAL is a relative measure of the impact of one vehicle on the road based on the power 4 of the ratio of its axel weight divided by a reference axel weight (18 000 pounds = 18 kips).

[10] PCE could be a complex index of space needed by each vehicle on the road, or simply the vehicle length divided by 4.8 m.

PROPOSED APPROACH BY FCI PHASE

The rest of the paper presents for each phase of the FCI how allocation issues could be addressed.

Allocation in Phase 1

The allocation in phase 1 is limited to two types of elements. First, the non-transportation share of some common costs could be excluded and allocated to other activities. For instance, some coast guard ice breaking, research and rescue costs are linked to fisheries or coast protection. Second, infrastructures built to accommodate more than one mode. In such a case, all costs could be allocated to the main mode according to their financial records. Examples include some bridges, rail crossings, and multimodal stations.

Allocation in Phase 2

For some elements of the transportation systems provincial/ territorial statistics on their costs are not available. Hence, relevant national totals would be allocated by province based on provincial indicators of activities, capacities or aggregated costs (that contain non-transportation elements). This appears to be needed for the following:

- Road capital expenditures series if based on the Perpetual Inventory Method but this would change with the Equivalent Uniform Annualized Cost approach
- Several road operating costs and revenues
- Railways class 1 and some class 2 costs and revenues
- Air carriers costs and revenues
- St. Lawrence Seaway

Allocation in Phase 3

The allocation in phase 3 could be different for each mode either because of causal links are different or because data were not available at the same level of detail. Despite these differences, all efforts should be given to ensure the best comparison among modes.

All modes would follow the same model:
1) Definition of cost element
2) Choice of one or two allocation factors based on causal link

Road Cost Allocation

Road cost allocation has been the subject of many studies that are relevant to the FCI even if they often focus on pricing. The proposed allocation causal links and allocation factors are based on the review of United Kingdom's DoT [1993], nine European applications reviewed by Link *et al*. [1999], US FHWA [1997], the Australian National Transportation Agency [2005] and Nix *et al*. [1991] for Canada.

Transport Canada contracted a study entitled "Estimation of the Representative Annualized Capital and Maintenance Costs of Roads by Functional Classes" [March 2006] that shows that the Equivalent Uniform Annualized Cost (EUAC) of roads varies significantly by region (14 regions) and road class (14 classes of road).

Another contracted study completed by Doré *et al*. [2005] shows that road wear due to traffic varies also by soil type.

Road Deterioration due to Traffic				
Highway Classification	Fine Grained Soil			Coarse
	Wet freeze		Dry freeze	Average Conditions
	High Frost	Low Frost	High Frost	
Major HWY	65%	70%	50%	80%
Other HWY	60%	65%	45%	70%
Local Roads	55%	60%	45%	60%
Municipal Roads	55%	60%	45%	60%

Source: Doré *et al.* [2005]

The EUAC study provides several elements of road cost for which causal links could be defined and tied to allocation factors. Road activity will be measured using traffic profile and activity information from different sources including the existing Weight-in-Motion (WIM) devices, other provincial and municipal data, and the Canadian Vehicle Survey.

Retained road cost elements and their tied allocation factors are:

Non-recurrent initial building costs are subdivided into two categories, a basic set of expenses for all users (allocated by PCE-km) and an additional set of expenses to accommodate heavy vehicles (allocated by ESAL-km). The relative importance of these two sets of elements would have to be determined by engineering experts under a specific contract.

Recurrent initial building costs, as well as maintenance costs linked to road wear due to traffic, are calculated based on Doré *et al.*'s table (allocated by ESAL-km). Residual road wear costs are allocated with a general allocation factor (PCE-km).

Bridge costs would simply be amalgamated with the other road costs and allocated as the other elements because refining the allocation method by using the gross weight of the vehicle would be costly given the relative importance of this item (about 5% of the total network costs).

Regular and winter maintenance costs could be allocated using a general allocation factor (PCE-km) while enforcement costs could be allocated by vehicle-km.

Rail Cost Allocation

As for the road, the main allocation issue for rail is the allocation of infrastructure costs between freight and passenger services. The allocation would start by distinguishing the network used only by freight trains from the network also used by passenger trains. Only costs tied to the mixed traffic sub-network would be allocated between freight and passenger. Implemented allocation methods, in particular in Europe[11], have limited usefulness for the FCI because of the importance of subsidies in many of these countries. However, the United Kingdom allocation formula is instructive. In his review of European cost allocation methods, Nash [2005] corroborates the assumption that the higher speed of lighter passenger trains compensates the greater gross weight of freight trains and that justifies

[11] Ferrovie dello Stato (Italy) [2001] and Nash [2005]

the direct use of the gross weight ratio rather than a power of it, as is the case for road vehicles.

Rail cost elements retained and their allocation factors are the following:

- Infrastructure costs (Gross ton-km or revenue)
- Regular and winter maintenance, security enforcement (car-km)
- Some class 2 train operating costs (revenue)
- The allocation of rail costs, examining potential refinements such as train stations (passenger) and switching/marshalling yard costs (net tonne-km).

Air Cost Allocation

The air cost structure is broken down on very detailed sets of costs for the national airport system (26 airports) and some aggregate statistics for the others. Forsyth [2005] shows the relevance of a step-wise allocation process[12] for airports, in particular for airside assets. Europe Economics [2001] mentioned the natural lack of constraint for fixing the airport tariffs. In this context, it is not surprising that the US FAA envisaged applying a Ramsey pricing approach to its air traffic control activities[13].

Elements retained of the air costs and their respective allocation factors would be the following:

- Building, airports terminals (passenger and perhaps tonnage for cargo)
- Airside assets (e.g., runways) (gross tonnage-landing)
- Operating costs (passenger-km, tonne-km[14])
- Air traffic control (aircraft-km)

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[12] A step-wise allocation distinguishes costs by group of users. Elements used by all are allocated to all users; additional elements used by a sub-set of users are allocated to that sub-set of users, following an incremental process.

[13] See US GAO document GAO/RCED-97-106 [1997]

[14] Freight being generally considered as complementary activity to passenger air transportation, only incremental costs would be allocated to freight

Marine Cost Allocation

The marine cost structure is defined using a very detailed sets of costs for the national port system (19 ports) and some aggregated statistics for the others. Potential marine cost elements and linked allocation factors would be the following:

- Ports (terminal, handling) (tonne of freight)
- St. Lawrence Seaway (ship per section)
- Winter maintenance (ship-km in winter)
- Marine traffic control (ship-km)
- Pilotage (ship-km in relevant zone)

Allocation in Phase 4

Social costs need to be allocated on the basis of the relationships between activities-damages-costs. Social costs that are to be factored in the FCI include the ones associated with accidents, delays due to congestion, air pollution (including greenhouse gas emissions) as well as noise.

Accidents generate costs that are already internalized by users through, for examples, insurance payments and repair expenses. In accounting the accident costs, the FCI would have to ensure that no cost would be counted more than once. Allocating cost between 'normal maintenance' and 'repairs due to accidents' could represent an unsolvable issue given available statistics.

Most accidents involve only one group of users and the allocation would then be straightforward. For instance, 86% of the 2927 fatalities due to road accidents in the year 2000 involved passenger light vehicles only. The cost of these accidents would be allocated to the light vehicles users without uncertainty. Costs would be further allocated by province, and class of road using available accident data on road speed limits, rural/urban distinction, etc. In other cases, where accidents involved two different groups of users (e.g., rail and road (33 deaths) or truck and passenger car (13% of fatal road accidents had trucks involved)) some data and studies on drivers' behaviour could be used to allocate costs among the different groups by the proportion of those at fault in each group.

Congestion delays have yet to be assessed for all modes and it is possible that they could be the subject of only rough estimates. For the nine major cities urban road network, a recent study assessed the value of these delays and it will constitute the main source of information. The FCI would have to ensure also that no congestion cost would be counted more than once. For instance, it is likely that recurrent congestion is already taken into account in the definition of freight tariffs and therefore they should not be added to already accounted operating costs or for-hire carriers' revenues. These costs would have to be allocated with precision to ensure accuracy of modal comparison in phase 5.

Transportation is only one source of pollutant emissions. According to Environment Canada's National Pollutant Release Inventory[15], transportation activities in the year 2000 were the source of 0.2% of PM, 0.7% of PM_{10}, 2.9% of $PM_{2.5}$, 2.8% of SO_2, 43.3% of NOx, 15.6% of COV, 51.6% of CO, and 26% of greenhouse gases in CO_2 equivalent at the national level with some variance by province and region. The valuation process of these emissions that has to be linked to pollutant concentration, environmental and health impacts. The valuation of these impacts would have to assume either an average impact or a marginal one. This choice could represent an implicit allocation if the impacts were not constant per unit of emission. Moreover, since important elements of valuation, such as population density, differ from one area to another, the cost allocation in phase 4 will have to take these differences into account. Valuation of noise impact is also linked to the relative importance of the population exposed to the noise near transportation activities.

Allocation in Phase 5

FCI phase 5 compares different modes for representative shipments and trips. Therefore, further allocations would be needed to take into account the typical vehicle involved (e.g., bulk vs. containers), and the specific conditions of the trips (e.g., with or without backhaul, level of

[15] See: http://www.ec.gc.ca/pdb/cac/cac_home_e.cfm

occupancy)[16]. As for the other phases of the FCI, the causal links would have to be assessed and allocation factors would have to be measured and used for the allocation.

It is in the phase 5 that Ramsey pricing could be implemented in some cases to reflect actual pricing practices in the industry. Joint cost allocation, such as empty return, would also have to be factored in this last phase of the FCI.

CONCLUSION

Allocation of costs and revenues is crucial to complete the Full Cost Investigation. A sound allocation methodology needs to be based on principles of equity, efficiency and applicability to enhance the acceptability of findings to emanate from the FCI. Allocation of costs should start by defining and measuring causal links for attributable costs. Allocation methods for each mode could be different but differences should not be significant enough as to compromise the comparison between modes. Differences could be imposed by data availability or causal link differences.

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[16] See Rietveld *et al.* [2001]

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