WHO PAYS FOR HIGHWAYS: IS A NEW STUDY OF HIGHWAY COST ALLOCATION NEEDED?

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PREFACE

The Congress faces several legislative proposals regarding highways in this session. Congressional response to these proposals will both directly and indirectly determine which highway program needs are met with federal assistance and what tax burden is borne by the various user groups. Thus, the current balance between program benefits to and user taxes paid by the several highway user groups may be altered.

This technical analysis, "Who Pays For Highways: Is a New Study of Highway Cost Allocation Needed?" was prepared by the Congressional Budget Office in response to requests by the Subcommittee on Oversight of the House Committee on Ways and Means and by the Subcommittee on Transportation of the Senate Committee on Environment and Public Works. The study examines the methods and findings of past federal attempts to analyze the distribution of highway costs and revenues (termed "cost allocation studies"), and considers the need for a new effort in light of pending legislative proposals. An earlier, unedited version of this analysis was prepared as a CBO special study with the title "Highway Taxes and Highway Costs" in May 1978. There have been no substantial changes made in this version. In particular, no attempt has been made to reflect further program changes in both House and Senate highway bills after their approval by the respective Committees on Public Works.

The authors of this paper are Reid H. Ewing, Richard R. Mudge, and Porter K. Wheeler. It was prepared in CBO's Natural Resources and Commerce Division under the supervision of Damian J. Kulash. The authors are grateful to John C. Oehmann of the Federal Highway Administration for valuable explanation of past studies. Others in the Federal Highway Administration, including Stanley Gordon of FHWA's bridge division, were helpful in providing data. Marion F. Houstoun edited the manuscript. Laurie L. Dye provided invaluable secretarial support.

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SUMMARY

In the Highway Revenue Act of 1956, the Congress declared that the highway tax burden should be distributed equitably among the various classes of persons using the federal-aid highways, and those otherwise deriving benefits from such highways. This policy reflected Congressional recognition that different kinds of vehicles unequally affect (or benefit from) highway program costs and thus should be differentially taxed; for example, heavy trucks should pay for the costs of the thick pavements, extra-wide road lanes, and high bridge clearances that they require.

To assist the Congress in making equitable highway tax decisions, the 1956 Highway Act also called for a study to determine, among other things, the allocation of highway costs among the various user classes. The results of that long-term study and a supplementary report, published by the Bureau of Public Roads in 1961 and 1965 and then updated by the Federal Highway Administration (FHWA) in 1969 and 1975, have been considered by the Congress when it has undertaken changes in highway-user taxes, particularly in determining which highway excise taxes should be raised or lowered and by how much.

THE NEED FOR A NEW COST ALLOCATION STUDY

A new cost allocation study appears to be needed for several reasons. A careful evaluation of the cost responsibility of each class of vehicles is essential if increased highway taxes, which appear likely in the near future, are to be imposed equitably. Furthermore, current legislative proposals emphasize new highway programs whose cost responsibilities may differ markedly from previous programs, raising questions about the imposition of additional taxes that cannot be answered by reference to previous cost allocation studies. Finally, existing cost allocation studies are based upon information about traffic and construction practices that is now sometimes outdated or unreliable, and they used procedures that were unnecessarily restrictive.

The Need For Additional Highway Revenues

During this session, the Congress will make major decisions regarding federal highway assistance. More specifically, the Congress will consider:

- Which highway programs should be provided during the next several years,
- Whether these programs should be oriented toward highway construction or toward highway replacement and restoration,
- Whether the Highway Trust Fund, which finances the nation's highway programs, should be extended, and
- Which taxes should be added or increased.

At present, excise taxes on motor fuels, tires, tread rubber, new trucks, trailers, and buses, motor vehicle parts and accessories, lubricating oil, and heavy vehicle-use of highways support the Highway Trust Fund. These taxes now yield $6.7 billion in revenues a year, about $4 billion of which is attributable to automobiles and the rest to trucks of various kinds.

Inflation and a slower than historic growth in projected highway revenues make an increase in highway taxes appear likely in the near term. If enacted, the highway bill recently reported by the House Public Works Committee would require a 38-percent increase in highway taxes. The considerably smaller bill reported by the Senate Committee on Environment and Public Works would be only just supported by current taxes.

If highway taxes are raised, the Congress will need to make an informed judgment about an equitable imposition of those taxes. A new cost allocation study, incorporating reliable and up-to-date information on the traffic mix on federal-aid highways, on the tax burden of highway users, and on federal highway expenditures, could be a valuable aid to the Congress in making that judgment. In addition, some proposed highway programs appear to differ markedly from former programs in terms of the costs attributable to each vehicle class. A thorough re-examination of highway cost allocation is essential, if an equitable set of highway-user charges is to be maintained.

Changing Programs

Most of the more than $4 billion in increased funding proposed in the House highway bill would go to two greatly expanded programs: $2 billion for bridge replacement and $1 billion for resurfacing, rehabilitation, and restoration (RRR). These programs represent a very different mix of activities as compared with the more construction-oriented programs of the past. Past cost allocation procedures, which are directed chiefly toward the costs of new construction, may not accurately assign the costs of rehabilitation programs.

The proposed upgrading of bridges to enable them to carry heavier loads would primarily benefit the heavy vehicles now prohibited from using them. If these bridge improvement costs were borne exclusively by their beneficiaries, the bridge costs allocated to some groups of heavy vehicles would be substantially higher than they would under current allocation procedures.

Similarly, the costs of the proposed RRR program are likely to be closely related to pavement damage, and available evidence shows that the damage that heavy vehicles cause to pavement is immensely disproportionate to their weight. If all pavement damage were attributed to traffic, heavy trucks would be responsible for most RRR costs. But all damage cannot be traced to a specific class of traffic. Although current understanding of this factor is limited, weather may also be a major source of pavement deterioration, and its costs cannot be fairly assigned to any single class of vehicles. Highway taxes should be designed to reflect these factors.

In short, both of these new highway program areas--bridge replacement and RRR—appear to have costs that are occasioned very differently than was the case for previous programs. Thus, a simple increase in the tax on motor fuels, which is borne disproportionately by automobiles, or even a proportionate increase in all highway taxes, may not prove to be an equitable way to meet the need for increased highway revenues.

Changing Traffic and Conditions

The information used in federal cost allocation studies has become increasingly outdated and unreliable. The allocation of tax revenues, for example, has involved a considerable degree of estimation. Fuel-economy data from the 1950s were used to allocate motor fuel taxes in the 1965 and 1969 reports, and these data were only marginally adjusted in the 1975 analysis. Estimates of annual vehicle mileage have probably improved, but they are based on traffic counts which vary considerably in reliability.

Problems of data reliability are also apparent in the allocation of non-fuel tax revenues. For example, the federal use tax on heavy vehicles is paid by empty weight but distributed according to estimated operating weight. The operating weights themselves are based on state weight records, and recent Congressional hearings have shown that state performance in weighing trucks varies widely. In addition, overweight truck operations are alleged to be prevalent, though not accounted for in either revenue or cost attribution. Many of the questions of data reliability that surround existing cost allocation studies could be resolved in a new study of highway cost allocation.

SCOPE OF A NEW STUDY

The former federal studies of highway cost allocation have demonstrated that attempting to determine an equitable set of highway taxes is a complex subject fraught with differences of opinion. If a new highway cost allocation study is to be useful, it should be focused tightly on the issues, and its scope should be carefully defined:

- Only the costs of the federal-aid system of highways should be examined, leaving lower levels of government the task of defining and determining a equitable set of charges for nonfederal highway systems.

- The study should address the costs occasioned by each user group, rather than the benefits derived by each, since this can be done less ambiguously and coincides closely with past practice.

- The benefits gained and federal costs occasioned by property owners and other highway nonusers should not be a major focus of a new study, because property access is most often provided by nonfederal systems and the beneficiaries are commonly highway users.

- The indirect costs of roadway use, such as air pollution, should be assessed in a subsidiary study.

- The cost allocation study should be conducted on the basis of costs occasioned by each class of vehicle. Some initial guidelines on methodology to be used could help keep the study timely and focused.

These decisions defining the scope of a new highway cost allocation study do not clearly tip the balance of highway-user taxes toward either cars or toward trucks. They serve only to delimit a cost allocation study in concrete terms so that a broad base of unambiguous information can be brought before the Congress--information that can aid the Congress in assessing knowledgably the fairness of alternative structures of highway-user charges.

CHAPTER I. INTRODUCTION

During the current session, the Congress will make several decisions that will significantly shape the nation's highway programs. Authorizations for most federal highway programs, except the long-term authorization for the Interstate System, expire at the end of this fiscal year. The Highway Trust Fund, which finances the nation's highway programs, is scheduled to expire at the end of fiscal year 1979, and highway-related tax rates are scheduled for reduction at that time, although pressures for increased taxes are mounting. Thus, new authorizations and the financing of highways will both be addressed this year.

Any decision about changes in highway taxes requires information on which types of vehicles are responsible for highway costs--that is, how much tax the users of each kind of vehicle should be paying--as well as information on how much the users of these vehicles are currently paying. Answers to both these questions require an up-to-date highway cost allocation study. The purpose of this report is to review and assess past federal cost allocation studies and describe the major decisions that must be made in setting the scope of a new study.

Pending Legislation

The highway program proposals now before the Congress vary considerably in both funding level and program content, but there are some similarities as well. Both of the two major bills--one proposed by the Senate Committee on Environment and Public Works and another by the House Committee on Public Works and Transportation--call for higher funding levels in general, and substantial increases in particular program areas. The Senate bill (S. 3073) contains two years of new authorizations and calls for a program level of about $8.3 billion, with the largest increase going for bridge repair and replacement. The House bill (H.R. 11733), would sharply expand the level of highway assistance, with 1979 authorizations from the Highway Trust Fund of about $11.4 billion. The largest increases proposed in H.R. 11733 would occur in two programs. First, the primary and secondary system funds would increase from $1.75 billion to $2.75 billion, of which a total of $1 billion would be set aside for RRR (resurfacing, rehabilitation and restoration) work. Second, bridge replacement would be

expanded elevenfold to $2 billion annually. 1/ Other programs, which accounted for $5.4 billion in 1978, would increase to $6.6 billion.

The proposed increases in program funds in both these bills reflect a shift from an emphasis on new construction to one on maintaining and rebuilding the present highway system. Both bills would continue the Highway Trust Fund and extend the taxes accruing to the fund. In the case of H.R. 11733, substantial new revenue would be needed to finance the expanded program levels. 2/

The Highway Trust Fund receives revenues from several highway-related excise taxes. In 1977, revenue from these taxes totaled $6.7 billion, with the bulk (over two-thirds) received from a four-cents per gallon tax on motor fuel (primarily gasoline). The other taxes include a 10-percent tax on the wholesale price of new trucks, buses, and trailers; taxes on tires, tubes, and tread rubber; a tax on truck parts; lubricating oil; and on very heavy trucks. Automobile users, through the taxes on gasoline and tires, provide about 57 percent of total trust fund receipts. Single-unit trucks account for an additional 23 percent; combination trucks, for 19 percent; and intercity buses, the remaining 1 percent.

Previous Studies of Cost Allocation

In the 1956 highway legislation, the Congress declared the policy that the tax burden should be equitably distributed among the users of federal-aid highways. The determination of an equitable distribution of the tax burden was recognized as a complex problem, and the legislation requested various studies and investigations, which became known as "cost allocation studies," since their primary function is to allocate the cost of highway assistance among the various classes of highway users.

The most extensive cost allocation studies were submitted in 1961 and 1965, in response to the Congressional mandate provided in the 1956 act. An update, undertaken in 1969, by the Federal Highway Administration

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1/ The chairman of the Subcommittee on Surface Transportation has said that, when H.R. 11733 is considered by the full House, he plans to introduce an amendment to reduce the authorization by $1 billion a year, including a $500 million reduction in the bridge program.

2/ CBO Staff Draft Analysis, "Financing Provisions Related to the Surface Transportation Assistance Act of 1978," April 1978.

(FHWA) for internal purposes received fairly wide circulation. In 1975, a draft report was prepared by the FHWA, but it has never been officially released.

These cost allocation studies have influenced the choice and mix of highway taxes in several instances, but their results have never been the exclusive basis for legislative action. Indeed, a major failing of previous studies is that their results have not been presented in such a way as to provide direct legislative guidance. Despite this, the studies have had some influence on legislation. In 1961, major tax changes were instituted shortly after that year's cost allocation report. The Kennedy Administration proposals were based directly on its results and several of the tax changes adopted by the Congress grew out of the report. 3/ The tax changes of 1965 followed shortly after the 1965 report, which had stimulated in part the Johnson Administration proposals. Tax revisions proposed by the Nixon Administration were based in part on the 1969 report. The 1971 changes in the purchase tax on certain lightweight vehicles reflected a cost allocation study finding that these vehicles overpaid.

Cost allocation procedures not only raise many issues of technical interest, they also directly affect particular groups of highway users, and thus they may ultimately affect the entire transportation system. If trucks pay less than their share of highway costs, for example, they will prosper at the expense of other highway users. Similarly, trucks would be penalized if they overpaid. Since autos comprise a large proportion of all vehicles, a small overpayment per auto could represent a very large underpayment per truck. Underpayment or overpayment by commercial truckers could also affect their ability to compete with the railroads, thus influencing another area of national transportation policy.

Should Cost Allocation be Reviewed?

In raising or revising highway taxes, the Congress faces many complex questions, some of which cannot be adequately answered with available information. A revised study of cost allocation could be an aid to the Congress in addressing these issues. Existing information on cost allocation is useful in considering this year's highway legislation, but far greater refinement is essential for a satisfactory resolution of the issue.

3/ For further details, see CBO's background paper on Highway Assistance Programs: A Historical Perspective (February 1978).

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Extending all current taxes for two or more years would continue the existing tax burden. If that burden is unfair, it would of course remain so.

There are several reasons to question the fairness of continuing the current set of taxes for a multi-year period. These are explored in some detail in the body of this paper, but briefly:

- Past studies focused on the allocation of new construction costs. Today's programs reflect a rapid growth in resurfacing, rehabilitation, and restoration (RRR) activities, whose costs appear to be quite differently occasioned.

- The usefulness of past studies has eroded with time, since much of the data and analyses date from the late 1950s. Vehicle mix and characteristics have changed substantially since then and they will continue to change.

- The more recent 1969 and 1975 reports were only minor revisions of the earlier studies, and they do not provide a strong basis for guiding current legislative initiatives.

- The recent updates have focused on one particular methodology, the incremental cost method. Questions regarding the validity of this method and the details of its application by the FHWA continue to arise.

- Future changes in fuel economy and other characteristics of motor vehicles will probably result in important shifts in the revenues paid by each class of vehicle.

Aim of the Paper

The purpose of the paper is to help the Congress evaluate whether the current information on highway cost allocation is adequate or whether a new cost allocation study is desirable. This paper examines previous cost allocation procedures and the problems of data and methodology they have encountered. It reviews past studies to identify practices that may create problems when they are applied to current highway programs. Special attention is given to new program directions contained in proposed legislation.

In the event that the Congress decides to request a new study of cost allocation, this paper also identifies five decisions that should be made about the basic nature of such a study. These decisions are:

- Should the study encompass all expenditures on roads or be limited to expenditures on roads financed by the federal government?

- Should the allocation of highway taxes be based on the costs occasioned by the various vehicle classes or on the relative benefits derived by these classes?

- Should the study be limited to the cost responsibility of users of the highways or should it include nonusers (for example, the access benefits accruing to landowners)?

- Should the indirect or social costs of highways be included?

- What is the most appropriate allocation methodology for a reliable and timely study?

CHAPTER II. WILL HIGHWAY TAXES NEED TO BE INCREASED?

The Congress has a continuing interest in ensuring that the highway taxes that it sets are equitable. This interest naturally intensifies when a major question, such as whether or not to increase taxes, brings the issue to the forefront. Proposed highway programs now before the Congress suggest that increased taxes are likely to emerge in this session or soon thereafter.

The highway program will ultimately require increases in tax rates if the projected Highway Trust Fund revenues plus the cash balance available in the trust fund are less than the new highway authorizations required by the bill plus any unfunded balance from previous authorizations. A highway program small enough to fit within the projected available funds, and thus requiring no new taxes, could possibly be developed. The two major highway proposals now under serious consideration in the Congress do not, however, appear to be of this sort. Thus, unless a highway tax increase is postponed through some special budgetary manipulations, the Congress will almost certainly have to consider which highway taxes to increase and by how much.

The extent to which H.R. 11733 and S. 3073 require additional taxes to support them depends upon projections of future trust fund revenues and upon the length of time the Highway Trust Fund is extended. The bill being considered in the House, when coupled with a four-year extension of the trust fund, would require additional taxes under all of the prevailing revenue forecasts. The Senate bill could be approximately funded by current highway taxes.

The House Committee on Public Works and Transportation has requested a six-year extension of the Highway Trust Fund to finance a four-year extension of the highway program. Under H.R. 11733 and only a four-year extension of the trust fund, $66.9 billion would be needed to cover highway expenses (see Table 1). Only $52.4 billion would be available from the trust fund, leaving an additional $14.5 billion to be raised--equivalent to about a 38-percent increase in all highway excise taxes, or an added motor fuel tax of about 2.3 cents per gallon if only the taxes on motor fuel were increased.

The Senate bill contains only two years of additional authorizations. The Senate would increase the life of the trust fund by four years, but the additional two years of revenue are not essential for the support of the

TABLE 1. CBO ESTIMATE OF FUNDS AVAILABLE FROM THE HIGHWAY TRUST FUND (HTF), AND FUNDS REQUIRED UNDER H.R. 11733 AND S. 3073: IN BILLIONS OF DOLLARS

Funds Available			Funds Required		
H.R. 11733 Assuming a Four-Year Extension of the Trust Fund					
HTF Cash Balance at Start of Fiscal Year	1979	11.2	Unfunded Balance at Start of Fiscal Year	1979	18.0
HTF Revenues	1979	7.3	Authorizations a/	1979	11.4
HTF Revenues	1980	7.5	Authorizations a/	1980	11.1
HTF Revenues	1981	7.7	Authorizations a/	1981	11.2
HTF Revenues	1982	7.9	Authorizations a/	1982	11.2
HTF Revenues	1983	8.1	Authorizations a/	1983	4.0
Estimated Interest	1979-1983	2.3			
Close-Out Revenues	1984	0.4			
Total		52.4			66.9

Estimated gap = 52.4 - 66.9 = -14.5; equivalent to about 2.3 cents per gallon of motor fuel or a 38-percent increase in all highway excise taxes if tax changes are made at start of fiscal year 1979.

S. 3073					
HTF Cash Balance at Start of Fiscal Year	1979	11.2	Unfunded Balance at Start of Fiscal Year	1979	18.0
HTF Revenues	1979	7.3	Authorizations a/	1979	8.3
HTF Revenues	1980	7.5	Authorizations a/	1980	8.2
HTF Revenues	1981	7.7	Authorizations a/	1981	3.5
Estimated Interest	1979-1981	2.2			
Close-Out Revenues	1982	0.4			
Total		36.3			38.0

Estimated gap = 36.3 - 38.0 = -1.7; equivalent to about 0.4 cents per gallon of motor fuel or a 7-percent increase in all highway excise taxes if tax changes are made at start of fiscal year 1979.

a/ Interstate counted in the year made available, one year in advance.

proposed authorizations. As shown in Table 1, S. 3073 would need $38.0 billion to cover costs and would raise $36.3 billion during its two-year authorization period. This leaves an estimated revenue gap of about $1.7 billion—equivalent to about a 7-percent increase in all highway excise taxes, or about four-tenths of a cent per gallon if only the taxes on motor fuel were increased. This gap is small, in percentage terms, and could easily prove to be nil, if revenue collections run slightly ahead of projections.

The Treasury's estimate of future Highway Trust Fund revenues is higher than CBO's. But the Treasury methodology appears to be based largely on extrapolation of past trends, and may not account fully for future improvements in automobile fuel economy, which are likely to be stimulated by the Energy Policy and Conservation Act of 1975 and by the energy legislation now in conference. In any case, the Treasury estimates of trust fund revenues indicate that H.R. 11733 and S. 3073 would require increases of approximately 34 percent and 6 percent in revenues, respectively.

The Secretary of Transportation has suggested that the Congress use, when authorizing new programs, an estimate of trust fund revenues that assumes fulfillment of the President's energy goals of a 10-percent reduction in gasoline consumption by 1985. 1/ This estimate of revenues would be lower than CBO's estimate; thus it would indicate a need for somewhat higher tax increases.

In summary, the highway program now being weighed in the House appears to require substantial tax increases to support it, regardless of which revenue forecast is used. The proposal being considered in the Senate appears to be approximately in line with anticipated trust fund revenues, although slight tax increases might be needed to support it. In either case, the highway program would be at or beyond the funding capability of current highway excise taxes; in addition, the pressure for tax increases will mount in future years, as automotive fuel economy improvements restrain the rate of growth in receipts from motor fuel taxes, and as inflation continues to erode the purchasing power of Highway Trust Fund receipts. Even if increased highway taxes can be avoided in this session of the Congress, they promise to be a recurring issue. Since a thorough restudy of cost allocation would require several years, such a study could be begun now with little risk of being premature.

1/ Letter from Secretary of Transportation Brock Adams to Senator Russell B. Long, May 1, 1978.

CHAPTER III. ARE EXISTING COST ALLOCATION PROCEDURES APPROPRIATE FOR NEW PROGRAMS?

The Congress is currently considering major changes in the type and mix of projects funded through the federal highway program, and a program shift toward greater federal involvement in RRR (resurfacing, rehabilitation, and restoration) has already begun. Within the context of current FHWA cost allocation procedures, this chapter examines the ways in which some of these program changes might affect the allocation of costs among the various classes of vehicles.

Some simple examples are included to illustrate the implications of these program changes for both the allocation of highway costs and the equity of highway taxes. In order to understand these examples, the incremental cost technique used by FHWA to determine the cost responsibility of vehicle classes is briefly described. A more detailed description of past federal cost allocation studies is provided in Appendix A.

The incremental cost method used in previous cost allocation studies seeks to assign each element of highway cost to the vehicles that occasion it. Using accepted design procedures, highway costs are divided into increments that meet the requirements of increasingly larger and heavier vehicles. The costs of providing roads adequate for basic vehicles (which in the FHWA methodology are assumed to be automobiles and light trucks) are allocated to all vehicles on the basis of road use; the costs of providing successive increments of roads adequate for larger and heavier vehicles are allocated only to these heavier vehicles, again, on the basis of road use. Thus, automobiles pay only for a portion of the first increment (typically well over half of the costs), but the heaviest class of vehicles pays a share of all increments, including the full costs of the last increment. Within each increment, road usage is typically measured by either vehicle miles or axle miles of travel.

EFFECT OF HIGHWAY PROGRAM CHANGES ON COST AND REVENUE ALLOCATIONS

The results of a highway cost allocation study depend on the methods used to allocate costs among vehicle classes, data on the number and types of vehicles using the highway system, and the types of projects included in the highway program. Although an improved methodology and better vehicle data are likely to result in a more accurate allocation of costs, changes in cost responsibility could result merely from altering the types of

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highway projects undertaken; for example, the Congress is now considering several proposals to expand federal involvement in RRR-type work and in the replacement of deficient bridges.

Cost Allocation

Past federal cost allocation studies have grouped federal highway activities into three major spending categories, each with its own separate cost allocation formulas: pavements and shoulders; right-of-way, grading, drainage and so forth; and bridges. The cost responsibility assigned to heavier vehicles in these three categories varies considerably. Using FHWA cost formulas, over 95 percent of costs for right-of-way, grading, and drainage are considered common costs and are assigned without regard to vehicle weight. (Certain parts of this group, such as right-of-way costs, are assigned solely as common costs.) This proportion drops to about 75 percent for bridge construction and 62 percent for pavements and shoulders. 1/ Overall, in 1965, 81.4 percent of federal-aid highway costs were allocated as common costs, independently of vehicle size or weight, and 2.6 percent were allocated solely to the larger trucks (those over 16,000 pounds per axle or about 40,000 pounds gross operating weight).

Any major expansion in federal aid to bridges or RRR work would probably result in the allocation of a higher portion of highway costs to large trucks, since these are the spending categories that are most influenced by vehicle weight. Table 2 attempts to estimate the cost allocation implications of such a shift, using the highway program proposed by H.R. 11733 as an example. In this illustration, the highway program is divided into three parts: 1) a core program of $8 billion with the same mix among activities as in 1975, when the last federal cost allocation study was done; 2) an additional $2 billion program dedicated solely to bridge reconstruction; and 3) an additional $1 billion program devoted solely to RRR. These three parts approximate the highway program proposed in H.R. 11733. What is called the core program is basically the 1975 highway program but expanded to an $8 billion level from the $6.3 billion spent in 1975. This includes roughly 50 percent (or $4 billion) for the Interstate system and 30 percent (or $2.4 billion) for primary roads. This example reflects a realistic possibility as the federal highway program shifts toward greater emphasis on RRR and bridge replacement in the future. For simplicity, only published or

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1/ Bureau of Public Roads, Supplementary Report of the Highway Cost Allocation Study, H. Doc. 124, 89 Cong. (1965), Table 39, p. 118. These percentages vary slightly from year to year, depending on the distribution of highway work between urban and rural areas and among the different parts of the federal-aid system.

TABLE 2. ESTIMATED COST RESPONSIBILITY a/ BY VEHICLE TYPE FOR HIGHWAY PROGRAM PROPOSED BY H.R. 11733: IN MILLIONS OF DOLLARS

Vehicle Type	Core Program b/ ($)	(%)	Bridges c/ ($)	(%)	RRR d/ ($)	(%)	Total ($)	(%)
Automobiles	5,080	63.5	1,184	59.2	460	46.0	6,724	61.1
Buses	56	0.7	20	1.0	17	1.7	93	0.8
Single-Unit Trucks								
2-axle, 4-tire	832	10.4	182	9.1	73	7.3	1,087	9.9
2-axle, 6-tire	360	4.5	94	4.7	78	7.8	532	4.8
3-axle	184	2.3	68	3.4	29	2.9	281	2.6
Combinations								
Semitrailers								
3-axle	64	0.8	18	0.9	33	3.3	115	1.0
4-axle	208	2.6	72	3.6	90	9.0	370	3.4
5-axle	704	8.8	246	12.3	104	10.4	1,054	9.6
Full trailers	72	0.9	8	0.4	23	2.3	103	0.9
Semi and full trailers	440	5.5	108	5.4	93	9.3	641	5.8
All Single-Unit Trucks	1,376	17.2	344	17.2	180	18.0	1,900	17.3
All Combinations	1,488	18.6	452	22.6	343	34.3	2,283	20.8
All Trucks	2,864	35.8	796	39.8	407	52.3	4,067	37.0
All Motor Vehicles	8,000	100.0	2,000	100.0	1,000	100.0	11,000	100.0

a/ Cost responsibility refers to the costs occasioned by each class of vehicle, not their payments to the Highway Trust Fund.

b/ Drawn from Federal Highway Administration, "Federal Highway Cost Allocation: An Examination of Current Trends," December 8, 1975, Table II, p. 13.

c/ Estimate by CBO based on cost increments used by the FHWA.

d/ Derived from unpublished allocation data on pavement and shoulders from 1969 and 1975 FHWA cost allocations.

easily available data have been used in this example and no attempt has been made to alter FHWA methodology.

The allocation for the core program is taken from the final result of the 1975 cost allocation study. 2/ The cost allocation for bridges assumes a $2 billion program and uses the cost increments developed for the 1965 study (the only ones available) as well as the vehicle characteristics used in the 1969 and 1975 studies. The cost allocation for RRR assumes a $1 billion program, is derived from the cost increments for pavements and shoulders, and uses vehicle data from the 1969 and 1975 cost allocation studies. In the total column, these three components are combined into an $11 billion highway program quite similar to that called for by H.R. 11733.

Compared with the core program, the cost allocation for bridges shows a relatively small shift of responsibility away from autos and towards some of the larger trucks--in particular, semitrailers. As discussed elsewhere in this chapter, there appear to be deficiencies in the cost increments developed by FHWA for bridges; correcting for these is likely to result in a shift of responsibility away from the lighter and toward the heavier vehicle classes.

The results for the RRR cost allocation show a more dramatic change from the core program. 3/ The auto share of costs drops from 63.5 percent for the core program to 46 percent for RRR. The cost responsibility for some truck classes more than triples, while that for all combination trucks almost doubles. RRR, however, accounts for less than 10 percent of the total H.R. 11733 program; thus it has little effect on the total allocation of costs. Nevertheless, there may be reason to question whether or not the current level of RRR work is fully reflected in the latest federal cost allocation study. RRR accounted for 16 percent of the federal aid program in 1977, as compared with 10 percent in 1975 and 2 percent in 1970. 4/ If this increase has not been fully accounted for in the latest study, the costs attributable to heavier vehicles in this example could be significantly underestimated.

2/ Federal Highway Administration, Office of Program and Policy Planning, "Federal Highway Cost Allocation: An Examination of Current Trends," December 8, 1975, Table II, p. 13.

3/ After consultation with FHWA personnel, it was decided that formulas developed in previous cost allocation studies for work on pavement and shoulders most closely approximated RRR work.

4/ Calculated from unpublished tabulations supplied by FHWA.

Overall, the combined program shows surprisingly little change from the 1975 cost allocation. The allocation of costs to autos declines by less than 4 percent, and with the exception of semitrailers (whose share is up 15 percent), the cost allocation to most classes of trucks shows only minor shifts. A major reason for this relatively small change is that the combined program is still dominated by the size of the core program. The caveats expressed above concerning the treatment of the bridge and RRR programs are another reason the change is not more dramatic. Adjusting for deficiencies in the existing method would probably result in more noticeable shifts for all vehicle classes. As noted elsewhere in this paper, the existing cost allocation procedures can be substantially improved. In particular, the 1975 study was done in a hurry, and relied to a considerable degree on estimates and results from studies undertaken in the early 1960s.

Revenue Allocation

The relative future share of trust fund revenues from each vehicle class has been roughly estimated. As a first approximation, the major vehicle types—autos, buses, single-unit trucks, and combination trucks—are assumed to account for the same share of each highway excise tax in 1980 as was estimated by FHWA for 1975. 5/ This approach is modified to apply CBO's estimate of the effect of the 1975 Energy Policy and Conservation Act and the energy legislation now in conference on auto fuel economy. The results are shown in Table 3.

Assuming that all highway taxes are increased proportionately, the overall results for H.R. 11733 are quite similar to those found in the 1975 cost allocation study. Autos underpay by 12 percent, while single-unit trucks overpay by a substantial margin. There is a change, however, from the 1975 study, in that combination trucks would slightly underpay. Further, Table 3 masks the considerable variation found in different types of vehicles within each of these major categories. For example, past allocation studies have generally shown that diesel trucks tend to underpay significantly more than other trucks of similar size and weight.

This analysis contains many simplifying assumptions, quite apart from any inadequacies in the basic cost allocation methodology and in the input data. Accepting these simplifications for the moment, however, the analysis indicates that additional revenues should be raised from auto users and from users of combination trucks. Without tax increases, in 1980, users of single-unit trucks are projected to be paying approximately their share of

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5/ Unpublished data supplied by Federal Highway Administration, Office of Program and Policy Planning.

TABLE 3. SHARE OF HIGHWAY REVENUES AND COSTS FOR MAJOR VEHICLE TYPES UNDER 1975 HIGHWAY PROGRAM AND UNDER H.R. 11733: IN PERCENTS

	1975 Highway Program a/			H.R. 11733 Program b/		
	Cost	Revenue	Revenues/ Costs c/	Cost	Revenue	Revenues/ Costs c/
Automobiles	63.5	56.9	0.90	61.1	53.9	0.88
Buses	0.7	0.9	1.29	0.8	0.8	1.00
Single-Unit Trucks	17.2	23.4	1.36	17.3	25.0	1.45
Combination Trucks	18.6	18.9	1.02	20.8	20.2	0.97

a/ Federal Highway Administration, Office of Program and Policy Planning, "Federal Highway Cost Allocation: An Examination of Current Trends," December 8, 1975, Table II, p.13.

b/ Table 2 above for cost data. Revenues assume a proportionate increase in all highway excise taxes. Highway excise taxes are also assumed to be allocated as done by FHWA in 1975, except for automobile payments, where major improvements in fuel economy are taken into account.

c/ A ratio of less than 1 indicates an underpayment; a ratio greater than 1 an overpayment.

the costs of H.R. 11733 (a deficit of less than $3 per vehicle); auto users would be underpaying by about $2.8 billion or $26 per vehicle; and combination trucks would have underpayments of about $800 million, or about $590 per vehicle. The dollar value of the bus underpayment is still relatively small in this illustration, but it could grow substantially if the energy legislation now in conference is passed.

Thus, if the Congress were to enact a major increase in the highway program, such as that called for in H.R. 11733, an increase in highway excise taxes would almost certainly be required. To illustrate the range of available options and their widely different implications for a fair allocation of highway costs, Table 4 compares three options--a proportionate increase in all highway excise taxes; increases in gasoline and diesel fuel taxes only; and increases in all taxes, except those on gasoline and diesel fuel--with the cost allocation presented above for H.R. 11733. These results are illustrative rather than definitive, however, primarily because the cost allocation contains numerous simplifying and questionable assumptions.

TABLE 4. EFFECTS OF DIFFERENT TAX INCREASES ON HIGHWAY REVENUES PAID BY MAJOR VEHICLE TYPES IN 1980 UNDER H.R. 11733: IN PERCENTS

	Proportional Increase in All Taxes		Increase in Fuel Taxes Only		Increase in Non-Fuel Taxes Only	
	Revenue	Revenue/ Costs a/	Revenue	Revenue/ Costs a/	Revenue	Revenue/ Costs a/
Automobiles	53.9	0.88	56.9	0.93	46.9	0.77
Buses	0.8	1.00	0.7	0.89	1.2	1.45
Single-Unit Trucks	25.0	1.45	24.6	1.42	25.8	1.49
Combination Trucks	20.2	0.97	17.7	0.85	25.9	1.25

a/ A ratio of less than 1 indicates an underpayment; a ratio greater than 1, an overpayment.

The results are striking, even with this simple example. Increasing fuel taxes alone decreases the relative cost responsibility assigned to heavy vehicles (combination trucks and buses) and correspondingly increases the cost responsibility assigned autos--which would still underpay. Of the major vehicle groups, combination trucks would, however, underpay by the largest percentage (15), equivalent to between $200 and $250 a truck.

The results of increasing the non-fuel taxes alone (which are paid primarily by trucks) are even more dramatic. All major truck classes would overpay substantially, with single-unit trucks overpaying by close to 50 percent and combination trucks, by 25 percent. Autos now underpay by 23 percent.

Although policy conclusions as to taxes and their appropriate levels should not be drawn from this example, it clearly indicates that relying on only one tax, or on one type of tax, could seriously distort the tax burden across vehicle classes, no matter which cost allocation formula is used. Furthermore, the cost allocation method that is used can significantly influence whether or not a set of taxes appears to be fair. For example, if the results of the 1969 cost allocation study had been used for the core highway program (and some reasonable arguments could be advanced for doing so) and if a revised allocation formula for the bridge replacement program were used (such as the one presented in Table 5), combination trucks might underpay, even if only nonfuel taxes were increased.

ALLOCATION OF BRIDGE COSTS

The FHWA (then called the Bureau of Public Roads) examined ways in which bridge construction costs could be attributed to vehicles of different weights as part of its original cost allocation study in 1961. Two approaches were tried. First, the states were asked to report the costs of bridges, built in the last half of 1956, according to the heaviest vehicle that they were designed to carry. These data were converted into an index of relative bridge costs, which is easily converted into costs attributable to each category of weight (see column 2, Table 5). Second, engineering studies were conducted of typical bridge types in order to develop a theoretical allocation of construction costs. The resulting allocation formula has been used by FHWA in all its incremental cost studies (see column 1, Table 5).

There are serious drawbacks to these approaches. Both are more than 20 years old. Hence, both fail to reflect important changes in bridge design and in construction costs. It is not clear, however, how these changes would redistribute cost responsibility among vehicle classes.

In addition, the first approach may be inadequate because the data on state construction costs for bridges designed for light loads (under 20,000

TABLE 5. ALTERNATE ALLOCATIONS OF COST RESPONSIBILITY FOR BRIDGE REPLACEMENT: IN PERCENTS

Observed Vehicle Gross Weight a/ (thousands of pounds)	Increments Used By FHWA Based on Design Studies b/	Based on Bridge Costs Reported by States c/	Based on Weight Restrictions for Structurally Deficient Bridges d/
Less than 10	74.8	72.3	55.1
10 to 20	9.2		11.9
20 to 30	5.8	2.3	10.5
30 to 40	5.2	12.1	10.7
40 or More	5.0	13.3	11.9
Total	100.0	100.0	100.0

a/ For single-unit trucks. Corresponding gross vehicle weight (in pounds) for combination trucks:

Single Unit	Combination
10,000	13,500
20,000	27,000
30,000	40,000
40,000	54,000

b/ Bureau of Public Roads, Supplementary Report of the Highway Cost Allocation Study, published as H. Doc. 124, 89 Cong. (1965). Calculated from Table 39, p. 118.

c/ Ibid. Calculated from cost indexes in Table 34, p. 110.

d/ Calculated from unpublished data in the National Bridge Inventory (August 1977) supplied by Federal Highway Administration. Numbers are derived from inventory weight limits for all structurally deficient bridges and from bridge construction increments used by FHWA.

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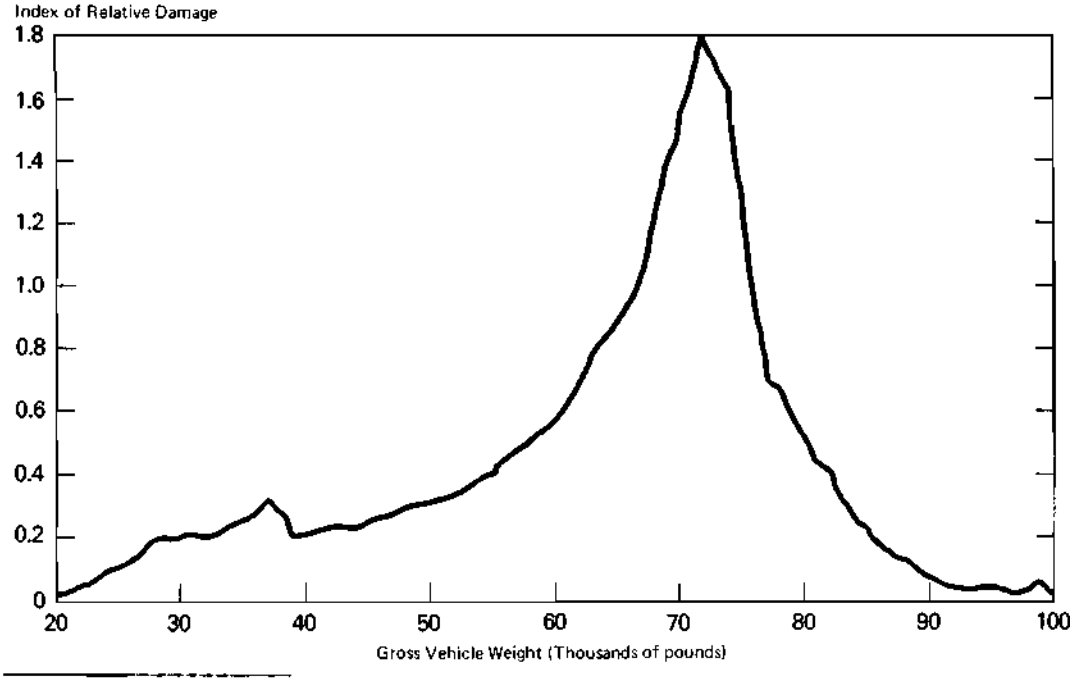
pounds gross vehicle weight) are based on a small sample size, which may be biased since these bridges appear to be concentrated in a small number of states. Further, bridges built to lower load specifications tend to be on less traveled roads and less expensive construction details (guardrails, for example) may therefore have been used. This would imply that light vehicles were not assigned their full cost responsibility.

The engineering studies conducted by FHWA are, by their very nature, theoretical. Although they have the advantage of using consistent design standards for each type of bridge considered, they--like the state bridge construction data--bear little if any relationship to the amount of damage caused by different vehicle classes--that is the degree to which the effective life of a bridge is reduced by each kind of vehicle that uses it. Quantitative data on vehicle damage to bridges is not available in the same detail as for vehicle damage to pavements. There is evidence, however, for one important type of damage to bridges with steel welds—structural fatigue. Fatigue damage increases with the third power of gross vehicle weight; thus, a 60,000-pound vehicle causes over 1,700 times the fatigue damage of a 5,000-pound vehicle. Figure 1 plots this relationship, adjusted for the number of vehicles in each weight class in 1970. 6/ Fatigue appears

Figure 1.
RELATIVE DAMAGE CAUSED BY VARIOUS TRUCK WEIGHTS



6/ John W. Fisher, Guide to 1974 AASHTO Fatigue Specifications (American Institute of Steel Construction, 1974) Fig. 33, p. 23.

to be the major cause of bridge failure, with the exception of those caused by natural disasters (which account for the vast majority of bridge failures) and ship collisions. 7/ Even when total failure (a very rare occurence) does not happen, fatigue problems, which are often responsible for cracking, appear to be a significant reason for "posting" or reducing the legal load limit that a bridge can carry.

The two bridge cost allocation methods developed by FHWA are concerned with the construction of new bridges, and they probably are not applicable to a program of replacing and repairing existing deficient bridges, which do not always require construction of totally new bridges. A bridge repair program is likely to emphasize superstructure rebuilding, an area where costs are known to be more dependent on vehicle weight. 8/ In 1977, 42 percent of the federal-aid bridges considered structurally deficient had substructures that either needed no repair or could be repaired by regular maintenance crews. 9/ Thus, the bulk of the repair costs for these bridges would depend on the weight of vehicles which use them. This means that, relative to the factors used in past federal studies, there should be a shift in cost responsibility toward the heavier vehicles.

An alternative way of allocating cost responsibility for a bridge repair program would be to examine the weight restrictions placed on structurally deficient bridges (the class of bridges that would be repaired first in such a program). Vehicles with gross weights above the legal load limit for any deficient bridge are the ones most likely to benefit from any improvements in these bridges. Further, these vehicles are likely to have caused a disproportionate share of the damage to the bridge. Using data available from FHWA's National Bridge Inventory, a simple cost allocation was developed for all structurally deficient bridges (see column 3, Table 5). This calculation assumes that each weight class pays a share of the repair costs of only those bridges from which it will benefit. For example, 31 percent of all structurally deficient bridges place no restrictions on vehicles weighing under 10,000 pounds; those vehicles would be allocated none of the

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7/ David W. Smith, "Why Do Bridges Fail?" Civil Engineering-ASCE (November 1977), pp. 58-62.

8/ Bureau of Public Roads, Supplementary Report of the Highway Cost Allocation Study, H. Doc. 124, 89 Cong. (1965), p. 113.

9/ Unpublished data supplied by FHWA from National Bridge Inventory. The 42 percent refers to bridges with a substructure condition rating of 6 or better. Bridges over other highways were excluded because they are not now eligible for aid under the bridge replacement program.

costs of repairing those bridges. Similarly, vehicles with a gross operating weight of between 10,000 and 20,000 pounds would be allocated none of the costs of improving the 23 percent of all bridges that place no restrictions on vehicles under 20,000 pounds, although they would be allocated a portion of the costs of all other bridges. The incremental costs developed by FHWA (see column 1, Table 5) were used to estimate the costs required to improve a bridge from one vehicle weight class to another. 10/

The results of this simple allocation are substantially different from the results of procedures used in past studies; for example, almost 45 percent of bridge replacement costs would be allocated by weight, in contrast to only 25 percent in the FHWA formula.

Although this alternate cost allocation depends upon a number of simplifying assumptions, it is probably more representative of the actual cost responsibility of a bridge reconstruction program than those used previously. In any case, the discrepant results of these two approaches raise serious questions about the applicability of the FHWA cost allocation methodology to a program emphasizing repair and replacement of deficient bridges.

ALLOCATION OF RRR COSTS

In recent years, federal-aid highway statutes have expanded the definition of highway construction to include RRR work within the federal

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10/ In mathematical shorthand, the increment (I_j) for weight class j (where there are five weight classes) was calculated as:

$$I_j = \frac{C_j \left(\sum_{i=1}^{j} F_i\right)}{\sum_{j=1}^{5} C_j \left(\sum_{i=1}^{j} F_i\right)}$$

where,

F_j = fraction of structurally deficient bridges with inventory weight limits within weight class i.

C_j = bridge construction cost increment used by FHWA for weight class j.

highway program, RRR-type expenditures have increased eightfold, from about 2 percent of all FHWA expenditures in 1970 to 16 percent in 1977. 11/ This major change in the federal highway program should cause a significant shift in the allocation of federal highway costs. None of the cost allocation methods developed for previous studies focused on RRR work directly; but, of the major categories of highway activities considered in those studies, RRR most closely resembles pavement and shoulder work. Thus, one simple, illustrative way to allocate costs for RRR work would be to use the FHWA incremental cost allocation for pavement and shoulders. Although the percentage has varied from year to year, the 1965 federal cost allocation study assigned 38 percent of the costs of pavement and shoulders by weight--a higher percentage than that assigned either of the other two major categories of highway expenditure (25 percent for bridges and 5 percent for right-of-way, grading, drainage, and so forth). 12/ Thus, if FHWA methodology is applied, the recent dramatic increase in RRR work should shift highway cost responsibility toward heavier vehicles.

Pavement costs can also be allocated on the basis of the relative damage caused by different types of vehicles. Using the results of the AASHO (American Association of State Highway Officials) road tests, the number of axle loads of vehicles of different weights that cause similar damage to new pavements can be calculated. For example, approximately 2,500 automobiles cause the same amount of pavement damage as 1 truck, loaded to the gross weight permitted by the current federal maximum for Interstate roads.

Allocating RRR costs on the basis of the relative amount of damage caused by different types of vehicles has considerable conceptual appeal. Several major caveats are necessary, however, before adopting the existing pavement damageability results.

First, although the results of the AASHO road tests provide reasonable descriptions of the effect of traffic on new pavement, their direct application to resurfacing or reconstruction is questionable. Since pavement

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11/ Calculated from unpublished tabulations supplied by FHWA. If a similar calculation is made for all betterments, including widening and reconstruction activities, the growth has been from 14 percent in 1970 to 33 percent in 1977.

12/ Bureau of Public Roads, Supplementary Report of the Highway Cost Allocation Study, H. Doc. 124, 89 Cong. (1965), calculated from Table 39, p. 118.

overlays, such as those used in resurfacing, appear to be more durable than completely new pavement, the effects of this difference--if any--need to be examined. Second, little is known about the relative effects of weather and traffic on roadway deterioration. The AASHO road tests, which were undertaken for only two years, did not permit a thorough, long-term assessment of weather-related effects. It can be argued that damage caused exclusively by weather should be considered a common cost, rather than be allocated primarily to heavier vehicles. Of course, if the effect of weather is small relative to that of traffic, then its exclusion will not cause a major distortion. Third, RRR activities can involve other work than simply repaving; thus, a more complex allocation of costs may be needed.

Each of these three potential problems merits further analysis, but inasmuch as they are also applicable to the methodology used in the past, they should not inhibit development of a better methodology. Even with its imperfections, the relative damage concept would probably result in a more reasonable allocation of costs, as compared with the approach used in past federal studies.

CONCLUSION

The results of previous federal cost allocation studies may not be applicable to the future mix of federal highway programs. In particular, the recent shift in emphasis toward federal responsibility for bridge replacement and for highway rehabilitation (RRR) appears to result in a modest shift in cost responsibility away from automobiles and toward heavy trucks.

In addition, the applicability of FHWA bridge cost allocation methods to a new bridge repair and replacement program is clearly open to serious questions. Not only are the data upon which the former are based 20 years out of date, they also appear to bear little relationship to the relative damage caused by different vehicle classes or to the vehicle classes that occasion the needed repairs. Similar criticisms can be made about applying the cost allocation factors developed for pavement and shoulders to RRR work. If RRR costs were assigned in proportion to the relative pavement damage caused by each vehicle, the changes in cost allocation could be much more dramatic than those resulting from a change in highway program mix. A new cost allocation study should be able to develop allocation procedures that would provide a more accurate allocation of cost responsibility for federal RRR work and bridge repair.

New highway excise tax revenues could be generated in many ways; for example, through a proportional increase in all taxes, an increase in motor fuel taxes only, or an increase in all taxes except those on motor fuel.

The relative share of revenue allocated to each vehicle class in those examples differ significantly. No matter which cost allocation method is used, a simple increase in any one tax appears unlikely to improve the equity of highway taxes. An equitable tax structure almost certainly requires developing a package of tax changes with different rates. An accurate allocation of both costs and revenues is essential in designing such a package.

CHAPTER IV. ARE THE DATA UP-TO-DATE AND RELIABLE?

Cost allocation studies attempt to allocate program costs and tax revenues to each group of roadway users, so that some balance in public expenditures can be struck between how much each user contributes to costs and how much each pays. This objective is difficult to achieve, because highway taxes are simultaneously levied on several groups of vehicles, and considerable estimation is involved in determining the revenues of any one group. Moreover, since roads are used jointly by all classes of vehicles, the costs that are occasioned by each group cannot generally be observed directly, and must be inferred from complex engineering and statistical evidence.

The source of most highway tax revenues is a 4-cent per gallon tax on motor fuels. About 74 percent of all highway tax revenues in 1977 came from this tax, which is paid by all highway users. A tax on tires of 10 cents per pound produced 11 percent of highway tax revenues in 1977, and a 10-percent tax on the manufacturer's wholesale price of trucks, buses, and trailers produced an additional 9 percent. The remaining 6 percent came from a tax on the annual use of heavy vehicles, an 8-percent tax on the wholesale price of motor vehicle parts and accessories, and a tax of 6 cents per gallon on lubricating oils.

The principal highway taxes are levied on more than one vehicle type, and the amount paid by each type of vehicle is not recorded. In order to attribute tax revenues to specific vehicle types, it is necessary to estimate fuel consumption, tire sales, and vehicle sales associated with each vehicle type. The attribution of highway costs to each user group is even more involved than the attribution of revenues. In order to allocate costs across vehicle classes, the cost of each roadway feature (such as an extra foot of pavement width) must be estimated and assigned to each vehicle class. Allocations are interrelated, since most roads are designed for, and used by, a mix of vehicles. As a result, the assignment of cost responsibility depends on engineering data as well as data on roadway use and traffic composition.

Although most of the data needed to allocate highway revenues and costs exist, they are not always current. The most extensive highway cost allocation study in recent times was begun over 20 years ago, in response to requirements of the 1956 highway act. The highway program and the vehicles in operation have significantly changed since then. The number of vehicles and traffic level have increased sharply; especially in urban areas. The traffic mix of autos, small trucks, and large trucks has also changed, as has their annual travel and rate of fuel consumption. Highway construction

costs and the relative magnitude of cost components, such as land and pavement, have likewise changed. Further, the direction of federal aid is changing: construction of high quality, limited access highways for the Interstate System was initially emphasized, but in recent years other programs have received a growing share of federal assistance.

Subsequent cost allocation studies have updated many of the data to reflect these changes. Current-year vehicle registration data, for example, have been used in each study. Because of time and budgetary constraints, however, certain inputs have not been updated. For example, the size of pavement cost increments has remained unchanged from the 1965 study through the 1975 analysis. Pavement cost increments should have been updated to reflect changes in travel by various classes of vehicles.

Even where the underlying data have been updated regularly, their reliability is questionable in several cases because of the estimation procedures employed. States provide the Federal Highway Administration with data on numbers of vehicles and travel by vehicle type, but their estimates are based on limited counts and surveys, which are subject to considerable sampling error. Variations in data collection among states also affect the reliability of data that have been updated. The only sources of reliable data were studies performed in the late 1950s.

ATTRIBUTION OF HIGHWAY REVENUES

This section describes the manner in which federal cost allocation studies have allocated tax payments into the Highway Trust Fund across vehicle types and classes of road users. Although the allocation of revenues might seem straightforward at first glance, most tax receipts have, in fact, been indirectly assigned to vehicle classes by one or another form of estimation. The fuel tax, for example, is neither paid directly by fuel users nor identified with those users. Rather, the seller of fuel pays the tax. Separate tax receipts from all gasoline, diesel, and other motor fuel sales are available, but the consumption of these fuels is not restricted to one class of vehicles. Thus, tax payments are not directly measured, even by general vehicle class; they must be allocated across vehicle classes by estimation.

Motor Vehicle Registrations

Motor vehicle registrations are the first data element used in previous cost allocation studies to estimate tax receipts by vehicle class. Motor vehicle registrations were originally classified in the 1965 study according to the following categories:

- o Visual type, for example, 3-axle single-unit trucks;
- o Gross weight, for example, 20,000 to 26,000 pounds;
- o Major user group (later dropped); private or for hire;
- o Type of fuel used, gasoline or diesel.

State registration data formed the basis for estimates of the number of motor vehicles in each class. In 1956, these estimates were augmented by portable-scale weight surveys and other visual counts. Table 6 shows the estimated level of motor vehicle registrations in each of the cost allocation studies, broken down by major vehicle type. 1/ Registrations reported in the 1965 cost allocation study were in fact estimates for 1964, which appear to be based on actual registration data through only 1962. Neither the 1969 nor the 1975 study provides details on the estimates of vehicle registrations for those years.

The number of autos has increased steadily, but autos as a percentage of all vehicles declined in the early 1970s. Single-unit trucks have shown

TABLE 6. NUMBER AND PERCENTAGE OF ALL MOTOR VEHICLE REGISTRATIONS BY VEHICLE CLASS, FOR SELECTED YEARS: IN MILLIONS

Vehicle Class	1965		1969		1975	
	Number	Percent	Number	Percent	Number	Percent
Autos	68.5	83.4	86.2	83.8	106.5	80.4
Buses	0.3	0.3	0.4	0.3	0.5	0.4
Trucks						
Single-unit	12.4	15.1	15.4	15.0	24.4	18.4
Combination	0.9	1.1	0.9	0.9	1.2	0.9
Subtotal	13.4	16.3	16.3	15.9	25.5	19.3
Total	82.2	100.0	102.9	100.0	132.5	100.0

NOTE: Components may not add to totals because of rounding.

1/ See Supplemental Report of the Highway Cost Allocation Study, 1965, p. 51.

rapid growth, especially in the early 1970s, and have grown as a percentage of the vehicle fleet, picking up the share lost by autos. The category of single-unit trucks includes vans, campers, pickups, and other small trucks, all of which grew rapidly; it also includes numerous dump, tank, and cement units of heavy gross weight.

As can be seen in Table 6, combination trucks account for a very small part of the vehicle fleet, less than 1 percent of the nation's highway vehicles in 1975. Combination trucks travel many miles each year, however, and occasion costs out of proportion to their numbers.

Gross weight and axle weight play an important role in pavement and structure cost allocation, but estimates of the distribution of trucks by gross weight in past studies were subject to considerable error. Many states register trucks based on empty weight, so additional studies and estimates were necessary to classify the available data into gross weight categories. In addition, the actual weight distribution data were based on a very limited sampling of trucks. Weight data gathered regularly for enforcement of maximum weight restrictions are so variable that hearings on their adequacy were held recently and the Secretary of Transportation subsequently cited a number of states for weighing an inadequate proportion of truck traffic. 2/Even where states record registrations according to gross weight, there may have been a built-in bias toward understating weight by those registering the vehicle.

Motor Vehicle Travel

The other crucial data element used in estimating tax receipts is travel by type of motor vehicle. Each state makes traffic counts biannually and conducts weight studies as well. In 1957, a particularly intensive study was conducted to increase the coverage beyond the normal traffic counts, since secondary roads and urban roads were not adequately represented in regular vehicle counts. Each state prepared an estimate of vehicle miles for 1957, which was subsequently "transformed into predicted values for calendar year 1964" in the 1965 study. 3/

2/ See the hearings before the Oversight Subcommittee of the Committee on Ways and Means, October 28, 1977, et seq, "Impact of Truck Overloads on the Federal Highway Trust Fund."

3/ Supplemental Report of the Highway Cost Allocation Study, 1965, p. 52. Travel data estimation was similar to the treatment of registrations.

Annual traffic counts were used to expand the detailed 1957 data on vehicle miles. Traffic counts, however, are more suitable for measuring trends in volume on specific road segments than for measuring vehicle miles by vehicle type. There may be a wide margin for error in these mileage estimates by class, since the only real check is total fuel tax collections.

Since 1966, the states have submitted more detailed estimates of vehicular travel by highway system in a standard annual report. 4/ Even so, estimates of vehicular travel used in the 1969 cost allocation study were prepared in a fashion similar to those in the 1965 study. Travel by visual class was distributed among weight classes, based on the same distribution used in the 1965 study, implying that no change in the weight distribution had taken place. The 1975 study neither discloses the sources of it travel estimates nor distributes travel by weight class. The 1975 distribution of travel by visual type nevertheless showed sharp travel increases for combination trucks, presumably reflecting the relaxation of federal weight restrictions in the 1974 Federal-Aid Highway Amendments.

Fuel Tax Estimates

Each cost allocation study has distributed fuel tax revenues accruing to the Highway Trust Fund among the various vehicle classes on the basis of the number of vehicles (motor vehicle registrations), the amount of travel, and the estimated fuel consumption per mile of each class.

The 1965 study obtained average fuel consumption in gallons per mile from detailed studies undertaken in the late 1950s and early 1960s. Fuel tax payments for each vehicle class were estimated by multiplying fuel consumption (gallons per mile), times vehicle travel (miles per year), times tax rate (cents per gallon). Estimates were then prorated to make estimated payments sum to actual payments. The fact that estimated payments of the gasoline sales tax were only 5 percent higher than actual payments suggests that revenue allocations in the 1965 study were reasonably accurate in aggregate terms, though considerable error for individual vehicle classes remains a possibility. Further, the components of the estimate were not independent, since travel estimates were based in part on fuel consumption figures.

Later studies used the estimated fuel consumption rates from the 1965 study without significant modification. The only modification was a

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4/ See U.S. Department of Transportation, FHWA, Highway Statistics (annual), Table VM-2.

slight upward adjustment in auto fuel consumption in the 1975 study to reflect the use of pollution-control devices in late-model automobiles. 5/But this was a period of declining fuel economy for small trucks and rising fuel economy for large trucks; thus, failure to update fuel consumption rates for trucks may have resulted in some overestimation of fuel tax payments by heavy trucks and some underestimation of fuel tax payments by light trucks. Table 7 suggests that the extent of error in estimating truck fuel consumption was significant but not huge.

Other Taxes

It is somewhat less clear how other taxes were allocated across vehicle classes. More care was taken in the allocation of fuel taxes because they produce more revenue. Allocation of the remaining taxes therefore may involve more error.

Tires. None of the cost allocation studies cite studies of differences in tire use among vehicle classes. The 1965 study divided vehicle miles traveled by autos by the number of tires sold during several different years to estimate the average life of a set of four tires. 6/ Tire tax payments were then obtained by multiplying the tire tax rate, times the estimated weight of tires, times the number of tires per vehicle, all divided by the estimated life of tires. This method of estimation rests on some weakly founded assumptions, and spreads the tire tax payments over all highway users, rather than current actual payees. Rough assumptions were also made regarding the use of retreads by autos and, separately, by trucks. Despite these problems, estimated and actual tire tax payments were in fairly close agreement in the 1965 study.

Tire-use rates from the 1965 study were adopted without modification in the 1969 study and with only minor modification in the 1975 study. The 1975 study assumed a 90-percent decline in the use of retreads and inner tubes on automobiles, but made no adjustment for the potentially more significant increased use of radial tires on automobiles. Failure to adjust for the longer life of radial tires probably resulted in an overestimation of automobile tire tax payments in 1975; still, the overall effect on revenue allocation is probably minimal, since the tax on tires is small relative to the motor fuels tax.

5/ U.S. Department of Transportation, FHWA "Allocation of Highway Cost Responsibility and Tax Payments, 1969," p. 64.

6/ Supplemental Report of the Highway Cost Allocation Study, 1965, p. 309.

TABLE 7. ESTIMATED TRUCK FUEL ECONOMY BY GROSS VEHICLE WEIGHT AND FUEL TYPE FOR SELECTED YEARS: IN MILES PER GALLON

Gross Vehicle Weight Class (in thousands of pounds)	Gasoline		Diesel	
	1957 a/	1972 b/	1957 a/	1972 b/
Less than 6	12.4	11.3	12.3	11.7
6-10	10.8		9.6	
10-14	9.0	7.1	7.5	7.1
14-16	8.2		6.5	
16-19.5	7.8		7.2	
19.5-26	7.2	5.8	6.2	7.0
26-33	5.9		5.6	
33-40	5.4		4.9	
40-50	5.1	5.3	5.2	5.7
50-60	4.7		5.7	
60 or More	4.1		4.6	

a/ Third Progress Report of the Highway Cost Allocation Study, H. Doc. 91, 86 Cong., 1 sess. (March 2, 1959). Data were recombined to conform to these weight classes. Quoted in Jack Faucett Associates, "Trucking Activity and Fuel Consumption 1973, 1980, 1985 and 1990," prepared for Federal Energy Administration, 1976, p. 59.

b/ American Trucking Association, Inc., Department of Research and Transport Economics, unpublished tables on truck travel and fuel consumption, 1972 average for all driving cycles. Quoted in Jack Faucett Associates, "Trucking Activity and Fuel Consumption 1973, 1980, 1985 and 1990," prepared for Federal Energy Administration, 1976, p. 59.

Excise Taxes. Excise tax payments on truck, bus, and trailer purchases were estimated from sales prices of representative vehicles in each class of commercial vehicle. However, instead of allocating across vehicle classes according to actual payments, the receipts were allocated to all eligible vehicles. That is, truck excise taxes collected in a given year were allocated across the entire truck fleet. The effects of inflation and of changes in vehicle composition were ignored in the process. In particular, older vehicles were credited with higher taxes than they actually paid since their excise tax payments were in fact based on lower purchase prices. If the tax payments of each vehicle class were calculated independently, this estimation procedure would have little effect on the ultimate results. If, on the other hand, aggregate figures were used and tax receipts were redistributed across classes as a result of this factoring in of the entire truck fleet, then recent increases in light, single-unit truck sales would have generated excise tax receipts that were assigned to other classes. 7/

Highway-Use Tax. The final tax considered here is the highway-use tax on heavy vehicles. By statute, this tax is collected only from users with vehicles exceeding 26,000 pounds in gross weight, and is based on gross weight. The estimates of tax payments in past highway cost allocation studies were also based on gross weight. Yet, the schedule used by the Internal Revenue Service bases tax payments on empty weight coupled with a presumption of normal load. 8/ Similar vehicles pay the same tax, whether they normally carry light or heavy loads, and that tax does not increase with gross weight beyond a certain ceiling established by the unloaded weight. Thus, for example, a 3-axle, single-unit truck with an unloaded weight of more than 16,000 pounds is assessed $120 irrespective of actual load.

The 1969 highway cost allocation study showed 227,000 3-axle, single-unit trucks in the 40,000 to 50,000 thousand pound category, and the 1975 study showed 345,000 of those vehicles over 40,000 pounds. Heavier vehicles of this sort clearly are not paying the tax called for by the statute, but they have nonetheless received credit for tax payment in the cost allocation studies by virtue of the estimation procedure employed.

7/ Such a misallocation seems doubtful, but the assignment mechanism is not clear in the 1965 report. The same problems would apply to tire taxes, which were also spread across the entire fleet.

8/ Internal Revenue Service, Publication 349, Federal Highway Use Tax. The IRS position, which has been sustained in the courts, argues that the actual gross weight would be impossible to monitor effectively.

Adjusted Estimates. Adjustments were made to each subset of estimated tax revenues to bring the estimates in line with actual tax collections. Estimated tax revenues were simply prorated on the assumption that no systematic error existed across vehicle classes. In the 1965 study, aggregate gasoline tax receipts were estimated to be 5 percent higher than actual collections, close enough to provide some assurance that prorating estimated receipts by vehicle class would provide a valid estimate of actual receipts. The estimate of aggregate diesel fuel tax receipts, however, fell short of actual collections by more than 50 percent. A simple, across-the-board adjustment may not have allocated tax receipts across classes of diesel users in the right proportions since the procedure used to estimate fuel-tax payments must have been seriously in error for at least some classes. Another large and troubling discrepancy in the 1965 study appeared in the heavy-vehicle use tax; the estimated tax payment of one particular vehicle type was found to exceed the actual payment by 44 percent. 9/ This discrepancy suggests, in addition, that the IRS heavy-vehicle use tax formula is less significant than the statutory standard of taxation based upon gross weight demands.

ALLOCATION OF HIGHWAY COSTS

The allocation of highway costs has involved, first, the categorization of highway costs by work item and, second, the allocation of costs by work item across vehicle classes. But federal-aid highway expenditures are nowhere categorized by FHWA exactly as required for purposes of cost allocation. Thus, some degree of approximation is inherent in the allocation of highway costs.

Federal highway cost allocation studies have divided total highway costs into four cost categories:

- Right-of-way, utility adjustment, roadside development, and traffic and pedestrian services,
- Grading and drainage,
- Pavement and shoulders, and
- Structures.

9/ Department of Commerce, Bureau of Public Roads, Supplementary Report of the Highway Cost Allocation Study, H. Doc. 124, 89 Cong. (1965).

The first cost allocation study based its breakdown of federal-aid highway costs on projections from the 1957 highway needs study. States had estimated expenditures by type of road, roadway element, and work item for the period between 1956 and 1971. The first cost allocation study prorated estimated expenditures for the entire period to bring them in line with actual tax payments in 1964, the midyear of the projected expenditure period. The second cost allocation study did the same, but with 1969 tax payments serving as the benchmark.

State estimates of highway needs have not proven particularly reliable; this casts doubt on the highway expenditure data used in these studies. State highway engineers have difficulty estimating the cost of work items on current projects put out for bid, let alone projects several years into the future. Further, they have no way of knowing precisely what mix of projects will be funded in future years. For example, high performance federal-aid highways designed for 20-year lives often require resurfacing in less than 20 years. Finally, state highway engineers do not know precisely how inflation will affect the relative cost of work items in future years. The cost of highway paving has escalated faster than the cost of highway grading, and the cost of highway grading has escalated faster than the cost of bridge construction. All of these factors cast doubt on the validity of data from the 1957 highway needs study.

The 1975 analysis improved on previous studies by using actual rather than projected highway cost information. The breakdown of highway costs by road type, roadway element, and work item was obtained from computerized files on current project costs. This date source had its shortcomings, too, however.

First, the breakdown of costs in project information files was and is based on estimates prepared by state highway engineers at the time projects are initiated. It is not uncommon for estimated and actual project costs to differ by 25 percent or more. Cost estimates for individual work items are even less precise.

Second, the breakdown of costs in project information files is not complete. Some activities, such as right-of-way acquisition and utility adjustment, are always broken out as separate work items. But other items, such as grading and drainage, are generally lumped in with pavement construction, and hence they must be broken out, a process which is approximate at best. The 1975 study assumed that grading and drainage costs constituted 20 percent of itemized pavement costs, and that the costs of other activities combined with pavement construction, including certain roadside development and traffic service activities, were negligible.

Finally, the breakdown of costs in the project information files is based on project obligations rather than on expenditures. Obligations can, of course, differ markedly from expenditures in any given year because obligations on multi-year highway projects are liquidated over many years. In effect, then, the 1975 study was comparing payments into the trust fund in 1975 with payments out of the trust fund over a period of years, years that might not reflect costs occasioned in 1975.

Once highway costs were broken out as described above, federal cost allocation studies assigned the cost of work items to vehicle classes by the incremental method. (See Appendix A for a full discussion of this method.) The 1965 study based the assignment of pavement and shoulder costs on engineering judgments and pavement performance equations derived from a test on experimental roads; it based the assignment of bridge costs on typical bridge designs prepared by study staff engineers; and it based the assignment of all other costs on a survey of state highway design practices. Cost assignments were specific to the highway technology of the early 1960s and to the estimated mix of traffic and expenditures on federal-aid highways in 1964.

The credibility of these cost assignments was undermined by the heavy reliance on survey results and engineering judgments. Lacking detailed cost information, the study staff tended to assign costs to the basic or common cost increment, although certain costs are, in fact, unequally occasioned by vehicles of different types. For example, extra grading is often done in mountainous areas to accommodate trucks with low power-to-weight ratios. Yet the survey of state highway design practices, upon which grading and drainage cost increments were based, obscured such subtle distinctions and all normal grading costs were assumed to be common costs. Heavy vehicles were undercharged for such costs.

The cost assignments used data from experimental roads conducted under very special conditions, which might limit their general application. For example, all experimental vehicles traveled at 35 mph, causing greater deflection of surfaces than would occur at higher speeds. Only one soil type was represented at the test site, a soil with less than average carrying capacity. Only one climatic pattern was represented at the test site, a pattern atypical of most of the United States. And the test lasted only two years, not long enough for climatic damage to highways to be fully manifested. Nevertheless, the results were applied without modification to highways in all parts of the country. The use of those equations without modification for long-term climatic effects may have understated the proportion of costs which are common to all vehicles. In this case, heavy vehicles may have been overcharged.

Resurfacing of highways and reconstruction of bridges have absorbed an increasing proportion of total federal-highway expenditures in recent years. Resurfacing alone has increased from about 2 percent of federal expenditures in 1970 to almost 10 percent in 1975. Relative to construction of new pavements and bridges, these growing programmatic activities have a smaller component of common cost because the largely common costs of pavement base and subbase, and bridge substructure construction are not incurred in resurfacing or bridge reconstruction. The failure to distinguish between rehabilitation-oriented activities and new construction may have caused the 1969 and 1975 studies to underestimate the cost responsibility of heavy vehicles.

The use of prestressed concrete and high-strength steel in bridges, and air-entrained concrete and stabilized-base courses in pavements, has become standard practice over the years. Bridges and pavements built with these new techniques are better able to withstand extreme loads. If survey and test results had been updated, the cost increments attributable solely to heavy vehicles might have been reduced, tending to offset the previously discussed misallocation of resurfacing and bridge reconstruction costs.

CONCLUSIONS

In general, both the data base and the allocation methods employed in past federal cost allocation studies seem to raise as many questions as they resolve, leaving considerable doubt as to the actual revenues and costs attributable to various vehicle classes in recent years.

The allocation of tax revenues, for example, has involved a considerable degree of estimation. Much of the basic data have not been updated over the years. For example, fuel-economy data collected in the 1950s were used to allocate motor fuel taxes in the 1965 and 1969 studies, and with only marginal adjustments, in the 1975 study. Estimates of annual vehicle mileage have probably improved, but they are derived primarily from state traffic counts that vary considerably in reliability.

Problems exist in the allocation of other tax revenues. The federal use tax on heavy vehicles is paid by empty weight but allocated across vehicle classes on the basis of operating weight. The operating weights are themselves based on state weight records, and recent Congressional hearings have shown that state performance in weighing trucks varies widely.

The assignment of costs was based on survey and test results that were not especially reliable when first applied to highway cost allocation in the early 1960s. Those results have become even less reliable over time,

due to changes in highway technology and in the mix of traffic and expenditures on federal-aid highways, changes neglected in subsequent cost allocation studies.

Many of these data problems could be alleviated by a new cost allocation study. In particular, more current data could be collected and, where estimation is required, improved estimation techniques could be used. Although serious data problems are likely to remain, regardless of the approach taken, data improvements alone could lead to more accurate and reliable study results.

CHAPTER V. SETTING THE SCOPE OF A NEW STUDY

If a new cost allocation study is undertaken, its scope should be drawn carefully to ensure that the findings will be useful to the Congress in developing an equitable set of highway taxes. This chapter identifies and discusses five choices that must be made in setting the scope of a cost allocation study. Each one of these choices can influence study conclusions and thus each can, in turn, affect the level and type of highway taxes imposed. If an equitable and useful study is to be forthcoming, it is essential that these choices be made at the outset on the basis of their technical merits. If these choices are not made in the initial stages of the study, then a wide range of findings could emerge, and the selection of the preferred procedure could be influenced by comparisons of the answers that each method produces, rather than by their inherent merits. Such pressures could unnecessarily influence the results of a cost allocation study. Failure to set the ground rules at the outset could weaken the application of study results.

In view of the above concerns, a request for a new cost allocation study should ensure that the following questions are answered early in the process:

- Should a new cost allocation study be based on all highway expenditures by all levels of government, or just on those of the federal government?
- Should costs be allocated on the basis of the costs occasioned by each user group or on the benefits that each derives?
- Should the costs of providing roadway access to nonusers be separated from the costs occasioned by highway users?
- Should indirect costs of highway use (such as air pollution) be reflected in the allocation process and in the resulting user taxes?
- Which of several available techniques should be adopted by a new cost allocation study?

WHICH ROAD SYSTEM SHOULD BE STUDIED?

Roads are constructed by federal, state, and local governments and maintained primarily by state and local governments. The procedures, problems, and results of a cost allocation study depend in part on which roads and which highway-related expenditures are analyzed. Past federal cost allocation studies have focused primarily on the federal-aid highway system and on construction costs. The 1969 study included some state and local highway expenditures, including maintenance and administrative costs; maintenance costs were considered separately in the 1965 study.

A major choice in defining the scope of a new cost allocation study turns on the questions of whether the study should be limited to federal expenditures, or whether it should be expanded to include all roads and all related expenditures by every level of government. An analysis of only federal expenditures implies a limited scope, including principally construction and RRR activities. An all-inclusive study would include numerous maintenance activities, such as filling potholes and mowing grass, as well as construction of the multitude of state and local roads that are not on the federal-aid system. Inventories and other records are, however, much less detailed for state and local roads.

From a Congressional point of view, the Highway Trust Fund revenues are used primarily for the federal-aid system, and that is the only highway system over which the Congress has direct influence. Although there may be a common national interest in ensuring that user taxes are assessed equitably across all road systems, increasing the scope of a cost allocation study does not guarantee overall equity, however, because the Congress does not control user charges imposed by state and local governments. Nor would a comprehensive federal study of all road systems necessarily provide an adequate basis for setting state taxes, because state traffic and highway costs may vary markedly from the national averages. Furthermore, the states may wish to emphasize a different set of objectives than those adopted by the federal government in their highway financing procedures.

Nevertheless, there are conceptual drawbacks in considering only federal expenditures or only the federal-aid system. The full costs of a road over its useful life include construction, RRR activities, administration, policing, and routine maintenance, and only part of these costs are federally financed. In principle, highway users should pay for the full, life-cycle costs of the roads they use. A study limited to only federal highway expenditures would thus miss an important portion of highway costs. Nonetheless, as the federal government assumes a greater role in RRR work, the significance of this drawback would be reduced.

Although some theoretical advantages are to be gained by including all highways in a new cost allocation study, such a study poses serious practical problems. The data collection problems of an all-inclusive study are much greater in scope, more complex, and likely to require many years to resolve. For example, highway-related tax receipts must first be collected for all 50 states as well as for all local governments and then allocated to major vehicle groups--a serious technical problem at the federal level alone. Similarly, data on all categories of highway expenditure must be collected for every type of road and then allocated by type of vehicle. This task is made more difficult by the lack of the uniform reporting standards and recording practices that characterize federally financed highway projects.

In sum, if a new cost allocation study is to be timely, it probably should be restricted to the federal expenditures for roads. It is not clear that extending its scope to include all roads and all road-related expenditures would lead to more equitable federal or state taxes. In addition, consideration could still be given to a more comprehensive study, to be completed much later.

SHOULD ALLOCATION BE BASED ON COSTS OR BENEFITS?

Should the tax burden be determined by the highway costs attributable to each user class, or should it be determined by the benefits accruing to each user class as a result of public highway expenditures? That is, should the taxes be based on costs incurred? Or, should the taxes be based on the ability and willingness of the various user classes to pay? This is clearly related to a question that arises repeatedly in public regulation of transportation prices: Should prices be based on the cost or on the value of service?

The 1956 highway statute poses some ambiguity concerning Congressional intent in this regard, because Section 210 requested an investigation and report to the Congress on the proportionate share of highway costs attributable to different user classes and further stated that the proportionate share was to be based on: (1) the effects of the use and frequency of different vehicles; and (2) the benefits derived from such use. The Congress has not taken an explicit position on the proper method for allocation of cost, except to require that federal costs be offset by highway-related receipts. The appropriate basis for cost allocation was debated during the 1961 highway legislation, but the compromise legislative solution imposed neither a cost-based nor a benefit-based cost allocation.

Benefit-Based Taxes

The appeal of a benefit-based allocation is that highway users deriving the greatest benefits from federal highway construction activities would pay a proportionately higher share of federal highway taxes. On the assumption that the value of a highway project to its users would exceed the costs incurred by the federal government--that is, that the project would be a worthwhile one--the implication is that some net benefits would accrue to the government. The government would, however, have to impose highway taxes to recapture the benefits, and payments would generally bear a different relation to cost for each user class. Thus, in order to capture all of these benefits, a highly complex and highly differentiated tax structure would be required.

Selection of this approach by the government has not been common. Indeed, the earliest involvement of the federal government in transportation policy was to restrict private pricing practices, particularly discriminatory tariffs. For example, the Interstate Commerce Commission was established primarily to regulate the railroads and to restrict their ability to charge rates which reflected the value of service to individual users.

Nevertheless, the government need not charge taxes that would extract the entire amount of benefits. Taxes could be scaled down so that tax payments were in proportion to benefits and just equivalent (in total) to expenditures. Such a scheme could easily conflict with a cost-occasioned tax structure, and it would by definition contain a considerable degree of tax differentiation among users. The fineness of differentiation and the number of different tax classes utilized would be very difficult to establish. For example, auto travelers might be differentiated by income class, by family status, or even by recreational habits. It is likely that nonessential travel (such as sightseeing trips or recreational journeys), which tends to be price-sensitive, would thus pay very little in taxes, whereas more essential travel (such as work trips or school trips) would be taxed heavily. Such an outcome may conflict with other government objectives.

Benefit-based taxes would also be difficult to administer for freight vehicles. Because of large variations in the value of truckloads and in the value of truck services, benefit-based truck taxes would have to be specified separately for each commodity and for each destination as well. The complexity of such a scheme is a serious drawback.

One of the principal benefits of highway improvements is reduced travel time. These time savings do not necessarily reflect financial savings, especially where the time saved represents increased leisure time for the motorist. This is particularly true of auto users, who are generally not

engaged in commercial activity directly associated with their use of the auto. In trucking operations, however, the time savings generated by improved highways can often be measured as direct financial benefits resulting from decreased wages, increased productivity, or reduced inventory costs. Thus, commercial users of highways may capture financial benefits while the more numerous private individuals are capturing time savings whose value is not easily determined. In general, drawing up an exhaustive list of benefits is difficult, and calculating the monetary value of such benefits as time savings is extremely dubious.

In short, the imposition of charges or taxes based on benefits by user class seems fraught with practical problems, and contains a number of conceptual difficulties as well. Problems of estimating benefits by user classes have led to their exclusion from recent federal studies of cost allocation.

Cost-Based Taxes

User taxes based on costs occasioned by different classes of highway users have strong foundations in economic theory and they also reflect behavior in the private sector. In principle, taxes can be based on costs in a way that ensures that the benefits to society will be as great as possible while still defraying the costs, and that each user's decisions about how much transportation to consume will reflect society's cost of providing the service. Setting aside the issues of side-effects (for example, pollution) and of non-user benefits, highway users would pay a share of highway costs corresponding to their impact on design, construction, and maintenance costs.

The imposition of charges or highway taxes on the basis of the costs occasioned by users has several appealing features. Users are encouraged to pattern their use relative to the costs associated with it. It is an equitable approach, since no class of vehicles is required to pay for any other class. It is also an efficient approach, according to economic theory.

Favoring cost-based charges does not, however, solve the problem of identifying the proper level of charges. It is difficult to translate the philosophical decision to base taxes on costs into an empirical tax schedule. Two general problem areas can be identified: the identification of costs occasioned by each user class, and the assignment of common costs.

The second area represents an especially severe problem, for the attempt to trace and identify directly the costs occasioned by each user class falters when the issue of common costs is encountered. Common costs

are costs that are not attributable to any single class of vehicle, but are the joint responsibility of all vehicles using the road. For example, the costs of traffic signals are common costs because cars, buses, trucks, and all other highway vehicles need them equally. In past highways studies, the proportion of costs found to be common costs has been very high and the method by which they are allocated has had a profound effect on the study results.

Although this approach raises a number of problems, on balance, the cost-based approach seems more tractable than any benefit-based approach. It is also more easily understood and probably stands a better chance of being accepted as equitable.

SHOULD ACCESS BENEFITS AND COSTS BE ADDRESSED?

Some of the costs of building highways, and some of the benefits derived from them, are attributable to the persons or activities located along the road. Although many of the benefits of access to and from a roadway are paid for by their beneficiaries through charges on the use of the road, some may not be. For example, many local streets carry insignificant amounts of traffic, but play a crucial role in furnishing the nearby property owners with access to the overall road network. Such access benefits, and their associated costs, pose problems in cost allocation because they may imply that some highway costs are traceable to nonusers.

The Congress specifically included roadway access benefits among the benefits to be investigated when it called for a cost allocation study in the Highway Revenue Act of 1956. The resulting study, however, investigated the costs occasioned by access, rather than the benefits derived, primarily because of the difficulties of measuring benefits and identifying beneficiaries. Subsequent federal studies have virtually ignored access cost responsibility, on the assumption that access costs have remained small and nonuser benefits are still not quantifiable.

Both assumptions are probably valid. In the 1961 cost allocation study, nonuser costs occasioned on federal-aid highways were estimated to be 7 to 18 percent of total costs as compared with 2 to 6 percent of all costs for the Interstate and primary systems. Nonusers were assigned a much larger responsibility for the costs of the secondary system, but the practical significance of this is diminished by the recent functional realignment, which sharply reduced the federal-aid secondary mileage.

The benefits of improved access could, of course, be much larger than the costs occasioned by it. Highway improvements cause changes in the way land is used, raising productivity and standards of living above and

beyond any reduction in transportation costs. Unfortunately, it is difficult to estimate these added benefits without double counting, and it is also difficult to link these benefits to their ultimate beneficiaries. Interindustry economic forecasting models could be helpful, but these models are very sensitive to underlying assumptions and focus exclusively on the transportation of goods, neglecting passenger transportation. Thus, there is probably no way to arrive at reliable and all-inclusive estimates of nonuser benefits.

In any case, access benefits may not be of overriding practical significance in highway cost allocation for a number of reasons. First, expenditures on the federal-aid system are increasingly for RRR-type activities, which do not have much impact on economic development, land use, and land value, relative to the impact of new construction.

Second, access benefits may accrue largely to the same individuals and organizations benefiting from the use of highways. Most access benefits are gained only through highway use. Of course, some access benefits accrue to others. For example, shopping centers at freeway interchanges are beneficiaries, but their customers pay most of the highway-user charges. Similarly, factories near an Interstate highway enjoy access to markets, but the motor carriers that serve them pay the highway charges. Even in these examples, however, the nontraveling beneficiary of highway access may effectively pay the related costs. For example, as tax payments by trucks are passed along through the rate structure, shippers ultimately pay for their access benefits.

Finally, it is not clear that any practical, federally imposed tax could capture access benefits any better than an equitable mix of user taxes. Taxes designed to capture increases in land value have proven unpopular and difficult to administer. Alternatively, using general fund revenues to underwrite the nonuser-occasioned costs of the federal-aid highway system might be less equitable than reliance on highway taxes.

In summary, further analysis of access benefits could be helpful, but there appears to be little merit in making this a major focus a new cost allocation study.

SHOULD INDIRECT HIGHWAY COSTS BE INCLUDED?

Highway improvements may produce significant benefits that are only indirectly related to highway use, and they may also produce significant costs. Indirect benefits were investigated in the first federal cost allocation study, but indirect costs, such as traffic noise and air pollution, were not included.

Since the passage of the 1956 Highway Revenue Act, awareness of indirect costs has grown, and costs occasioned indirectly could be considered an important component of total costs. Air quality in urban areas has deteriorated significantly during the past two decades, and motor vehicles have been major contributors to that deterioration. Vehicle emissions damage both health and property. Vehicle-related noise, highway-related urban blight, and transportation-induced activity relocation have similarly increased during the past two decades, as limited-access highways were constructed in urban areas. Neighborhood opposition to highway construction has become increasingly intense, reflecting these indirect costs.

Congressional concern about these highway-related problems has increased. Legislation aimed at curbing air pollution from motor vehicles was enacted in 1965, and legislation aimed at reducing fuel consumption was enacted ten years later. Relocation assistance for persons displaced by federal-aid highways was authorized in 1962, and funding for noise abatement measures on existing federal-aid highways was authorized in 1973. Assessment of the social and environmental effects of highways became a requirement under the Federal-Aid Highway Act of 1968, and highway noise standards were introduced in the Federal-Aid Highway Act of 1970.

In sum, Congressional concern over the indirect costs of highways has grown since the first highway cost allocation study was requested. The increased significance of indirect costs raises the question of whether they should be included in determining the cost responsibility of users. Their inclusion would probably have little effect on the environmental, noise, or disruption problems themselves, because highway use is affected only slightly by fuel and other taxes. In the past, the Congress has generally dealt with such problems through regulation rather than through pricing measures.

Nevertheless, highway charges would be more equitable if they reflected indirect costs, and it may be useful to explore further the practicality of doing so. To take air pollution as an example, some studies have found relationships between selected pollutants and damage to property and health; a few have even estimated the dollar value of that damage in terms of medical cost or decline in property value. Yet, so many factors affect property values and health that it continues to be very difficult to isolate the effects of air pollution.

The indirect costs of highway usage have become apparent and should not be ignored. But these costs could take much longer to investigate than direct costs, and they can never be estimated with as much precision. Therefore, indirect costs might best be investigated in a supplemental study. Such a study should indicate to the Congress the relative magnitude of

indirect costs and the extent to which different classes of highway users occasion them.

WHICH COST ALLOCATION TECHNIQUES SHOULD BE USED?

The allocation of highway costs among different classes of users has been performed in several different ways by federal and state governments. Of these, three general techniques stand out as particularly significant:

- o Occasioned-cost methods,
- o Benefits-derived methods, and
- o Simple-factor methods.

The line between these approaches is not always clear because of numerous variations, but fairly distinct principles guide each technique.

Occasioned-Cost Methods

Occasioned-cost methods assign to each user group all costs for which that group alone is responsible and a share of the costs for which all vehicles are together responsible. The incremental cost technique is the best known of all occasioned-cost methods, and it has been the chief approach relied upon in federal cost allocation studies and in numerous state studies. This technique is built on the recognition that heavy and large vehicles often require special highway features, and it allocates the costs of these special features to the vehicles that occasion them. The three federal cost allocation studies have progressively increased their dependence upon the incremental method.

Benefits-Derived Methods

Another family of techniques distributes total costs among users on the basis of the benefits derived, as opposed to the costs occasioned, by each class. The best known version of this approach, the differential-benefit method, allocates the costs of improvements in roadway design (such as the addition of lanes to increase speed or the realignment of routes to reduce travel distance) among users according to the value of the benefits received by each user group. For example, the costs of a reduction in travel distance would be allocated among users in proportion to the value of the travel time saving that each received. The 1965 federal cost allocation

study applied this technique as well as the incremental cost method, but difficulties in attaching values to benefits have generally reduced reliance on this technique.

In a recent study of highway cost allocation by the Urban Institute, 1/ a benefit-based technique known as the inverse-elasticity method was used in conjunction with the occasioned-cost technique. The inverse-elasticity method distributes the costs among users in proportion to their willingness to pay, as reflected by the observed responses of different user groups to increases in highway-user charges. This benefit-based method has not been used in any federal or state studies of highway cost allocation.

Simple-Factor Methods

Simple-factor methods involve the allocation of costs by a single measure, generally related to system use, for example, vehicle ton-miles. These methods have been used in some states, primarily because of their simplicity. Such techniques have only once been examined in federal cost allocation studies, and it is generally believed that far greater refinement can and should be obtained by using other methods.

Considerations Influencing the Choice of Technique

The occasioned-cost method has probably gained the greatest public and legislative acceptance as the technique that can best operationalize the principle of equity--that is, the principle that any roadway users that require special public expenditures on their behalf should pay for those expenditures. Just as the user-pays principle has become a cornerstone of the nation's policy on highway finance, so too has the occasioned-cost method become the conventional way of extending this principle so that each user pays an appropriate share. For example, heavy trucks should pay for the costs of the thick pavement, extra-wide lanes or the high bridge clearances that they require, while cars should pay most of the costs of the extra lanes needed to carry predominantly automobile traffic during rush hours in congested urban areas.

The incremental cost method that was used in previous federal cost allocation studies comes fairly close to assigning costs to the roadway users

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1/ Kiran Bhatt et al., Congressional Intent and Road User Payments, The Urban Institute, March 1977.

that occasion them. The chief problem with this method, however, is that it departs from the principle of occasioned costs in two ways. First, it does not account for costs occasioned by any factor other than increased size and weight. For example, the cost of the extra freeway lanes needed to carry rush hour vehicles--mostly automobiles--are not proportionately assigned to automobiles.

Second, and more significant, the incremental method takes far too narrow a view of occasioned costs, relying exclusively on engineering estimates of the additional construction costs associated with different facilities and ignoring the functional reasons for undertaking construction projects. For example, in allocating the costs of building a bridge, the incremental method assigns to heavy trucks the costs of the additional structure, width, clearance, and pavement thickness that are required to design and build the bridge for trucks, over and above those needed to design and build the bridge for cars. But if a bridge now exists where a new one is contemplated, and if that existing bridge could adequately carry automotive traffic indefinitely, then the entire cost of replacing that bridge is occasioned by heavy vehicles. Similarly, if a road must be resurfaced with at least three-quarters of an inch of pavement because a lesser amount would not bind to the original surface, and if that minimal thickness is sufficient to serve heavy vehicles as well as cars, the incremental method assigns no costs exclusively to heavy vehicles. But if a heavy truck does several thousand times as much damage per load application as a car, then each truck mile occasions as much cost as several thousand automobile miles over the life of the facility. In brief, as these examples illustrate, the reliance of the incremental method on an engineering-based method of assigning costs tends to ignore some relationships that become apparent only when allocations are based on the function or actual use of the highway improvement.

More understanding is needed concerning how different types of vehicles occasion highway-related costs, and this necessarily involves gaining more knowledge about the factors other than traffic that occasion the need for improvement projects. An important element in any new cost allocation study should be a detailed assessment of how costs are related to traffic, environment, and other factors. For example, the interaction of traffic and weather to create pavement damage bears further investigation, as does the linkage between the need for special new programs (such as bridge replacement), and particular vehicle classes. Such special investigations would be useful in improving the allocation of highway costs to individual classes of vehicle.

Common Costs

Even when such studies are completed, however, there will continue to be a pool of common costs--highway costs that cannot reasonably be attributed to any single vehicle class. For example, the costs of the right-of-way, most roadside signs, and many safety improvements are occasioned jointly by all classes of vehicles. Further analytical studies can reduce the proportion of overall highway costs that, for want of any reasonable alternative, must be classified as common costs, but it cannot eliminate them entirely.

It is the treatment of common costs that poses the greatest philosophical and analytical difficulty. The incremental method used in previous federal cost allocation studies resulted in the assignment of 81 percent of all system costs as common costs. 2/ Although not directly comparable, the recent Urban Institute study applied a somewhat broader interpretation of occasioned costs and found that 75 percent of all costs were common costs. 3/ This high percentage of costs found to be common in all studies suggests that a sizeable pool of common costs is to be expected, no matter how thoroughly the matter is studied.

The allocation of common costs is thus apt to be crucial in determining who pays for roads. But economic and public finance theory are ambiguous concerning how this allocation should be made. A variety of approaches have been proposed and applied; none can claim to be distinctly superior in every respect—theoretical justification, empirical validity, appeal to fairness, and prior acceptance in practice. The choice among techniques for allocating common costs will continue to be a difficult one, but it need not be made before other parts of a new cost allocation study are begun. Should the Congress conclude that a new cost allocation study is warranted, the advantages and disadvantages of different techniques for allocating common costs should be evaluated in order to determine which technique or techniques to use.

2/ This figure is the percentage of costs attributed to the basic roadway under the incremental method in the 1965 cost allocation study. It tends to overstate the share of common costs, since, as noted in this section, some of these costs are occasioned costs that could, under a broader interpretation of cost responsibility, be attributed to specific vehicle classes.

3/ Bhatt et al., Congressional Intent and Road User Payments.

CHAPTER VI. IS A NEW COST ALLOCATION STUDY NEEDED?

There have been numerous changes in highway programs, road design standards, vehicle dimensions, traffic mix, and engineering procedures since a federal highway cost allocation study was first called for in 1956. Subsequent studies of highway cost allocation have only partially reflected these changes, and more refinement is both possible and desirable.

The federal-aid highway program is likely to grow in the future, and additional taxes will probably be needed to finance that growth. For example, this paper estimates that financing the proposed Surface Transportation Assistance Act (H.R. 11733) would require a 38-percent increase in highway-user taxes. Whether or not this particular proposal is adopted, the pressure for expanded highway programs, and thus for increased motor vehicle-user taxes, will mount in future years. In addition, improvements in fuel economy will curb the increase in the revenues from current taxes on motor fuels, and inflation will erode the purchasing power of the Highway Trust Fund. Continued pressure for increases in highway-user taxes thus appears likely. Should the Congress choose to impose increased highway taxes, in order to impose them equitably, it will need to know how highway costs should be apportioned among different classes of vehicles. Collecting the requisite information requires complex studies, which could take several years to complete. Furthermore, the federal government appears to be assuming increasing responsibility for preservation of the highway system, in that it is currently financing some RRR and bridge repair activities formerly assumed by the states. Even if the practices conventionally employed for allocating costs are used, it appears that cost responsibility by vehicle class should be revised to fit these new programs. In addition, conventional techniques could be considerably improved by a new cost allocation study that is carefully geared to today's practices, programs, and capabilities.

The cost allocation methods now in use also rely on data regarding traffic and construction activities that are often outdated or unreliable. Some components of the allocation process--vehicular fuel economy for example--have not been significantly updated or refined since the first cost allocation study was begun more than twenty years ago. Moreover, alternative cost allocation techniques have been developed, enabling the application of techniques that have greater conceptual soundness.

Yes, A New Study Is Needed

On balance, then, a new study of highway cost allocation is needed for several reasons. First, a well-founded description of cost responsibility by each class of vehicles is essential if new highway taxes, which will likely be required in the near future, are to be imposed equitably. Second, current legislative proposals emphasize new highway programs whose cost responsibilities appear to differ markedly from previous programs. These differences raise questions about cost responsibility that cannot be answered by reference to previous cost allocation studies. Third, existing cost allocation studies were based upon information about traffic composition, fuel economy, and construction costs that is now sometimes outdated or unreliable, and they used procedures that were unnecessarily restrictive. Changes in the underlying information base have probably eroded whatever balance originally existed between costs occasioned and tax payments. Finally, some changes for the future are predictable---for example, mandated improvements in fuel economy--and they should be recognized when setting new taxes. Most of these failings could be substantially reduced by a major new study of highway cost allocation.

Guidelines For A New Study

The studies available now do not provide a sufficient basis for a reliable and equitable assignment of costs to the various classes of highway users. A new study should be carefully focused to provide information that is both sound and appropriate; otherwise, there is a substantial risk that findings will be inconclusive or inapplicable. There are various ways to steer such a study in a useful direction, and each has particular strengths and weaknesses. Experience suggests that the following general guidelines would improve the effectiveness of a new study:

- Only the costs of highways borne by the federal government should be examined, leaving examination of the costs of other systems to lower levels of government.

- The study should address the costs occasioned rather than the benefits derived by each user group, since the former approach can be done less ambiguously than the latter and coincides with past practice.

- The benefits gained and federal costs occasioned by property owners and other nonusers should not be a major focus of a new study, because property access is most often provided by non-federal-aid systems and the beneficiaries are commonly highway users.

- o The indirect costs of roadway use should be weighed in a supplementary study, but because of measurement and evaluation problems, they should not be factored directly into highway cost allocations.

- o The cost allocation study should be conducted on the basis of costs occasioned by each class of vehicle. Some initial guidelines on study methodology could help ensure that this study is both timely and appropriately focused.

If the above general guidelines are adopted, the resulting cost allocation will not necessarily bear more heavily, or less heavily, on any class of vehicle than the current cost assignment. These guidelines would, however, help to set before the Congress a thorough review of current data on highway costs and the ways in which they can be most equitably assigned to each vehicle class.

APPENDIX

APPENDIX A. REVIEW OF PAST FEDERAL COST ALLOCATION STUDIES

BACKGROUND

The Highway Revenue Act of 1956, which established the Highway Trust Fund, called for a cost allocation study to determine what taxes and tax rates would ensure, insofar as practical, an equitable tax burden on highway users and other beneficiaries of federal-aid highways. Although the concept of what is equitable depends on personal values, in this context it has generally been interpreted to mean that each of the major classes of highway users (autos, for example) should pay for highway costs it occasions. The act also specified that the study be coordinated with a test, conducted by AASHO, of the effect of different types of vehicles on pavement deterioration, presumably by utilizing the results of that test to assign responsibility for pavement costs to vehicles of different weights.

The Congressionally mandated study was immediately initiated, but due to the tremendous volume of requisite data and analysis, preliminary results were not available until 1961. 1/ The study could not be completed until the AASHO road test had itself been completed and its results fully analyzed. Thus, the final results of the cost allocation study were not transmitted to the Congress until 1965. 2/ Since the 1965 study was supplemental to the 1961 study, the two are sometimes referred to jointly as the first highway cost allocation study.

The results of the first study have been updated twice to account for the changing mix of traffic on federal-aid highways, the changing tax burden on highway users, and the changing pattern of expenditures on federal-aid highways. The first update was initiated internally by the Federal Highway

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1/ Bureau of Public Roads, Final Report of the Highway Cost Allocation Study, H. Doc. 54 and 77, 87 Cong. (1961).

2/ Bureau of Public Roads, Supplementary Report of the Highway Cost Allocation Study, H. Doc. 124, 89 Cong. (1965).

Administration in 1969. 3/ The second was undertaken by FHWA in 1975 at the request of the Deputy Secretary of Transportation, but it has never been released because the Department of Transportation does not judge its results to be sufficiently reliable for policymaking purposes. 4/

Those four studies are the only federally initiated highway cost allocation studies since the Highway Trust Fund was created. Their scope of inquiry, data inputs, methodologies, and findings are reviewed below.

Scope of Inquiry

Section 210 of the Highway Revenue Act of 1956 directed that the first federal highway cost allocation study investigate:

(1) The effects on design, construction, and maintenance of Federal-aid highways of (A) the use of vehicles of different dimensions, weights, and other specifications, and (B) the frequency of occurences of such vehicles in the traffic stream,

(2) The proportionate share of the design, construction, and maintenance costs of the federal-aid highways attributable to each class of persons using such highways, such proportionate share to be based on the effects referred to in paragraph (1) and the benefits derived from the use of such highways, and

(3) Any direct and indirect benefits accruing to any class which derives benefits from federal-aid highways, in addition to benefits from actual use of such highways, which are attributable to public expenditures for such highways. 5/

The first federal highway cost allocation study investigated all the above. Subsequent studies have become progressively narrower in scope, as

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3/ U.S. Department of Transportation, Federal Highway Administration, "Allocation of Highway Cost Responsibility and Tax Payments: 1969," 1970.

4/ Federal Highway Administration, Office of Program and Policy Planning, "Federal Highway Cost Allocation: An Examination of Current Trends," December 1975.

5/ Section 210 of the Highway Revenue Act of 1956.

illustrated in Table A-1. The level of effort has also decreased with each study--the original studies required many years to complete, while the 1975 study was completed in little more than a month.

TABLE A-1. SCOPE OF INQUIRY OF PREVIOUS FEDERAL HIGHWAY COST ALLOCATION STUDIES

	1961/1965	1969	1975
Costs Occasioned in			
Construction	x	x	x
Maintenance	x	x	
Costs Occasioned on			
Federal-aid highways	x	x	x
Other highways		x	
Costs Occasioned by			
Highway Users	x	x	x
Nonusers	x		
Benefits Derived by			
Highway Users	x		
Nonusers	x		

NOTE: x = topic studied.

The first federal highway cost allocation study brought available evidence to bear on the extent of user and nonuser benefits, but could not produce an overall estimate of either, because of difficulties in measuring benefits and in identifying ultimate beneficiaries. It therefore assigned highway cost responsibility to users and nonusers on the basis of costs occasioned. Highway costs related to traffic were assigned to highway users; those required for access to property were assigned to nonusers (the methodology is discussed in more detail below).

The 1965 cost allocation study investigated highway maintenance as well as construction costs, but in much less detail. Since maintenance costs were the responsibility of state and local governments, they were considered peripheral to a study of federal tax equitability. Broadening of the definition of construction in federal highway projects since that time has blurred the dividing line between construction and maintenance.

The 1969 cost allocation study narrowed the scope of inquiry in two respects. Benefits derived from highway use were not investigated, because of complex data collection problems, and costs occasioned by nonusers were not investigated, because results of the 1965 study were thought to still be valid. As in the 1965 study, benefits derived by nonusers were not estimated because of difficulties in measuring such benefits and in assigning them to specific nonuser classes.

The 1969 study broadened the scope of inquiry in one major respect. It investigated costs occasioned by users of all highways, not just those in the federal-aid system. This was done to put "the federal share of the total highway program . . . in its proper perspective" and also to serve as a model for states that wanted to undertake their own cost allocation studies.

The 1975 study returned to the practice of the 1965 study, considering only the federal-aid system. Similarly, it disregarded the maintenance of federal-aid highways, since related costs were the exclusive responsibility of states and localities.

Data Inputs

In order to compare highway cost responsibility with highway tax payments of user classes, federal highway cost allocation studies have required information on highway expenditures by system and work item; on highway use, by system and vehicle type; and on highway tax revenues, by vehicle type. They have also required information relating highway expenditures, usage, and tax revenues to specified user classes.

All federal cost allocation studies have relied on traffic data collected by state highway departments. The quality of data has therefore varied, because state vehicle counts and classification have been made by different means over different time periods, and at varying numbers and types of locations. Only rarely have proper sampling techniques been applied. Likewise, all federal cost allocation studies have relied on highway expenditure data provided by state highway departments. The quality of data has been suspect since these data are derived from long-range expenditure projections and preliminary project cost estimates.

The two most recent federal cost allocation studies have updated information on highway expenditures, highway usage, and highway tax revenues, but they have used information from the first study to attribute each of the above to vehicles of different types. For example, while the 1975 study updated fuel tax revenue data, with only a few exceptions, it used motor fuel consumption rates from various studies in the 1950s and

early 1960s to allocate fuel tax revenues across vehicle classes. Vehicle fuel efficiency has, however, changed in the last two decades, and it is expected to show even greater changes in the future, as the standards contained in the Energy Policy and Conservation Act of 1975 and rising energy costs encourage improvement in fuel efficiency.

All federal cost allocation studies have been underpinned by subjective decisions. For example, automobiles were assigned responsibility for 11½ feet of the typical 12-foot-wide lane, although reasonable arguments can be advanced for assignments of only 10 feet, or all 12 feet, to automobiles. Although the choice made by FHWA may be correct, it is essentially an arbitrary one, with an important effect on the outcome of any cost allocation study. (See Chapter IV for a more detailed discussion of the reliability of these data.)

Allocation Methodologies

As the scope of inquiry has narrowed, a number of allocation methods have been discarded (see Table A-2). Only part of this change has been due to the rejection of methods that were clearly lacking in rigor, reliability, or accuracy.

TABLE A-2. ALLOCATION METHODOLOGIES USED IN PREVIOUS FEDERAL HIGHWAY COST ALLOCATION STUDIES

	1961	1965	1969	1970
User Cost Responsibility				
Incremental method	x	x	x	x
Differential-benefit method	x	x		
Gross ton-mile method	x			
Cost-function method	x			
Nonuser Cost Responsibility				
Relative-use method	x			
Earnings-credit method	x			

NOTE: x = methodology used.

Cost Allocation Between Users and Nonusers. Some nonusers of highways, primarily people who benefit from having highway access to their

place of business or other property, clearly benefit from highways and could be assigned some of the costs of building highways. The first study divided cost responsibility between highway users and nonusers by the relative-use and the earnings-credit methods. In the relative-use method, trips were divided into access and through components, and each component was assigned to the class of road (for example, Interstate, primary, secondary) on which it occurred. The costs of each road class were then divided between nonusers and users in proportion, respectively, to the amount of access and through travel on them. In the earnings-credit method, two calculations were made. First, nonusers were assigned a constant cost per route-mile large enough to cover the full cost of the lowest level of access roads, and users were assigned the balance of costs on other roads. Second, users were assigned a constant cost per vehicle-mile large enough to cover the full cost of the highest level of arterial roads, and nonusers were assigned the balance of costs on other roads. Finally, the two results were averaged, because the first calculation provided a lower bound on nonuser cost responsibility and the second calculation provided an upper bound.

The 1969 and 1975 federal highway cost allocation studies did not investigate nonuser cost responsibility. The 1969 study did, however, adopt the results of the earnings-credit method as applied in 1961, noting that the earnings-credit method is "held by many to be the most practical procedure for accomplishing this assignment of cost."

Cost Allocation Across User Classes. The first cost allocation study used four different methods of assigning cost responsibility to different classes of users. Two methods were apparently used only for the sake of completeness. In the gross ton-mile method, the simplest approach used, vehicle classes were assigned highway costs in proportion to their gross operating weight multiplied by their annual miles of travel on federal-aid highways. In the cost-function method, highway costs were first classified as either weight-related, travel-related, or vehicle-related and they then were allocated across vehicle classes in proportion, respectively, to their gross ton-miles of travel on federal-aid highways, their vehicle miles of travel on federal-aid highways, and their number of registered vehicles.

Because of the oversimplification and lack of detail of those two methods, the Bureau of Public Roads found that neither could provide reasonable estimates of either the benefits derived or the costs occasioned by highway users. Thus, after the 1961 study, these methods were dropped from consideration in favor of methods that could provide more reasonable estimates—the differential-benefit method and the incremental cost method. Results of these latter methods were used by the Congress in its revision of highway-user taxes in the Federal-Aid Highway Act of 1961.

In the differential-benefit method, the value of various benefits to highway users from highway improvements was estimated. The benefits considered were:

- o Reductions in vehicular operating costs,
- o Reductions in accident costs,
- o Reductions in travel time, and
- o Reductions in driving strains and annoyances.

Vehicle-operating cost savings were estimated from changes in fuel consumption, tire wear, and vehicle maintenance expense accompanying specific highway improvements (for example, grade separations, road straightening, and surface improvements). Accident cost savings were estimated from data on accident rates and associated costs on different types of roads. The value of travel time savings was derived from traveler response to toll roads providing time savings over parallel roads. The value of reduced driving strain, presumed to be a function of congestion, stop lights, and the like, was also based on traveler response to toll roads that were assumed to be free of such problems.

The differential-benefit method, while providing some useful insights into benefits derived by highway users, had serious methodological flaws. In particular, value judgments became all-important in the identification, measurement, and valuation of user benefits. In addition, the Bureau of Public Roads used a rather narrow definition of benefits--ignoring less direct benefits, such as the effect of improved travel time on the market for truck services and thus on truck profitability. Because of its great reliance on subjective judgments, the differential-benefit method has been largely discarded in favor of the incremental cost method. Results of the incremental method were emphasized by the Bureau of Public Roads in its 1965 report to the Congress, which stated that ". . .findings of the differential-benefit study should be used to supplement those of the incremental study and to delimit the range of possible allocation values. They should not replace the incremental findings; nor is there any clear reason for averaging the cost allocation values given by the two methods." In the last two federal cost allocation studies, and in six or eight recent state cost allocation studies, the incremental method has alone been used to allocate cost responsibility across highway users.

The incremental cost method has gained widespread acceptance because of its relatively unambiguous application. The method simply seeks to assign each element of highway cost to the vehicles that occasion it.

Using accepted design procedures, the costs of providing roads are divided into increments that meet the requirements of progressively larger and heavier vehicles. The costs of providing roads adequate for basic vehicles (assumed by FHWA to be automobiles and light trucks) are allocated across all vehicle classes on the basis of road use; the costs of providing successive increments of road adequate for progressively larger and heavier vehicles are allocated across those vehicle classes, again on the basis of road use. Thus, automobiles are only responsible for a portion of the first increment (typically well over half of total costs) while the heaviest class of vehicles is responsible for a share of all increments, including the full costs the last increment. Within each increment, road usage is typically measured by either vehicle miles or axle miles of travel.

While theoretically straightforward, the application of the incremental method requires many assumptions and approximations. At the outset, a decision must be made as to which vehicles are "basic" users of highways (those for whom the highways are principally built)--a decision which profoundly affects the allocation of certain costs. Automobiles and light trucks have been so designated in all federal cost allocation studies. If heavier vehicles had been selected as the basic users, a quite different allocation of costs would have resulted.

Vehicles must next be categorized in a way that reflects the very different costs they occasion. Vehicle weight has been used in federal cost allocation studies as a proxy for all vehicle characteristics that might necessitate more costly roads. Highway costs must then be divided into cost increments, beginning with the costs common to all users and adding the costs occasioned by heavier vehicles. Increments used in the first federal cost allocation study were based on results of the AASHO road test and on engineering judgments. They have been used without modification in subsequent studies.

Certain costs are considered to be common to all roads, no matter what type of vehicles use them. These common costs are attributable to all users and are included in what FHWA calls the first cost increment. Examples include the cost of right-of-way acquisition, utility adjustment, roadside development, traffic and pedestrian services, all grading and drainage except on interchanges and climbing lanes, and all maintenance, except on surfaces and shoulders. The designation of these costs as common was based on a survey of state highway engineers in the late 1950s.

Bridge construction costs have been divided into increments on the basis of bridge designs for different loadings prepared by engineers on the first study team. All federal cost allocation studies have assigned between 74 and 87 percent of bridge construction costs to common costs (depending

on the type of road and federal-aid highway system involved) and have included them in the first cost increment.

Pavement and shoulder construction costs have been divided into increments on the basis of AASHO road test results relating pavement damage to the number, weight, and type (single or tandem) of axle loadings. All else being equal, as the number of axles passing over a road increases, or as their weight increases, a surface has to be thicker to remain serviceable for the same length of time. It was assumed in the first study that the goal of highway design is to hold this service life constant under all traffic conditions. The increment of pavement attributable to the heaviest vehicles was defined as the difference between the actual thickness of pavement and the thickness that would be required if the amount of travel remained the same but the weight of the heaviest vehicles was reduced to the weight of the next heaviest category. This resulted in a lower estimate of annual damage to the pavement. Using that estimate, and the results of the AASHO road test relating pavement thickness to service life, an estimate was made of the pavement thickness required to maintain the original service life if the heaviest vehicles were reduced in weight. This was then subtracted from the initial thickness to obtain the increment attributable to the heaviest vehicle class.

The next increment was obtained by reducing the weights of the two heaviest vehicle classes to that of the third heaviest class, computing a new estimate of annual damage, calculating the thickness required to maintain the same service life, and subtracting this from the thickness computed previously. This process was repeated for progressively lighter vehicles until the entire pavement was divided into increments. The final step was to estimate the costs of providing each increment. All federal cost allocation studies have assigned between 50 and 70 percent of pavement and shoulder construction costs to the first cost increment, depending on the type of road and the federal-aid highway system involved.

Finally, it is necessary to select appropriate measures of road use and to allocate the cost increments to different vehicle classes in proportion to those measures. Axle-miles traveled by vehicle class (the number of miles traveled times the number of axles per vehicle) were used to allocate all common costs in the 1965 study, and to allocate common pavement and shoulder costs in later studies. Later studies used vehicle-miles traveled by vehicle class, however, to allocate other common costs. Vehicle-miles traveled were also used to allocate bridge costs.

Although widely accepted, the incremental method has some of the same methodological flaws as other cost allocation methods, and it too relies heavily on value judgment.

Study Findings

Changes in the relative use of federal-aid highways by different vehicle classes in the type of improvements made on federal-aid highways, in the kinds of highways on which improvements are made, and in the mix of taxes paid by highway users have changed the results of federal cost allocation studies over time. Changes in the scope of studies and in their allocation methodologies have, however, had a much more profound effect on results.

The 1961 study assigned cost responsibility to nonusers by the relative-use and earnings-credit methods. Results are summarized in Table A-3. Depending upon the method used to allocate costs and the specific costs allocated, between 7 and 18 percent of federal-aid highway costs were assigned to nonusers.

TABLE A-3. HIGHWAY COST RESPONSIBILITY ASSIGNED TO NONUSERS BY TWO COST ALLOCATION METHODS: AS PERCENT OF TOTAL HIGHWAY COSTS

Federal-Aid Highway System	Relative-Use Method	Earnings-Credit Method
Interstate and Primary		
Construction costs	6.2	1.4
All costs	6.2	1.8
Secondary		
Construction costs	14.0	40.1
All costs	14.0	47.4
All Federal-Aid Highways		
Construction costs	7.0	14.3
All costs	7.0	18.3

SOURCE: Bureau of Public Roads, Final Report of the Highway Cost Allocation Study, H. Doc. 54 and 72, 87 Cong. (1961).

The 1961 study assigned cost responsibility to highway users by the cost-function, differential-benefit, and ton-mile methods. A 1961 supplement to that study used an early version of the incremental method. Results are summarized in Table A-4. The ton-mile method assigned 5-axle tractor-semitrailer combinations a cost per vehicle-mile 22 times that of automobiles. At the other extreme, the differential-benefit method assigned them a cost per vehicle-mile only 5 times that of automobiles.

TABLE A-4. HIGHWAY COST RESPONSIBILITY ASSIGNED TO MAJOR USERS OF FEDERAL-AID HIGHWAYS BY VARIOUS COST ALLOCATION METHODS: IN CENTS PER VEHICLE-MILE OF TRAVEL

Vehicle Class (total private and for hire)	Cost-Function Method	Differential-Benefit Method	Ton-Mile Method	Incremental Cost Method
Automobiles	0.264	0.330	0.230	0.316
Single-Unit Trucks				
2-axle, 4-tire	0.246	0.350	0.228	0.266
2-axle, 6-tire	0.525	0.461	0.572	0.514
Tractor-Semitrailer Combinations				
3-axle	2.004	1.263	2.373	1.409
4-axle	2.779	1.451	3.339	1.857
5-axle	4.294	1.779	5.135	2.493

SOURCE: Bureau of Public Roads, Final Report of the Highway Cost Allocation Study, H. Doc. 54 and 72, 87 Cong. (1961).

The 1965 study used the incremental cost method to assign cost responsibility for both construction and maintenance of federal-aid highways to vehicle classes. As shown in Table A-5, tractor-semitrailer combinations were responsible for 19 percent of construction costs, but only 10 percent of maintenance costs. The disparity was nearly as large for single-unit trucks,

though they were responsible for a higher percentage of maintenance than of construction costs.

TABLE A-5. CONSTRUCTION AND MAINTENANCE COST RESPONSIBILITY ASSIGNED TO MAJOR USERS OF FEDERAL-AID HIGHWAYS BY THE INCREMENTAL METHOD: IN PERCENTS

Vehicle Class	Construction	Maintenance
Automobiles	64.1	68.5
Single-Unit Trucks		
2-axle, 4-tire	5.8	9.4
2-axle, 6-tire	5.6	7.0
3-axle	1.1	0.9
Tractor-Semitrailer Combinations		
3-axle	3.8	2.5
4-axle	11.7	6.0
5-axle	3.4	1.6
Other Vehicles	4.5	4.1
Total	100.0	100.0

SOURCE: Bureau of Public Roads, Supplementary Report of the Highway Cost Allocation Study, H. Doc. 124, 89 Cong. (1965).

The 1969 study used the incremental cost method to assign responsibility for costs on and off the federal-aid highway system to vehicle classes. Here again, a change in the scope of inquiry significantly altered cost responsibility. Results for major systems are presented in Table A-6.

TABLE A-6. COST RESPONSIBILITY ASSIGNED TO SELECTED HIGHWAY USERS OF VARIOUS HIGHWAY SYSTEMS: IN CENTS PER VEHICLE-MILE OF TRAVEL

	Federal-Aid					
	Interstate		Primary		Local Roads	
	Rural	Urban	Rural	Urban	Rural	Urban
Automobiles	1.538	1.474	0.968	0.865	2.261	0.919
Single-Unit Trucks						
2-axle, 4-tire	1.576	1.507	1.031	0.905	2.353	0.979
2-axle, 6-tire	2.214	2.334	1.578	1.655	3.871	2.169
3-axle (diesel)	3.558	4.897	2.548	4.150	7.217	5.640
Tractor-Semitrailer Combinations						
3-axle (gasoline)	3.818	4.120	2.747	3.790	9.088	6.403
4-axle (gasoline)	4.246	5.243	3.137	4.546	9.847	6.762
5-axle (diesel)	4.765	6.419	3.649	5.723	12.252	7.838

SOURCE: U.S. Department of Transportation, Federal Highway Administration, "Allocation of Highway Cost Responsibility and Tax Payments: 1969," 1970.

Changes in data inputs over time have resulted in much less pronounced changes in cost responsibility. The incremental method has been used to allocate federal-aid highway construction costs in 1961, 1965, 1969, and 1975. Highway expenditure, travel, and revenue data were updated in later studies, but this did not greatly alter the results, as shown in Table A-7. Past studies show that automobiles have consistently paid less in highway taxes than they have occasioned in highway costs, with the difference increasing to an underpayment of about 10 percent in 1975. Automobiles have accounted for roughly 60 percent of both payments and costs in all three studies.

TABLE A-7. COST RESPONSIBILITY AND TAX PAYMENTS ASSIGNED TO MAJOR USERS OF FEDERAL-AID HIGHWAYS IN VARIOUS FEDERAL COST ALLOCATION STUDIES: IN PERCENTS

Vehicle Class	Allocated Total Cost Responsibility by Incremental Method			Tax Payments to the Highway Trust Fund		
	1965	1969	1975	1965	1969	1975
Automobiles (gasoline)	64.1	64.2	63.5	60.9	60.4	56.9
Single-Unit Trucks						
2-axle, 4-tire (gasoline)	5.8	7.2	10.4	9.7	12.0	11.0
2-axle, 6-tire (gasoline)	5.6	4.1	4.4	8.4	7.4	7.9
3-axle (gasoline)	1.0	0.6	0.3	1.6	1.1	0.9
3-axle (diesel)	0.1	1.1	2.0	0.2	2.0	3.4
Tractor-Semitrailer Combinations						
3-axle (gasoline)	3.5	1.6	0.6	3.4	1.8	1.3
4-axle (gasoline)	7.7	4.1	0.6	6.7	3.7	1.3
4-axle (diesel)	4.0	1.6	2.1	2.8	1.0	2.3
5-axle (gasoline)	1.0	1.3	0.1	0.8	0.2	0.3
5-axle (diesel)	2.4	5.5	8.7	1.7	3.6	8.6
Tractor-Semitrailer-Full Trailer Combinations						
5-axle or more (diesel)	0.8	4.4	4.9	0.4	2.3	3.3
Other Vehicles	4.0	4.3	2.4	3.4	4.5	2.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

SOURCES: Bureau of Public Roads, Supplementary Report of the Highway Cost Allocation Study, H. Doc. 124, 89 Cong. (1965); U.S. Department of Transportation, Federal Highway Administration, "Allocation of Highway Cost Responsibility and Tax Payments: 1969," 1970; Federal Highway Administration, Office of Program and Policy Planning, "Federal Highway Cost Allocation: An Examination of Current Trends," December 1975.

Single-unit trucks as a group have paid more in highway taxes than they have occasioned in highway costs, typically by a significant margin. They have collectively accounted for about 20 percent of payments and about 15 percent of costs in all three studies. No systematic variation in overpayment is evident either with respect to vehicle size or fuel type.

Finally, tractor-semitrailer combinations have gone from paying somewhat less in highway taxes than they occasioned in highway costs to paying slightly more. This change is attributable to a rise in the price of new trucks, parts, and accessories, all of which are subject to a federal excise tax, and to a shift in federal spending from the Interstate system to highways less heavily utilized by heavy trucks. No systematic variation in underpayment or in overpayment is evident with respect to vehicle size, but diesel-powered combinations have consistently underpaid because of the better fuel economy of diesel engines, and their correspondingly lower fuel tax payments. The 1975 study found that the largest diesel-powered combinations were still underpaying (by 33 percent or $650 per vehicle).

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