

# Recent Advances in Highway Cost Allocation Analysis

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A wide range of proposals has been advanced over the last two decades to deal with the general problem of cost allocation, but highway cost-allocation practice has stuck to a relatively narrow framework of equity. The choice at the present time is whether to continue to treat highways as a tax-supported public service or to recognize that the highway system is a major economic enterprise. Recent policy shifts in transportation and in other sectors strongly suggest that highway user charges be designed explicitly to meet efficiency as well as equity objectives.

Highway cost allocation has been confronted in the past as a problem of how to raise revenues from selected groups of taxpayers so as to meet a given budget in a fair and equitable manner (1). Economists have urged that the problem be viewed as one of pricing highway services in order to achieve efficient use of scarce resources (2-6), but this perspective has never explicitly been put into practice. Current efforts seek to integrate the two approaches in a way that will preserve the best of both (7-9).

## CRITERIA FOR SELECTING AMONG USER-CHARGE STRUCTURES

Normative standards against which to evaluate user-charge instruments and rates are fundamentally two: efficiency and equity (10,11). A third criterion can be the effectiveness with which stated goals are achieved, but the goals themselves usually relate to selected aspects of efficiency or equity.

### Efficiency

Although efficiency is not mentioned in the congressional mandate (Surface Transportation Assistance Act of 1978, Sections 506 and 507) for the federal highway cost-allocation study now under way, efficiency considerations are strongly implied. The notion that vehicles should pay for the costs they occasion is described as equitable, but it is also efficient that they do so because it encourages them to reduce these costs and make sure that the benefits they derive are greater than the costs created.

Short-run efficiency assumes a given set of capital facilities and seeks ways to secure the best possible utilization of those facilities. The theoretical mechanism for this optimization is pricing--interpreting the concept of a price broadly to include such factors as travel time and risk of accident, as well as user charges. Highway-user charges are the most direct means for achieving short-run efficiency with respect to the highway system.

Long-run efficiency deals with finding the best program of investment in fixed facilities while also satisfying the short-run efficiency criterion. Analytically, the path to long-run efficiency is followed by first comparing the incremental costs and benefits of alternative projects and then investing (or disinvesting) in the appropriate links of the highway network. Although user charges inevitably have an influence on the actual pattern of maintenance and investment, the theoretical linkages are indirect.

### Equity

The concern addressed by equity is the distribution of costs and benefits among groups within society. In contrast to efficiency, equity is a term that is

frequently mentioned, yet one that provides very little positive guidance. It is essential that the redistributive impacts of alternative user-charge schemes be thoroughly illuminated, and the imposition of equity constraints on efficiency solutions will be necessary both analytically and politically; however, there is no hard and fast way to assert that some user charges are equitable and others inequitable. Equity is inherently a matter of political choice, although technical analysis can contribute to the political debate by formulating equity constraints and displaying their consequences. For example, the requirement that users pay the full costs (or some prespecified share) is an equity constraint.

Horizontal equity is most directly related to popular ideas of fairness; it urges that equals be treated equally. Vehicles in equal circumstances--from the standpoint of the highway provider--should be charged equally; however, there may be instances in which price discrimination is useful for achieving other efficiency and equity objectives. Vertical equity describes the distribution of net gains among income classes, a factor of major concern but one on which highway-user charges have only a minor impact. Equity impacts are of prime interest in designing user charges, but equity objectives only make sense in conjunction with efficiency objectives.

## THE NEED FOR AN IMPROVED FRAMEWORK

Earlier studies have agreed that some share of highway costs should be borne by users, that using "cost-occasioned" distribution is a fair way to allocate costs among users, that the amount of cost occasioned by a vehicle class can be determined by disaggregating items of expenditure and assigning them to vehicle classes, and that equity lies in the method for allocation rather than in the distribution of the tax burden it produces. An algorithm known as the incremental cost method has been popular in recent studies, but there is very little professional consensus on which are the best methods for the practical determination of highway-user cost responsibilities. The incremental cost method takes as its starting point a basic highway, usually one designed for automobiles alone. Additional classes of vehicles cause additional increments of cost, and these increments are apportioned among the members of each class.

A thorough exposition of these concepts and others that have been considered at some point for use in highway cost-allocation analysis would be an enormous and not very rewarding task. Without exception, the methods are ad hoc and unsupported by theory. Unfortunately, there is no pragmatic test for these methods that would tend to select the workable ideas from the mistaken ones, so the absence of theory is a serious handicap to improvement. Without an attempt to criticize previous efforts, some arguments can be offered for rethinking the overall framework within which highway-user-charge analysis is conducted.

1. Efficiency should be explicitly recognized: It has already been noted that payments in accordance with costs occasioned can be consistent with an efficiency goal. Many other policies that relate to highway transportation, e.g., reduction in

fuel consumption, deregulation of trucking to encourage competition, and the cost-benefit evaluation of highway investment projects, imply an efficiency orientation. Failure to incorporate efficiency concerns on the pricing side seems pointlessly myopic.

2. Equity is too ambiguous: Fairness, or equity, even when applied as rigorously as possible, is a criterion that relies very heavily on value judgments and leaves a great deal of room for discretion. The costs of climbing lanes, for example, can be assigned to light vehicles or to heavy ones, depending on whether the starting point for analysis is taken to be an automobile or truck highway. Fairness can be resolved politically in such a manner, but planners should recognize that a pure equity approach does not lead to technically stable answers. Much of the previous highway cost-allocation work reveals the underlying ambiguity by drifting superficially over numerous alternative concepts or by being inflexibly arbitrary.

3. Intermodal policy should be consistent: Deregulation is proceeding in the airline and railroad industries; minimal user charges have been initiated for inland waterways. In all of these actions, intermodal price competition was an important concern. Electric power, telephone, postal service, and intercity bus enterprises face similar types of problems, and there is no reason for highway policy to stand out as incompatible with the concepts used in analogous industries. Whatever policy direction is taken next, private transportation modes and publicly owned modes should be priced comparably and treated analytically as similar sorts of beasts.

#### DESIGN OF A HIGHWAY COST-ALLOCATION STUDY

Although precise methods and techniques are still incomplete, the outline of a reasonably robust conceptual framework can be presented at this time. The problem of federal user charges will be taken as a prototype, the same framework being also applicable to state user-charge studies. Much of the knowledge gained from previous cost-allocation studies, as well as parallel work in related fields, will prove to be useful, but there are also many areas in need of further development. In the following, the cost-assignment problem rather than the selection of user-charge instruments will be emphasized, in part because the choice of instruments depends on empirical and pragmatic matters that are too detailed for general treatment.

An outline of the problem (Figure 1) indicates the major tasks to be accomplished. Costs should be broken into (a) variable and (b) fixed, variable costs being those on which variable user charges (e.g., fuel tax, weight-distance fees) are based. If these charges do not raise sufficient revenues to cover costs, then a residual will remain that can be met from access charges (e.g., registration fees) or general revenues (e.g., property taxes). Because practical realities will force many compromises, both the prices and the assignment of residual costs will need to be evaluated (in the form of a number of alternatives) against efficiency and equity criteria. Once a workable set of user charges has been constructed, the federal portions of these charges can be broken out and matched against the budget.

#### Total Costs

In general, expenditures and costs are not the same thing. Even if expenditures represent the social value of the particular resources covered by the expenditure, many costs do not appear as expenditures. Some examples are (a) exemption from paying a tax and (b) no interest charged on capital funds. In

addition to capital and maintenance expenditures, the following costs should be tabulated.

1. Hidden costs: Some costs appear in public budgets but not in the budget of the agency responsible for highway expenditures. Vehicle code enforcement and traffic control may be hidden in police budgets, electricity consumption may be buried in a utility budget, and payroll administration may be centralized rather than included in the transportation agency budget.

2. Negative externalities: Negative externalities in the form of air pollution, noise, water pollution, and other unpriced effects on the physical, natural, and human environment constitute real costs to society. Even though we may never be able to place accurate dollar values on these costs, present policies can be (and are being) improved on by a recognition of such costs.

3. Interference costs: Private costs in the form of delay time, vehicle wear, fuel, and accidents are relevant to the correct pricing of highway services. These relationships will be explained below.

4. Tax expenditures: Exemption of fuel from general sales taxes and exemption of highway property from local property taxes result in a favorable treatment of highways in comparison with other activities that are not exempt. To the extent that these taxes pay for general government services (as opposed to income transfers), highway users are being subsidized by those engaged in other activities.

5. Interest forgone: The pay-as-you-go philosophy, in which each year's expenditures are matched with the same year's revenues, hides the fact that invested capital has an opportunity cost represented by the rate of return (i.e., interest) that the money would earn in another activity. Money spent from the Highway Trust Fund does, in fact, lose the interest it would be earning if left in the fund.

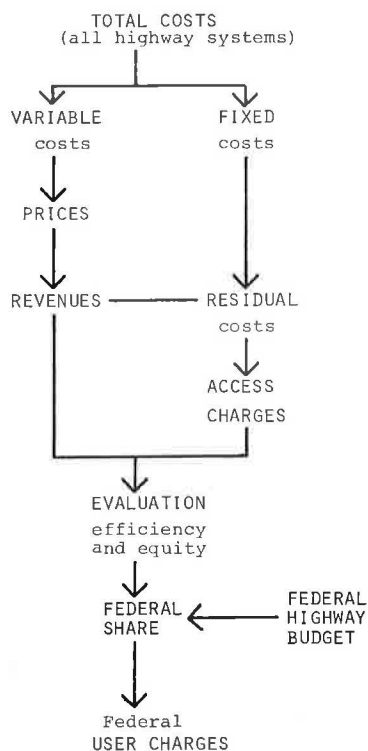
#### Prices

Theory tells us that the price charged for use of the highway should be equal to the (short-run) marginal use cost. If less is charged, the user may not value the use as much as society values the resources used up; if more is charged, some potential users are deterred, even though they would gain more from the travel than it costs society. This principle only applies to charges, such as a fuel tax or a weight-distance tax, that vary directly with usage. Access charges (such as an annual weight fee) and general taxes are subject to different considerations. Partly because of the particular nature of variable highway costs and partly because of the general tendency for variable charges to be more costly to administer than access charges, the design of practical mechanisms for imposing correct prices on highway users presents a major challenge.

1. Pavement damage: Probably the most easily accepted basis for user charges is pavement wear; there is a clear connection between expenditures and the cost imposed by particular vehicles. Additional empirical research is needed to better establish the relationship between axle weight and the cost of damage to a particular road, but a solid information base has been developed (12,13). The preferred user charge would be a weight-distance fee based on equivalent single-axle load repetitions for each vehicle, but some approximation based on averages will undoubtedly be necessary for most vehicle classes.

2. Interference costs: The concept of the con-

Figure 1. Outline of federal highway user-charge determination.



gestion toll has been known for some time; numerous direct and approximate means for collecting it have been proposed. With the exception of a few bridge tolls that vary with time of day and direction, no highway-user charges in the United States are in any way related to congestion.

Interference costs include such congestion-related costs as accidents between vehicles, excess vehicle and tire wear, and excess fuel consumption, as well as travel delay. In contrast to pavement wear, interference costs rise in the short run (i.e., on a given highway) with increases in vehicle volumes of travel, which results in a deviation between the marginal social cost of travel and the price paid by the user. The price paid by the user is in the form of delay time and other private congestion costs, rather than in the form of a money price. Because marginal cost is above average cost, a price (or toll) needs to be charged (presumably by the facility operator) to bring congestion down to the efficient level. The relative contributions of different vehicle types to a congested traffic stream can be measured in passenger-car equivalents, a measure of road space effectively occupied by a vehicle of a given type under given terrain, vehicle-mix, road-type, and congestion conditions (14).

Congestion pricing is not taken very seriously by noneconomists, apparently on the basis of the twin notions that congestions is (a) something that is confined to users and (b) not a real cost anyway. Yet congestion reduction is regarded as a real benefit when expenditures for additional highway capacity are evaluated, i.e., when money is spent for the purpose of reducing congestion. From a theoretical perspective, congestion pricing is the only efficiency rationale for recovering any of the fixed costs of highway construction and maintenance (5). In the case of telephone calls, for example, a congestion toll is reflected in the price per minute during peak (business) versus off-peak periods. The

telephone system is subject to large fixed costs (the capacity and extent of the network cannot be varied by time of day), and the marginal cost of inputs is not significantly greater during peak periods. Thus, the peak premium is a measure of the opportunity cost of not having time available for some potential user. The important difference between telephone calls and highway travel, however, is the relative ease with which the telephone caller can be charged according to time of day and duration of call.

3. Externalities: The imposition of noise, asbestos dust, fumes, litter, and the like on persons who have not been compensated for these injuries by persons who are not required to pay an emissions or damage charge can be regarded as a "taking" by the polluters from the pollutees. In legal terms, the perpetrators of the externalities should be required to purchase pollution rights or easements in order to engage in polluting activities. Efficiency clearly calls for highway users to pay a charge for the externalities they create (15) according to the amount and nature of the damage caused so that the correct charge will be a function of use and emission rate.

Besides the lack of precedent, implementation of externality charges is hindered by the facts that the damage caused varies by location and vehicle type and that it is difficult to place a value on the damage. We should be able to improve, however, on the price of zero that is currently charged. For example, the cost of noise barriers could be collected from motorists along all highways wherever barriers are or should be constructed.

4. Other variable costs: Annual operating costs that bear some rough relationship to volume of use—highway and traffic police, management and administration, and perhaps snow and ice control—can be collected on a variable-charge basis. The relative magnitudes are small and the efficiency incentive negligible, so the precise instrument is not of critical importance.

#### Residual Costs

Under conditions of constant returns to scale, optimal investment in capacity, correct marginal-cost prices, and a "first-best" world, revenues from highway users would exactly equal long-run costs. Both variable and fixed costs would be fully recovered without the necessity of ever contemplating the allocation of any fixed-cost components. Congestion tolls would generate enough of a surplus over variable costs in the short run to pay the fixed costs in the long run. Under ideal conditions, the above revenues would completely solve the cost-allocation problem.

With reasonable confidence, we can assert that none of the ideal conditions are satisfied with regard to the U.S. highway system at the present time, and the likely direction of deviation from the ideal is to lead toward a shortfall between costs and revenues from efficient user charges. If no congestion tolls are imposed, revenues cannot be expected to recover fixed costs, and empirically, user revenues of all kinds are less than total public expenditures on highways. We are left, then, with an awkward problem.

Before considering how to approach the problem of residual costs, we can make sure the problem is minimized by taking advantage of variable cost pricing to the fullest extent in the following ways.

1. Even though congestion tolls are not actually levied, in the ideal sense, congestion or interference costs can be a basis for setting some other

user charge, even an access charge. If it is known which vehicles are responsible for congestion or increase the risks of accident, user fees can be imposed on those vehicles. Untying the charge from the actual amount of congestion removes the efficiency incentive, but price inelasticity or fairness may still warrant such an indirect instrument.

2. Similarly, externality charges can be levied, even though the instrument may be indirect and compensation is not actually paid for the damages caused. A fuel tax is only very roughly related to either congestion or externalities, but it does reflect usage for a given vehicle and it could be combined with an annual surcharge that is based on average emissions and contribution to congestion.

3. An expenditure budget may be covered by pricing variable costs that are not actually included in the expenditures. A correct charge for pavement damage, for example, might raise more revenues than the actual expenditures to repair the damage, both because (a) the pavement was being allowed to depreciate and (b) revenues were collected from trucks for the user costs imposed on light vehicles although compensation was not made to light vehicles. Such a strategy, however, implies investment and equity policies that are unacceptable for anything other than an emergency regime.

#### Allocation of Residual Costs

The residual-cost assignment problem can be structured in several ways, ultimately reconciling on pragmatic grounds those approaches that seem strongest. A typical procedure will involve allocating a set of costs to a vehicle class and then allocating the costs to individual vehicles. Some of the boundaries and possible starting points for residual-cost assignment are described below.

1. Subsidy from general revenues: All, none, or some portion of residual costs may be covered by revenues from general taxes. A decision to use general revenues for highway purposes should be made on the basis of the justification for a subsidy, such as increasing returns to scale, and not on spurious arguments about nonuser costs and external benefits.

2. Incremental fixed costs: Many professionals and policymakers regard the assignment of certain expenditure items to associated vehicle classes as equitable. For example, weigh stations can be assigned to trucks and guardrails to automobiles. Such assignments have an inherent degree of arbitrariness to them, but methods are available for placing bounds on reasonable solutions. No group of users should have to pay more overall than it would pay for a separate system of its own (16-18). The preferred revenue instruments are access charges (19).

3. Benefits: If emphasis is placed on the resource allocation that results from marginal-cost pricing of the existing system, then residual costs should be covered by taxes that change resource use to the smallest degree. To the extent that taxes are imposed on users, they can be scaled according to ability to pay, consumer surplus, the inverse of the consumer's demand elasticity, or benefits to the user (20,21). These strategies have a great deal in common.

4. Long-run marginal cost: If the capital stock is far from what would be optimal for expected demand conditions, efficient prices may be nowhere near ideal prices in the long run. Instead of reliance on the combination of short-run marginal cost for setting prices and efficient investment programs for adjusting the scale of the highway system,

prices can be set directly at long-run marginal cost. The rationale for this strategy is to avoid misleading signals for investment in related activities, as well as highway transportation, when long-run costs are understated by current prices. In practice, a long-run pricing objective can be supported by estimating future capital stocks and basing short-run prices on those rather than on what currently exists. Long-run incremental costs can be recovered from access charges based on criteria in the subsidy, cost, and benefit approaches described above.

5. Distributional equity: Alternative access-charge instruments can be compared as to which groups of the population ultimately bear the costs. Choices would depend on judgments about which of the population groups are most deserving.

6. Effectiveness: Choices among user-charge instruments can also be based on the effectiveness with which each one attains various transportation and nontransportation public goals. Effects on mobility of the elderly, employment, or urban revitalization may be considered, but the relationships are likely to be weak and the cost-effectiveness poor.

#### User Charges to Recover an Expenditure Budget

To select a single budget for cost recovery from the many government agencies that participate in financing the highway system is highly arbitrary. It is like having the makers of copper wire recover their portion of telephone system costs by imposing their own set of telephone service charges. The price of a telephone call would thus include the part charged by the copper makers, the part levied by the operators, the part imposed by pole erectors, etc. Each portion of the price would be set independently of all the other portions. The arrangement would be universally regarded, quite properly, as lunatic.

The highway enterprise lacks a single authority (for any portion of the system) that can establish a complete user-charge structure. If such authorities existed, they could purchase inputs from suppliers (who currently are government agencies) and charge consumers in accordance with costs and the characteristics of demand. Without this institutional structure, the only possible surrogate is federal government initiative.

How the federal government can arrive at its own share of highway user charges, even by expedient means, is unclear. Some alternative strategies are to (a) collect the same proportion of user charges on each system as the federal government pays in costs, (b) assign costs to vehicles according to the purpose of the travel and let the federal government impose user fees on interstate travel, and (c) establish a floor of federal charges that are uniform across the country and let state and local governments supplement the federal user charges for their own needs. The third of these is the only one that appears remotely workable in the near term, and it offers few appealing features.

#### CONCLUSIONS

To a degree we have come full circle, in that several of the residual-cost strategies sound something like the incremental-cost method that was dismissed at the beginning. Nonetheless, a great deal of progress has been made: Variable costs have been separated from fixed costs and given suitable treatment, the scope of the analysis has been expanded to include all costs (not just government expenditures) on all systems (not just the federal portion), and a framework has been constructed that allows for a



clear statement of the problem and an informed evaluation of alternatives.

Some of the improvements over previous methods are not immediately obvious. A form of partially distributed cost analysis was used in the past, but it was justified on the basis of the nonuser cost-responsibility myth (I should be taxed to help pay for my grocer's store because it serves me). When the assignment of residual costs is handled as a constrained optimization problem, at least we are informed of the criterion used and the consequences. The incremental-cost method was applied indiscriminately to variable as well as fixed costs without assessing its suitability. The emphasis on allocation of budgets rather than pricing of costs has meant that user charges have fallen along with expenditures (in real terms) at the same time that costs have been rising. Finally, attention is directed at the effects of alternative user charges on efficiency and equity, not at the largely pointless exercise of labeling expense items with vehicle-class names.

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## Proposed Fare Policy for Advance-Reservation Bus Service

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This paper reviews the present fare policy of the advance-reservation bus service in Barnstable County, Massachusetts, examines several alternative fare policies, and, finally, proposes a new policy. The present fare policy allows individuals to ride an unlimited number of times at a flat rate for any purpose during a three-month period. Four alternative fare policies are described. The alternative proposed for implementation would charge riders on the basis of the number of trips taken and the length of each trip. Reduced rates would be available for elderly or handicapped persons and for those who made group trips. Riders would be sent bills at the end of each month like telephone bills—the trips and miles traveled would be detailed as long-distance calls are. These invoices would be prepared by the existing computer system, which currently maintains complete client listings and generates detailed drivers' schedules. The cost of this minicomputer system, including hardware and software, was about \$50 000. The development of the billing and invoicing system would cost an additional \$5500. The paper also recommends further research into alternative fare policies, including their effects on travel behavior, revenue generation, and subsidy requirements. Other recommended topics are alternative mechanisms for implementation of such fare policies, such as sale of tickets,

punch passes, manual invoicing, and (as proposed) implementation as a component of a comprehensive computerized management information system.

As a result of increasing fiscal austerity at the federal, state, and local levels, government subsidies for public transportation services are expected to decline, although the need for and the costs of such services are increasing dramatically. As a result of this, consumers will be called on to pay higher proportions of total costs. As the amounts to be paid by consumers increase, the equity of the fare policies used will become of paramount importance. If public transportation is to maintain its feasibility in the 1980s, equitable fare policies, and means for implementing them, must be developed.