TRANSPORTATION RESEARCH RECORD 858

Cost Responsibility, User Charges, and Finance Issues

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Annual Vehicle Taxation Policies in Europe: Who Gains and Who Loses from Change?

STEVE COUSINS AND STEPHEN POTTER

Annual vehicle taxes can be replaced by taxes on fuel. This may be desirable for energy or transport policy purposes. The effects of this abolition option are examined (a) between interest groups in a single nation and (b) between member nations of the European Economic Community (EEC). In the United Kingdom, rural motorists claimed they would be disadvantaged by such a change. Use of the United Kingdom National Travel Survey showed that they would benefit or show no change in total tax paid. In the United Kingdom, 60 percent of new car purchases are made by companies. The cars purchased by companies are larger than privately purchased new cars and exhibit high annual mileages. Abolition of annual vehicle taxes would increase the taxation of company cars. In the EEC countries, abolition of annual taxes would result in more fuel tax paid by larger vehicles in the United Kingdom and Ireland; about the same level of tax in Denmark, Holland, and Germany; and less tax in France, Belgium, and Italy. The different annual automobile taxes provide some nontariff protection of national car manufacturing industries. A mix of higher fuel taxes, higher initial purchase taxes, and improved consumer information is recommended if annual automobile taxes are abolished in the EEC for reasons of energy and transport policy.

In the aftermath of the 1973-1974 oil crisis, several European studies (1-4) have examined the role of vehicle taxation in promoting energy-efficient transportation. Traditionally, vehicle taxation has been used primarily as an instrument of fiscal, industrial, and economic policy rather than transport policy. Vehicle taxes are general taxes that are levied from the transport sector. Of necessity, any use of vehicle taxation for transport policy purposes must influence these other policy areas.

There are three main types of vehicle taxes levied by European Economic Community (EEC) governments--purchase tax, a single tax on the initial purchase of an automobile; annual vehicle license tax, an ownership tax that, although it may vary with vehicle weight or engine size, remains constant however much that vehicle is used; and fuel tax, which of course is very much related to the vehicle's use and its fuel efficiency.

In recent years, an increasing concern with energy conservation and a shift in transport policy toward recognizing the social effects of high automobile use have led a number of European countries to question the validity of the annual vehicle license system.

For example, in Britain all owners of private automobiles pay the same license fee. This does little to encourage the development of fuel-efficient vehicles and does not reflect the use that a vehicle makes of the road system.

One possible change is the abolition of the annual vehicle license and its replacement by a variable tax, such as a tax on fuel. This option has been extensively debated in Britain (5), in the Netherlands (4), and for the EEC as a whole (1). In this paper we examine the transport goals to which changed taxation could contribute. We then examine the likely effects that such a use of transport taxes would have on different groups within a country and how different national interests are affected within the EEC.

BRITISH CASE STUDY

The British annual vehicle license system, vehicle excise duty (VED), is the only system in Europe in which all automobiles pay a fixed tax. Originally Britain had a graduated fiscal horsepower license, but this was replaced by the fixed-rate system in 1948. The major reason for this was to encourage the sale of large-engine automobiles, thus providing British manufacturers with a domestic market base on which exports to the United States and Australia could be built (6).

By the late 1970s the basis of this particular industrial policy had changed, and in 1978 it was proposed that the automobile license be abolished and the lost revenue be made up by an additional fuel tax. Five major reasons were cited by the Department of Transport (7):

1. Reduction in tax evasion, estimated to cost £50 000 to £63 000 annually;
2. Fairer basis (with the tax shifted to fuel, larger automobiles would pay more than small automobiles; also, it was known that higher-income households drive more and own larger vehicles, so this would produce a progressive tax system);
3. Administrative savings;
4. Energy conservation (the marginal nature of fuel tax would aid energy conservation and encourage the use and production of fuel-efficient vehicles); and
5. Change in transport policy--the shift to a totally marginal tax system would make people more aware of the real automobile costs relative to alternative transport modes.

The net effect of this proposal would have resulted in the amount of tax paid being directly proportioned to fuel used. This is a function of vehicle consumption rates and distance driven, as Table 1 shows.

PUBLIC REACTION

This proposal met with considerable resistance from the British Press and Parliament. Both were concerned with the distributional effects of such a change. It was seen as a move that would shift the burden of taxation from urban areas, where automobile mileages were perceived to be low, to the rural community, where automobile mileages were perceived to be high. The effects on low-income groups in rural areas were emphasized.

DISTRIBUTION OF COSTS AND BENEFITS

In order to test the validity of such claims, we conducted a study into the distributional effects of the existing and proposed automobile tax systems by using the very detailed information available from Britain's 1975-1976 National Travel Survey. To our surprise, this government survey had not been used in preparing the tax-change proposals.

There is a clear relationship between income and vehicle mileage, as Table 2 shows [1£ = $2.02 (1976 U.S. dollars)]. Under average motoring conditions, the "break-even" mileage between the two tax systems was estimated by the Department of Transport to be 7500 miles (12 077 km) in urban areas but 10 000 miles (16 108 km) in the countryside. The latter

Table 1. Index of fuel tax replacement of annual vehicle license for range of European automobiles.

Automobile Type	Engine Size (cc)	Index of Tax Paid Based on Fuel Consumption[a]	Index of Avg Annual Mileages[b]	Overall Index of Tax	Existing Annual Vehicle License Index
Citroen Dyane 6	600	100	100	100	100
Fiat 127	900	118	100	118	100
BL Mini 1000	1000	118	110	119	100
Renault 14 TL	1200	129	126	132	100
VW Passant	1300	164	144	236	100
Fiat 131	1600	180	144	259	100
BMW 320	2000	221	161	356	100
Mercedes 280	2800	267	161	430	100

[a]EEC Commission Interim Report (1).
[b]National Travel Survey, 1975-1976 (mileage and engine-size data from unpublished tables).

Table 2. Distribution of annual vehicle mileage in Britain by income of household.

	Annual Household Income (£)								
Annual Mileage (miles)	0 < 1250 N=241	1250 < 2000 N=520	2000 < 3000 N=1252	3000 < 4000 N=1424	4000 < 6000 N=2765	6000 < 7500 N=964	7500 < 10 000 N=645	10 000 + N=362	All N=8173
Under 3000	38	19	15	14	11	8	8	5	13
3000 < 5000	18	25	15	14	11	11	10	12	13
5000 < 7000	20	22	21	19	18	18	15	19	19
7000 < 9000	7	10	12	12	14	14	12	11	13
9000 < 10 000	3	2	3	3	3	3	5	3	3
10 000 < 12 000	5	9	13	14	15	16	18	14	14
12 000 < 18 000	8	9	13	16	18	21	20	22	17
18 000 < 25 000	1	1	5	5	5	5	7	7	5
25 000 < 35 000	1	2	2	3	4	3	3	6	3
35 000 < 50 000	–	–	–	1	1	2	1	–	–
50 000 +	–	–	1	1	–	–	–	–	1

Notes: In this table alone, all vehicles, including motorcycles, are included, since the tax-change proposal would affect all VED-paying vehicles; in subsequent tables, only automobiles are included, since their use is the main focus of this study. 1 mile = 1.6 km; 1 £ = $2.02.
Data are from National Travel Survey, 1975-1976.

reflects better fuel consumption on uncon- gested rural roads. Those who travel in excess of this figure would pay more if VED were replaced by fuel tax, and those driving less would gain. This indicates that the change to an all-fuel tax system would shift the burden of taxation onto higher-income groups and so make automobile taxes more progressive.

The fact that lower-income households would pay less overall tax does not deal with the rural/urban argument, in particular the argument that there are low-income rural motorists forced to drive higher mileages. But in actual fact, according to the National Travel Survey, the differences between average urban and rural automobile mileages are remarkably small, as shown below ("rural" is defined as households in settlements with populations of less than 3000; 1 mile = 1.6 km):

	Mileage (miles)	
Area	Urban	Rural
England	8 900	9 500
Wales	9 700	10 600
Scotland	10 400	10 100
Great Britain	9 400	10 000

Given a similar pattern of vehicle performance and fuel consumption, this 9 percent higher mileage would represent a shift in taxation to rural areas of a comparable magnitude. But fuel-consumption rates are not the same. In rural areas, Department of Transport road tests have estimated fuel consumption to be up to 25 percent better than in urban areas, due to lack of congestion. Hence, rather than representing a shift in taxation from urban to rural areas, the reverse is more likely.

TRANSPORT AND ENERGY POLICY

The transport and energy policy inputs in the proposal to abolish the automobile license reflected an increasing concern for trends in transport energy use and for the social effects that high car use was causing via the associated decline in public transport provision.

An important influence on such a transport and energy policy is the use of company automobiles. These are vehicles that are purchased by the company for an employee and are then available for the employee's normal household travel. It should be noted that usually these vehicles are not given to the employee because of high mileage driven in the course of work but as an addition to a salary. Although the use of company automobiles is greatest in the United Kingdom, it is also growing in other EEC countries.

Over the last eight years, companies have rapidly increased their share of the new-automobile market and now account for more than 60 percent of all vehicles sold in the United Kingdom. They have a major influence on the vehicle stock. As shown below, the type of vehicle purchased by companies and that purchased by private individuals are very different according to a Department of Transport unpublished 1979 analysis of registration documents:

Engine Size	Percent of Total	
(cc)	Company	Private
Up to 1200	11.3	29.5
1200-1500	28.5	33.9
1500-1800	28.6	18.1
1800-2200	17.6	10.8
2200-3000	11.1	4.3
3000+	2.9	1.4

Average engine size of company cars is 1650 cc and that of private cars is 1390 cc.

Sixty percent of company car purchases have engines larger than 1.5 L, whereas only 37 percent of private car purchases are larger than this size. Company vehicles also cover higher annual mileages and, taken together, this means that although the shift in taxation between rural and urban areas would be minimal, the abolition of annual automobile tax would have resulted in a large shift in taxation from private individuals to the commercial sector.

This proved to be an important factor in deciding the fate of the automobile tax reform proposal, for in May 1979 the Conservative Party, under Prime Minister Margaret Thatcher, came into power with a policy to improve business incentives and lower taxation. In November 1979, the Minister of Transport announced that the existing automobile license system was to be retained (8):

> We have carefully considered the arguments for and against abolishing excise duty on petrol-driven vehicles and replacing it by increased petrol taxation. But we have concluded that the case is not sufficiently strong to justify this major change. We were particularly concerned that abolition would place too big a share of the burden of motoring taxation on high mileage rural motorists and essential business users.

The cited reasons show the influences behind this decision. The widespread belief among rural motorists that they would be disadvantaged by this tax change had little basis in reality. But a perception or a belief, however inaccurate it may be, can still be an important political influence.

The above quotation also indicated the way in which transport and energy policy became subservient to fiscal policy. In terms of equity, income distribution, and transport or energy policy, there are no reasons why companies should not pay more taxes. They use the roads more and impose on other motorists a costly, high-fuel-consuming type of automobile. Yet the general desire to reduce company taxes led to the retention of the fixed annual tax. For much the same reason, the alternative of returning to the graduated automobile license system appears not to have been considered.

In Britain it appears that transport taxation is still a branch of general fiscal policy. A coherent policy on transport taxes, reflecting transport and energy goals, has yet to develop.

COMPARISON BETWEEN EEC NATIONS

All EEC nations, with the exception of the United Kingdom and Ireland, have an annual vehicle license system that is related to vehicle size. In Germany and Luxembourg, engine cylinder capacity determines the tax; in Belgium, France, and Italy there is a fiscal horsepower rating system. Ireland had a progressive fiscal horsepower tax until 1977 when annual tax was abolished for all but the largest category, 16-hp, and an annual registration fee was introduced. Only 1.5 percent of vehicles are of 16 hp or more and the annual registration fee has since been increased substantially. Thus for 98.5 percent of its cars, Ireland may be grouped with the United Kingdom as having a fixed tax system. Incidentally, no additional fuel tax accompanied the Irish abolition of the vehicle license in 1977. This was a tax-reduction measure designed to benefit higher-income groups.

Table 3 shows the range of tax paid according to the various vehicle license systems in Europe. There is a great variety in the rate of progression, from a ratio over this range of 1:1 in Britain to nearly 20:1 in Italy. For the British pattern of vehicle use, a fuel-tax replacement would produce a level of progression roughly halfway along this European league.

The abolition of the annual vehicle tax and its replacement by a fuel tax would have radically different effects in member countries. From Table 3, three groups of nations can be distinguished in which there would be similar socioeconomic and energy conservation effects:

Group 1: In the United Kingdom and Ireland, the tax change would be progressive; higher-income higher-fuel consumers would pay more, as was discussed in the previous section for the United Kingdom.

Group 2: In a second group, made up of Denmark, the Netherlands, and Germany, there would be little change in the distribution of taxation if annual licenses were abolished. This assumption does depend, however, on the positive relationship between the engine size of a vehicle and its annual mileage (see Table 1). Since little change is likely in the total taxation of vehicles of different sizes, unlike the case in the United Kingdom, the decision to adopt the change must be based purely on the merits of taxation of use versus taxation of ownership and the effects of this on energy and transport policy. The intrinsic importance of such a change in the method of taxation is discussed later.

Group 3: The third group of nations--France, Belgium, and Italy--would receive a considerable stimulus to the purchase of larger, less fuel-efficient vehicles if annual taxes were replaced by a fuel tax. This change would also favor high-income groups rather than low-income groups.

Table 3. EEC automobile annual license taxation systems.

Automobile Type	Fuel Consumption (L/100 km)	Unladen Weight (kg)	Engine Capacity (cc)[a]	Index of Vehicle License Tax Paid[b] United Kingdom	Ireland (1978+)	Denmark	Netherlands	Germany	Ireland (to 1977)	France	Belgium	Italy	Proposed UK Fuel-Tax Index
Citroen Dyane 6	6.1	600	600	100	100	100	100	100	100	100	100		100
Fiat 127	7.2	705	900	100	100	120	120	150	190	160	120	190	118
BL Mini 1000	7.2	615	1000	100	100	120	120	170	210	160	180	190	119
Renault 14 TL	8.0	865	1200	100	100	170	170	200	255	160	230	340	132
VW Passant	10.0	885	1300	100	100	170	170	210	255	160	230	390	236
Fiat 131	11.0	965	1600	100	100	170	200	260	380	400	340	570	259
BMW 320	13.5	1115	2000	100	100	170	240	330	460	400	520	800	356
Mercedes 280	16.3	1455	2800	100	780	290	340	460	690	690	990	1960	430

Note: Data are from EEC Commission Interim Report (1); information on Ireland from B.P. Feeney (2). 1 L = 0.264 gal; 1 km = 0.6 mile; 1 kg = 2.2 lb.
[a]Percentage of new registration under 1000 cc: UK, 11; Germany, 10; Ireland (to 1977), 18; France, 26; Italy, 53.
[b]Dyane 6 = 100.

Another way in which EEC countries have different interests is in the distribution of automobile manufacturers (9). The number of automobiles manufactured and assembled in the EEC in 1977 is distributed among the EEC countries as follows:

	Automobiles (000s)	
Country	Manufactured	Assembled
Germany	3.796	0
France	3.559	0
Italy	1.440	0
United Kingdom	1.316	0
Belgium	0	1.013
Netherlands	53	15
Ireland	0	50
Denmark	0	0
Luxembourg	0	0

The risk that energy conservation measures will depress the European automobile industry, though valid, is a concern that is very differently shared between the producer and nonproducer nations. In the United Kingdom, the 30 percent rise in real fuel cost over the period 1973-1975 was associated with a 25 percent fall in new-vehicle purchases. Automobiles in their first two years of life have high annual mileage--15 000 miles (24 000 km)--compared with 7000 miles (11 200 km) average for the rest of the vehicle's life (10). Therefore, transferring the annual tax to petrol will result in a real increase in motoring costs for those operating new vehicles, which would thus lead to fewer new automobile sales according to Mogridge's model (1977) (11).

There are also significant differences among the interests of the producer countries themselves. Simply removing the annual tax would cause grave problems for the French and Italian car industries, which specialize in the production of small vehicles. The highly progressive annual vehicle taxes in these two countries favor their own national car industries and so create some protection for domestic markets.

The German industry would appear to be little affected by such a change, since it has already succeeded in selling domestically produced large vehicles in spite of the existing progressive annual tax system. Factors such as a well-developed freeway system and the high per capita gross national product are probably relevant to the choice of large vehicles in Germany.

One avenue not yet explored in the studies of European vehicle taxation is to replace the highly progressive annual taxes in France and Italy by a fuel or use tax coupled with a progressive purchase tax. This would maintain the incentive to buy small (domestically produced) vehicles and maintain the current distribution of wealth and also allow some increased taxation of vehicle use rather than ownership. Member nations could substantially increase purchase taxes before reaching Denmark's current level, but automobile producers are likely to be opposed to such a policy. Purchase taxes as a percentage of pretax retail price are as follows (12) (those for the Netherlands and Denmark depend on price):

Country	Tax (% of retail price)
Luxembourg	10
Germany	13
United Kingdom	24.6
Belgium	25
France	33.3
Ireland	18
Italy	18
Netherlands	40-50
Denmark	150-234

Thus for the United Kingdom and Ireland, the abolition of annual fixed vehicle taxes would be a progressive economic and energy-conservation measure. The abolition of progressive annual vehicle taxes in Germany, the Netherlands, and Denmark remains valid only if the policy of replacing annual by use-related taxes really does achieve energy savings. For those countries with high progressive annual taxes, a partial removal is possible if coupled with an increased fuel tax. Total removal of the annual tax could be justified if it were coupled with both an increased fuel tax and an increased purchase tax to ensure the continuation of their highly progressive taxation system.

USER PERCEPTION OF AUTOMOBILE COSTS

Automobile running costs are not accurately perceived by the vehicle user (13). This contrasts with other use charges relevant to automobile users, such as car-park charges, road tolls, and public transport fares. These direct payments are clearly perceived. Metcalf (13) concluded that although of all running costs fuel is the only commonly perceived expenditure, money was twice as easily spent on fuel as on the direct expenditures.

So, for example, someone might use 20 pence worth of fuel to avoid a 10-pence parking charge. The mechanism that Metcalf proposed to account for this was that the driver does not normally perceive the cost of travel and so does not rationally compare the parking and driving options. (The driver is thus short of important information.) Dix and Goodwin (4) have shown that private motorists are precisely aware of the annual tax rate for their vehicle but have an inaccurate perception of the automobile's running costs per mile. Given this, shifting taxation from an accurately perceived cost (annual vehicle tax) to a poorly perceived cost (running costs and fuel) may nullify the energy and transport policy gains anticipated. Indeed, Dix and Goodwin consider that changes in the type of vehicles purchased might offset fuel savings, given the low short-term price elasticity in the United Kingdom (-0.1 to 0.15), although they consider the long-term elasticities to be higher (approaching -1.0).

Because of the problems of user perception of vehicle running costs and the comparative clarity of annual taxes, one approach is to try to overcome the lack of information that motorists have about running costs. Metcalf proposes the use of electronic travel cost meters on automobile dashboards, an innovation that is already available in some new vehicles. A similar approach, that of providing improved consumer information, can be made at the point of sale of new vehicles. EEC countries require new automobiles to display mile-per-gallon data based on a standard urban driving cycle and for cruising at 56 and 70 mph (90 and 110 km/h). This requirement could be extended to express total annual fuel costs (including the fuel-tax element) derived from national average mileages. This would aid the perception of annual costs in a way similar to the annual license for each vehicle type. However, these would not be exactly equivalent since the prospect of spending such a sum on fuel is not the same as an immediate payment, even though the former may be larger.

CONCLUSION

The EEC member countries could shift all or part of their annual vehicle license taxation to taxes on fuel without regressive changes in the distribution of wealth. Such a measure holds the prospect of achieving energy conservation and beneficial effects for the promotion of coordinated transport policies. However, the implementation of such a policy is complex, given motorist perceptions and the wide range of existing vehicle license systems and national car stocks.

In the United Kingdom and Ireland, the abolition of the flat-rate annual license and a return to a progressive system, be it related to engine size or a fuel tax, would certainly be beneficial, but for other countries the choice between a fuel tax and a graduated vehicle license is less clear and very much depends on a motorist's perception of costs and the way in which improved consumer information may supplement it.

The Dutch are currently considering the abolition of their annual vehicle license and its replacement by an increased fuel tax. If it proceeds, this should provide important evidence as to the role and potency of transport taxation in transport and energy policies. The value of consumer information innovations in conjunction with this taxation issue merits further investigation.

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Subsidies in Oregon Highway Transportation

MILAN KRUKAR, JOHN MERRISS, AND LOYD HENION

Subsidies have been identified in Oregon highway transportation since the first cost-responsibility study was done in 1937. The 1980 Oregon Motor Vehicle Cost-Responsibility Study identified similar equity problems. The lack of adequate highway funds makes it imperative that they be spent optimally and that all road users pay for their responsibility. In times of scarcity, favored groups can no longer be subsidized at the expense of others. The purpose of this paper is to examine the extent of subsidies inherent in Oregon's existing road user tax schedules. These subsidies are calculated on the basis of the tax schedules and recommendations developed from the 1980 Oregon Motor Vehicle Cost-Responsibility Study. The existing subsidies are compared with those found in the 1963 and 1974 Oregon cost-responsibility studies.

Subsidies have been identified in Oregon highway transportation since the first cost-responsibility study was done in 1937 (1). The 1980 Oregon Motor Vehicle Cost-Responsibility Study (2) has identified similar equity problems. The lack of adequate highway funds makes it imperative that they be spent optimally and that all road users pay for their responsibility. In times of scarcity, favored groups can no longer be subsidized at the expense of others.

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OREGON COST-RESPONSIBILITY STUDIES

Background

The State of Oregon has long been a leader in applying cost responsibility to road user taxation. The 1980 study is in the tradition of previous Oregon studies that date back to 1937 (1-5). The use of the modern incremental approach in Oregon for allocating certain construction and maintenance costs started with the 1963 study (3) after the completion of the American Association of State Highway Officials (AASHO) Road Test.

Since 1905, three principles have guided the development of Oregon's road user tax system. These are that (a) those who use the public roads should pay for them, (b) road users should pay in proportion to the road user costs for which they are responsible, and (c) road user taxes should be used for constructing, improving, and maintaining the highways. Oregon has followed a pay-as-you-go philosophy in paying for its highways (6).

Each of the Oregon studies has addressed the following questions:

1. Is there equity among road user classes and especially among the truck classes?
2. If there is inequity, how should the current highway tax structure be modified to rectify it?
3. What level of taxation is necessary to preserve the state's investment in highways and how should this tax burden be distributed among road users?

Expenditures Versus Costs Approach

Should cost-allocation studies allocate costs or expenditures to the various user classes? Cost responsibility should be based on the true costs imposed on the highway system by road users. Finances may be so limited that maintenance funds are insufficient to prevent the highway system from deteriorating faster than it is being repaired. The unrepaired mileage represents costs that are borne by society in one form or another. They must in fact be borne by current and future road users, either in the form of higher road user taxes to address the deferred maintenance or in the form of increased private costs for vehicle repairs and related operating costs.

Even though a particular budget may fall far short of meeting a true cost-responsibility funding level, the expenditures within that budget should be allocated on a fair and equitable basis.

The 1980 study uses three expenditure levels, which range from a level based on existing road user tax rates to one that approximates the true costs of maintaining the existing system. This third expenditure level is defined as "the budget that includes sufficient road user taxes to: (1) adequately maintain the existing highway system at 'status quo' condition levels, (2) keep road capacity at an acceptable but slowly declining level of service, and (3) provide some highway improvements."

The preservation program assumes that system deficiencies will remain at present levels throughout the next 10 years. The costs of postponed construction and deferred maintenance are not included. This budget level is based on costs identified in the 1981 State Highway Preservation Study (7).

Results from Cost-Responsibility Studies

Distribution of Shares

Comparing cost-responsibility studies for different time periods is difficult since the expenditures, conditions, and parameters are different. However, such comparisons do indicate changing trends that may be useful for future studies.

Table 1 shows the expenditure responsibility distributions between basic and heavy vehicles in the 1963, 1974, and 1980 studies. As shown, the unadjusted heavy-vehicle responsibility shares for the current-expenditure-level budget are 38.5, 36.2, and 47.1 percent for the 1963, 1974, and 1980 studies, respectively. After adjustments have been made for subsidies, these shares are reduced to 35.2, 35.4, and 44.5 percent, respectively. For the preservation-level budget (budget 3), the unadjusted and adjusted responsibility shares for heavy vehicles are 49.1 percent and 46.0 percent, respectively.

The principal explanation for this shift in responsibility toward heavier vehicles is that most of the additional funds in the preservation-level budget are going into overlays and pavement maintenance projects that are weight-related and hence involve a greater heavy-vehicle responsibility.

Net Responsibility and User Charges

1974 Study

This study found that basic vehicles (i.e., all vehicles weighing 6000 lb or less) were essentially meeting their responsibility under the current-expenditure-level budget. Adjustments were recommended in truck weight-mile rates to meet inequities as shown in Table 2 and Figure 1. The 1974 study recommended an increase in weight-mile tax rates for vehicles weighing between 6001 and 34 000 lb and a decrease in the rates applying to those vehicles registered between 34 001 and 76 000 lb. This recommendation was not adopted and the existing schedule remained in effect until 1977 when it was increased proportionally to match an increase of 2 cents in the state fuel tax.

1980 Study

Budget 1, the current expenditure level, totals $187.3 million. Expenditures for construction and maintenance are $155.5 million and maintenance accounts for more than one-third. Priority is given to preserving rather than expanding the existing highway system.

Table 3 shows the net responsibility and the recommended and existing weight-mile schedules in mills per mile. Net responsibility is obtained after adjusting for payment of registration fees and the reallocation of subsidies given to farm and exempt vehicles. The net responsibility for the lightest vehicle class, the 0-6000-lb gross weight group (the basic vehicle), is 4.312 mills/mile, whereas the net responsibility of the gross weight group of 78 001 to 80 000 lb is 69.984 mills/mile.

The net responsibility together with the existing and recommended weight-mile schedules are plotted in Figure 2. The net responsibility increases gradually but irregularly from 52 000 to 74 000 lb and then increases rapidly from 74 000 lb up to approximately 88 000 lb. This occurs because axle weight is a more important factor in cost responsibility than gross weight for heavy trucks. Truck combinations from 74 000 lb up to approximately 88 000 lb tend to use the heaviest allowable axle weights. The decline in responsibility for vehicles that weigh more than 88 000 lb gross weight reflects the fact that most of the vehicles operating in this weight range are double- and triple-trailer combinations that have more than five axles.

Budget 3, the preservation-level budget, represents the true costs of preserving Oregon's highway system. It represents the level of expenditures needed to do the necessary construction and maintenance projects to maintain the system at its present level. The 1981 preservation study (7) results show that in the next 10 years, based on 1980 dollars, it will be necessary to spend a total of $890 million, $170 million, and $204 million on pavement overlays, bridge replacement, and traffic operations, respectively, on state highways. This excludes the cost of maintaining city streets and county roads.

Total expenditures under this budget are $408.7 million. Expenditures for construction and maintenance total $361.8 million, which is 133 percent larger than those under budget 1. Although maintenance expenditures have been increased by $43.1 million over those in budget 1, the level of expenditures for surface maintenance has not increased. The increase has been allocated to other maintenance items. Expenditures for construction under this budget are $163.2 million higher than those under budget 1. Approximately 43.7 percent of all construction expenditures are for pavement overlays.

Table 4 shows the recommended weight-mile schedules in mills per mile. The net responsibility of the lightest vehicle class, the 0-6000-lb gross weight group (the basic vehicle), is 10.728 mills/mile, whereas the net responsibility of the 78 001- to 80 000-lb gross weight group is 171.069 mills/mile.

Implications from 1980 Study

Budget 1: Current Expenditure Level

The distribution of cost responsibility between basic and heavy vehicles is approximately the same as the projected 1983 distribution of road user revenue from these vehicles. This implies that the basic vehicle is meeting its fair share for the level of expenditures in budget 1. However, as automobiles become increasingly more fuel efficient, their payment will fail to meet their cost responsibility.

The results imply that projected 1983 revenue from existing weight-mile tax rates will be suffi-

Table 1. Comparison of cost-responsibility distributions between basic and heavy vehicles.

		Cost-Responsibility Distribution			
		Unadjusted		Adjusted[b]	
Study	Budget[a]	Basic Vehicles	Heavy Vehicles	Basic Vehicles	Heavy Vehicles
1963	1	61.5	38.5	64.8	35.2
1974	1	63.8	36.2	64.6	35.4
1980	1	52.9	47.1	55.5	44.5
	3	50.9	49.1	54.0	46.0

[a]Budgets: 1 denotes current expenditure-level budget and 3 denotes preservation-level budget.
[b]Adjusted for redistribution of subsidies.

Table 2. Comparison of existing and adjusted rates for Schedule B, Budget 1.

Declared Combined Weight Group (lb)	Existing Rate per Mile (mills)	Recommended Rate per Mile (mills)
0 to 6 000	5.5	5.5
6 001 to 8 000	7.0	8.0
8 001 to 10 000	8.5	10.0
10 001 to 12 000	10.5	12.5
12 001 to 14 000	12.0	15.0
14 001 to 16 000	14.0	17.5
16 001 to 18 000	15.5	20.0
18 001 to 20 000	17.5	22.0
20 001 to 22 000	19.0	23.5
22 001 to 24 000	21.0	25.0
24 001 to 26 000	22.5	26.5
26 001 to 28 000	24.0	27.5
28 001 to 30 000	25.5	28.0
30 001 to 32 000	27.5	28.5
32 001 to 34 000	29.0	29.0
34 001 to 36 000	30.5	29.5
36 001 to 38 000	32.0	30.0
38 001 to 40 000	33.5	30.5
40 001 to 42 000	35.0	31.0
42 000 to 44 000	36.5	31.5
44 001 to 46 000	38.0	32.0
46 001 to 48 000	40.0	32.5
48 001 to 50 000	41.5	33.0
50 001 to 52 000	43.0	33.5
52 001 to 54 000	45.0	34.0
54 001 to 56 000	46.5	34.5
56 001 to 58 000	48.0	35.5
58 001 to 60 000	49.0	36.5
60 001 to 62 000	50.0	38.0
62 001 to 64 000	51.0	40.0
64 001 to 66 000	52.0	42.0
66 001 to 68 000	53.0	44.5
68 001 to 70 000	54.0	47.0
70 001 to 72 000	55.0	50.5
72 001 to 74 000	55.5	54.0
74 000 to 76 000	56.5	58.0
76 000 to 78 000	Add 1.0 mill/ ton or fraction of ton over 76 000	62.5
78 001 and over		Add 4.0 mills/ ton or fraction of ton

Figure 1. Comparison of existing schedule B and adjusted schedule B under austere budget.

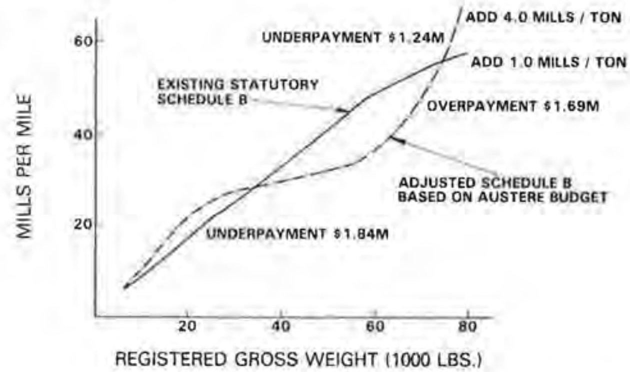


Table 3. Recommended and existing weight-mile tax schedules for diesel-powered vehicles, Budget 1.

	Mills/Mile		
Gross Vehicle Weight Group (lb)	Net Responsibility	Recommended Schedule	Existing Statutory Schedule
Cars	4.312	–	
0- 6 000	–	7.0	6.0
6 001- 8 000	12.368	10.0	8.0
8 001-10 000	11.546	12.0	9.5
10 001-12 000	11.884	13.0	11.5
12 001-14 000	12.212	14.0	13.5
14 001-16 000	12.266	15.0	15.5
16 001-18 000	13.908	16.0	17.5
18 001-20 000	12.520	17.0	19.5
20 001-22 000	13.004	18.0	21.0
22 001-24 000	13.333	19.0	23.5
24 001-26 000	13.850	20.0	25.0
26 001-28 000	16.405	21.0	26.5
28 001-30 000	18.222	22.0	28.5
30 001-32 000	19.447	23.5	30.5
32 001-34 000	21.527	25.0	32.5
34 001-36 000	23.073	26.5	34.0
36 001-38 000	23.557	28.0	35.5
38 001-40 000	23.031	30.0	37.5
40 001-42 000	20.946	32.0	39.0
42 001-44 000	31.993	34.0	40.5
44 001-46 000	32.533	35.0	42.5
46 001-48 000	31.198	36.0	44.5
48 001-50 000	35.525	37.0	46.0
50 001-52 000	34.292	38.0	48.0
52 001-54 000	27.561	39.0	50.0
54 001-56 000	32.781	40.0	52.0
56 001-58 000	28.028	41.0	53.5
58 001-60 000	30.498	42.0	54.5
60 001-62 000	33.280	44.0	55.5
62 001-64 000	33.381	46.0	57.0
64 001-66 000	37.739	48.0	58.0
66 001-68 000	42.891	50.5	59.0
68 001-70 000	47.811	53.5	60.0
70 001-72 000	43.763	56.5	61.5
72 001-74 000	43.384	59.5	62.0
74 001-76 000	55.673	63.0	63.0
76 001-78 000	71.455	66.5	64.0
78 001-80 000	69.984	70.5	65.0
80 001 and over		Add 4.0 mills/ton above 80 000 lb	Add 1.0 mill/ ton above 80 000 lb

cient to meet the fair share of heavy vehicles as a whole. However, it is strongly recommended that the weight-mile tax schedule be changed to conform more closely to the fair share of individual weight classes. Specifically, it is recommended that tax rates be reduced for the medium-weight trucks and increased for the heaviest-weight classes. The latter are the classes that are increasing at the greatest rate in numbers and miles driven and are also the ones that cause most of the weight-related road damage.

Budget 3: Preservation Level

For this expenditure level, the total responsibility of basic vehicles is 11.14 mills/mile. This represents a 110 percent increase from the corresponding responsibility under budget 1. The net responsibility of basic vehicles is 10.73 mills/mile. This implies that the gasoline tax should be increased by 11.0 cents to a total of 18.0 cents/gal.

Overall, heavy-vehicle weight-mile tax rates should be increased to bring in 128 percent more revenue than under budget 1. Any tax schedule adopted should conform closely to the net responsibility of individual weight classes.

Figure 2. Comparison of existing and recommended weight-mile tax schedules with net responsibility.

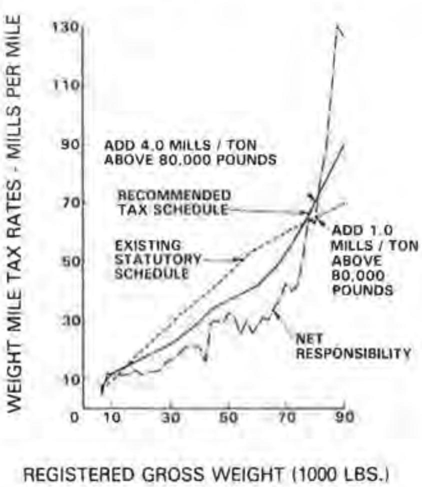


Table 4. Recommended weight-mile tax schedule, Budget 3.

Gross Vehicle Weight Group (lb)	Recommended Schedule (mills/mile)	Gross Vehicle Weight Group (lb)	Recommended Schedule (mills/mile)
0- 6 000	14.0	40 001-42 000	78.0
6 001- 8 000	19.0	42 001-44 000	83.0
8 001-10 000	22.5	44 001-46 000	88.0
10 001-12 000	25.0	46 001-48 000	92.0
12 001-14 000	28.0	48 001-50 000	95.0
14 001-16 000	31.0	50 001-52 000	97.0
16 001-18 000	34.0	52 001-54 000	99.0
18 001-20 000	37.0	54 001-56 000	101.0
20 001-22 000	40.0	56 001-58 000	103.0
22 001-24 000	43.5	58 001-60 000	106.0
24 001-26 000	47.0	60 001-62 000	110.0
26 001-28 000	50.5	62 001-64 000	114.0
28 001-30 000	54.0	64 001-66 000	119.0
30 001-32 000	57.5	66 001-68 000	125.0
32 001-34 000	61.0	68 001-70 000	131.0
34 001-36 000	65.0	70 001-72 000	138.0
36 001-38 000	69.0	72 001-74 000	146.0
38 001-40 000	73.0	74 001-76 000	155.0
		76 001-78 000	165.5
		78 001-80 000	177.0
		80 000+	Add 10.0 mills/ton above 80 000 lb

SUBSIDY ISSUES

Theory of Subsidies

Governments have traditionally used subsidies to help meet certain political and economic goals. Subsidies have been used to unite the country, to develop certain areas, to protect certain economic interests and groups, and to correct inequities due to external economies and diseconomies (8). If subsidies are necessary, they should be used to minimize economic disruption and maximize economic efficiency.

External economies may justify the use of subsidies to promote the social benefit. External diseconomies may justify the use of taxes to curb them. An economic case for subsidies (or taxes) may exist wherever an external economy or diseconomy creates a divergence between private pecuniary marginal cost as seen by a firm and social marginal cost.

Direct subsidies to transportation modes and groups have been justified on the basis of external economies. Subsidies have been given (a) to railroads to unify and develop areas; (b) to certain areas for highways for economic development to reduce poverty, e.g., the Appalachia highway program; (c) to develop new transport modes, e.g., the airlines; and (d) to revive existing transport modes, e.g., passenger train service and public transit.

Indirect subsidies are more difficult to justify. Frequently, the group benefiting does so at the expense of other existing competitive modes. Two examples that are very evident are the lack of adequate charges on inland waterway users (9) and inadequate charges for certain users of highways (10). The fact that there is very little vertical integration between the road owner and road user compared with the railways means that the road user is not paying full road charges. The result has been to put the railroads at an existing disadvantage with barge lines and trucking firms. External diseconomies due to environmental pollution by automobiles are indirect subsidies to road users.

Cross-subsidies have always existed. Certain groups have always financed others. Populated areas have financed roads in the less-populated areas. The rationale has always been that it would reduce the cost of transportation and hence lower the prices of goods and services. Fees from heavily traveled routes have been used to finance less-traveled routes. An example in the public sector is the cross-subsidization of certain ferry routes by the heavily traveled routes in the Washington State Ferry System (11). Here certain income groups have benefited at the expense of others.

Roads are not a pure public good; they have many of the economic characteristics of a natural monopoly and as such should be regulated by the state but not financed out of general taxation, nor should the road user be subsidized. The road marginal cost of a vehicle journey is not an insignificant portion of the overall road cost unless a superstrong road is built that would result in high capital costs and low marginal costs.

Subsidy Issue

Throughout the history of road user taxation in Oregon, the existence of subsidies has created some distortions in cost responsibility. A subsidy exists when consumers pay less than the full cost of the goods and services they use or when a firm or a public agency does not recover the full cost of operation from users or consumers. To the extent that any class of vehicles is not paying its share of road user responsibility, that class is receiving a subsidy that must be borne by other vehicle classes. Three types of subsidies are currently present in the Oregon road user tax structure. These are direct subsidies, cross-subsidies, and indirect subsidies.

Direct Subsidies

These subsidies take the form of exemptions from certain road user taxes granted to some types of vehicles. Currently there are two main classes of vehicles that receive direct subsidies--farm vehicles and publicly owned vehicles. As shown below, under the current-expenditure-level budget in the 1980 study, farm and publicly owned vehicles are underpaying by $3 855 400. This amounts to 2.1 percent of the total responsibility of all vehicles.

Item	Amount
Total responsibility of farm and publicly owned vehicles ($)	9 854 629
Payment by farm and publicly owned vehicles ($)	5 999 149
Payment to be redistributed to all other (nonexempt) vehicles ($)	3 855 480
Underpayment by farm and publicly owned vehicles (%)	39.1
Underpayment with respect to total responsibility of all vehicles (%)	2.1

The 1963 study found that these payments amounted to $2.79 million or 0.3 mill/vehicle mile. This amounted to 3.9 percent of total responsibility. The 1974 study showed that these underpayments amounted to $5.74 million, which represented 3.7 percent of the total responsibility. Direct subsidies have been reduced since the 1974 study by (a) an increase in farm vehicle registration fees, (b) a required payment of weight-mile taxes by farm vehicles hauling for hire, and (c) a required payment of the gasoline tax by publicly owned vehicles.

If society deems that it is in the public interest to subsidize these groups, then it is necessary to point out that such subsidies violate cost responsibility and result in larger burdens on other vehicle classes. Since agriculture benefits the entire state, it would be more appropriate to subsidize farm vehicles out of general funds rather than out of the highway trust fund.

Cross-Subsidies

Cross-subsidization in existing tax rates may occur between basic and heavy vehicles or among heavy-vehicle weight groups. The latter situation may occur when statutory weight-mile rates are out of phase with the actual cost responsibility of most weight groups.

Basic Vehicles Versus Heavy Vehicles

Are basic vehicles subsidizing heavy vehicles or vice versa? Table 5 shows that for the total adjusted and net responsibilities in the 1980 study both classes as a whole are paying virtually what they should be under current tax rates. Therefore, very little cross-subsidization exists between basic vehicles and heavy vehicles as a whole.

Heavy-Vehicle Weight Groups

Cross-subsidization of certain heavy-vehicle weight groups does exist because the current statutory tax rates do not conform well to the actual cost responsibility of these groups. This is shown in Figure 2 for budget 1 and diesel-powered vehicles.

Under the existing weight-mile tax rates, heavy vehicles less than 16 000 lb and more than 76 000 lb are underpaying relative to their responsibility, whereas vehicles between 16 000 and 76 000 lb are overpaying. In other words, heavy vehicles between 16 000 and 76 000 lb gross weight are cross-subsidizing the other two groups. This is also shown in Table 5. Combination trucks do not appear to be paying their full responsibility, as shown by the ratios of payments to responsibility shown below:

Registered Weight Class (lb)	Ratio of Registration Fees and Weight-Mile Taxes Paid to Total Adjusted Responsibility	Ratio of Weight-Mile Taxes Paid to Net Responsibility
50 001-60 000	1.48	1.68
60 001-70 000	1.39	1.50
70 001-80 000	0.95	0.94
80 001-90 000	0.65	0.62
90 001-100 000	0.58	0.55
Total (all vehicles between 50 001 and 90 000 lb)	0.93	0.92

As can be seen, the heaviest-weight classes are substantially underpaying relative to their responsibility. Under the recommended tax rates shown in Table 3, these cross-subsidies are substantially reduced, as shown in Table 6.

The 1974 study found that heavy vehicles that weighed less than 34 000 lb and more than 74 000 lb were underpaying by $1.842 and $1.237 million, respectively, relative to their responsibility, whereas vehicles between 34 000 and 74 000 lb were overpaying by $1.691 million. This is shown in Figure 3. The 1980 study found larger cross-subsidies along with different crossover points. This was due to the increasing emphasis on preservation-type projects and the increase in heavy-vehicle traffic.

The result of this cross-subsidization has been to encourage growth in the number of heavier vehicles and thus to accelerate the deterioration of Oregon's highways, since it is these weight groups that are responsible for most of the weight-related damage. It is recognized that economies of scale have also encouraged their rapid growth and use.

Indirect Subsidies

State Police Funding

The removal of State Police funding from the Highway Fund has resulted in an indirect subsidy to all Oregon road users. State Police traffic patrols are road user related and thus are the responsibility of road users. The voters of Oregon, however, specified through the passage of Ballot Measure 1 in May 1980 that this item should be paid out of general tax revenues. This amounts to some $24 million annually and represents a windfall to the Oregon road user, mainly to the basic-vehicle group.

Table 5. Cross-subsidies in existing tax rates between basic vehicles and heavy vehicles and within heavy-vehicle weight group.

Vehicle Group	Net Responsibility ($)	Actual Payment ($)	Difference		Total Adjusted Responsibility ($)	Actual Payment ($)	Difference	
			Dollars	Percent			Dollars	Percent
Basic vehicles	78 701 240	77 435 680[a]	1 265 560	1.61	100 554 077	99 288 517[a]	1 265 560	1.26
Heavy vehicles	70 669 127	69 722 991	946 136	1.34	80 724 006	79 777 870	946 136	1.17
Weight group (lb 000s)								
0-16	1 645 013	1 602 919	42 094	2.56	2 026 869	1 984 775	42 094[b]	2.08[b]
16-76	15 504 412	21 312 408	-5 807 996	-37.46	19 546 727	25 354 723	-5 807 996	-29.71
76+	53 519 702	46 807 664	6 712 038	12.54	59 150 410	52 438 372	6 712 038	11.35

[a]Assumes 16.5 mpg average for basic vehicles.
[b]Positive difference indicates underpayment relative to responsibility and negative difference indicates overpayment relative to responsibility.

Table 6. Cross-subsidies in recommended tax rates within heavy-vehicle weight group.

Vehicle Weight Group (lb 000s)	Net Responsibility ($)	Actual Payments Based on Recommended Tax Rate ($)	Difference[a] ($)	Percent Difference
0-16	1 645 013	1 793 337	148 324	9.02
16-76	15 504 412	18 190 015	-2 685 603	-17.32
76+	53 519 702	50 695 338	2 824 364	5.28

[a]Positive difference indicates underpayment relative to responsibility and negative difference indicates overpayment relative to responsibility.

Table 7. Preservation-study results of 10-year costs.

Component	Status Quo Quantity	Status Quo Cost ($000 000s)
Pavement (miles)	3524	890
Bridges	49	170
Operations[a]		204
Total		1.264

Note: "Status quo" presumes holding the line at the present condition levels by addressing the most severe problems. This program accepts that system deficiencies will remain at present levels throughout the 10-year study period because elements now in good or fair condition will become deficient by the end of the period.
[a]"Operations" include a mix of needs ranging from traffic signals to passing lanes.

Figure 3. Comparison of recommended tax schedule B with present schedule B.

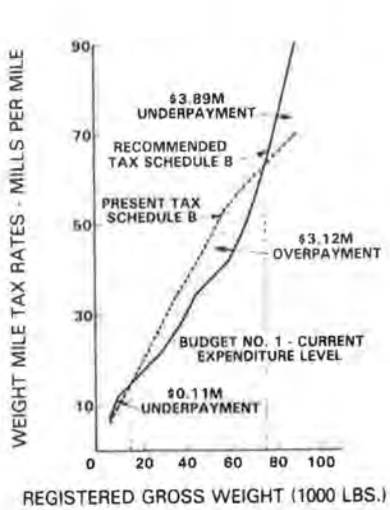
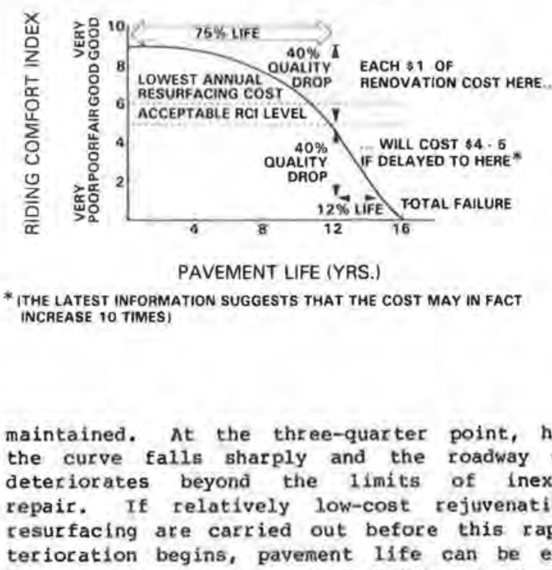


Figure 4. Road deterioration versus pavement life.



* (THE LATEST INFORMATION SUGGESTS THAT THE COST MAY IN FACT INCREASE 10 TIMES)

Lack of Adequate Expenditure Level

The failure of the state to adopt a budget that fully addresses the true cost of preserving the highway system indirectly subsidizes the present road user. To the extent that budgets 1 and 2 (not shown here) do not have adequate revenues to pay for preserving the system, these costs will be paid by future road users.

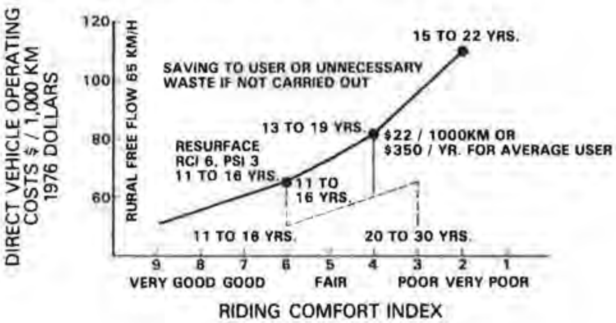
Table 7 (7) shows that to maintain the system in its present condition, Oregon would have to invest $1.264 million in 1980 dollars over the next 10 years. To achieve this, fuel-tax rates would have to be increased by 11.0-18.0 cents/gal and overall heavy-vehicle rates increased by 148 percent.

If this budget level is not adopted, there will be higher pavement repair costs in the future, as shown in Figure 4 (12). The basic pavement performance curve shows clearly that pavement deterioration starts slowly, and for about 75 percent of pavement life an acceptable level of service can be maintained. At the three-quarter point, however, the curve falls sharply and the roadway quickly deteriorates beyond the limits of inexpensive repair. If relatively low-cost rejuvenation and resurfacing are carried out before this rapid deterioration begins, pavement life can be extended for a fraction of the cost of waiting "just a couple of years more."

It costs more to drive on bad roads than on good roads (13-15). This is illustrated in Figure 5 (12), which displays how direct user costs increase with deteriorating road conditions. Dashed lines show what effect resurfacing would have on direct operating costs versus doing nothing. Without resurfacing, the average vehicle user would pay an additional $350/year in operating costs. This amount would be much higher for commercial vehicles.

It is estimated that badly worn roads add an estimated $437.1 million a year to drivers' costs in Oregon due to wasted fuel, excessive tire wear, and extra vehicle repairs. This total amounts to an average annual expense of $233/driver (16).

Figure 5. Rehabilitation effect on vehicle operating costs.



In other words, future road users will end up paying more, either in higher tax rates or in higher motor vehicle repairs and operating costs. In some cases, economic development may be slowed or indefinitely postponed, since good transportation is a necessary condition for development.

Recommendation

The goal should be to minimize subsidies as much as possible. Farm vehicles and publicly owned vehicles should pay their cost responsibility. To the extent that subsidies, as a matter of public policy, are considered to be beneficial to the people or the economy of the state, they should be paid from general tax revenues rather than from road user funds. Cross-subsidization should be minimized by adopting a weight-mile tax schedule based on the responsibility of each vehicle weight class. Indirect subsidies should be reexamined carefully to study the full implication to the Oregon taxpayer and future road users. This would mean adopting a preservation-level program with its required financing.

CONCLUSIONS

Subsidies continue to exist in Oregon highway transportation despite the best efforts to try to minimize them. As soon as one is eliminated, another appears. Cross-subsidization occurs because of the failure to adopt a weight-mile schedule that closely conforms to the net responsibility of individual weight classes. Direct subsidies, previously justified, should be looked into more closely by the State Legislature. Oregon is moving in the right direction, albeit at a slow pace.

ACKNOWLEDGMENT

The views expressed in this paper are ours and do not necessarily reflect those of the Oregon Department of Transportation.

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Abridgment

Elements of Short-Run Marginal Costs of Highway Use

RALPH C. ERICKSON

An investigation of the costs imposed on society by the highway system in a short-run marginal cost (SRMC) framework revealed few elements of social cost that are quantifiable. The SRMC concept applied to highway use implies that only costs that vary with highway use (variable costs) are valid elements for user charges. Analysis of each element included investigations to determine whether vehicle size and weight characteristics create additional costs or benefits to nonusers and whether estimated values of the impacts are available. The SRMC elements analyzed here are certain accident costs, traffic interference with nonmotorists, visual effects, neighborhood disruption, effects on rare and unique resources, ecological effects, and water and soil pollution. Most of the costs were found to be unquantifiable, but based on the nature of the impacts it could be determined that they generally do not vary across vehicle classes in significant amounts. Those with estimated values were substantial and this seems to indicate that significant impacts are now borne by society in general.

The importance of short-run marginal cost (SRMC)-based road user charges is that they bring to the attention of the highway user the costs that users impose on society when they make a trip decision, which produces efficient use of the existing road capacity.

A person contemplating an automobile trip makes a decision about the importance of the trip. Other elements, such as added congestion created by that trip, wear and tear on the roadway, and other factors, are not considered in that decision. In this paper, we are assessing the impacts that are beyond the normal tripmaker's considerations when the trip decision is made.

Some costs not considered in the tripmaker's decision are covered in part by other means. For example, premiums charged for automobile insurance reflect the costs associated with traffic accidents, including property damage, personal injury, and, to a lesser extent, death, pain, and suffering. Premiums are only loosely related to the amount of travel, but for each trip drivers are aware that if they cause an accident, their insurance premiums are likely to increase. When private markets thus force users to consider social costs of their trips, it is not necessary for the public sector to impose charges for those costs.

By their very nature, social costs are hard to quantify. Those components of SRMC theory that are fairly tractable--pavement wear, congestion, and air and noise pollution costs--are the subject of other research studies for the 1982 Federal Highway Cost Allocation Study (1). This paper analyzes the more intractable items. It is anticipated that most of the items cannot be expressed in monetary terms or quantified.

Without reliable estimates of nonuser costs in monetary terms, they cannot appropriately be incorporated into the final determination of highway cost allocation. It is still desirable, however, to document what is known about these items.

This paper will analyze the following SRMC elements not internalized by users: certain accident costs, traffic interference with nonmotorists, visual effects, disruption of the neighborhood, effects on rare and unique resources, ecological effects, and water and soil pollution. Each cost will be examined as follows: (a) a background section describing each item of cost and evaluating the components of each cost, (b) a section describing how the cost varies by vehicle class (size and weight), and (c) a section estimating the monetary value or relative magnitude of each cost.

NONINTERNALIZED ACCIDENT COSTS

Some costs--vehicle insurance and user fees that are already paid for by the highway user--will be ignored in this paper. Other accident costs are not covered by the user and they will be the focus of the following discussion.

When a highway traffic accident occurs, a series of events is set in motion that creates costs not normally considered highway user costs. Police response, fire and emergency vehicle response, traffic delays, losses to employers, prosecution, and probation and court costs that are directly related to traffic accidents are all costs created by highway use.

The heavier a motor vehicle, the more severe an accident that occurs. With greater volumes of heavy motor vehicles, severe accidents are more prevalent. Truck hazardous-cargo spills can create chaos that readily affects users and nonusers.

Vehicle size has some effect on vehicle safety. Long vehicles make passing more difficult and unsafe. Wide vehicles restrict visibility for following vehicles. The trend is toward larger trucks and smaller cars, which will further exacerbate these safety problems.

A few studies done in the last decade have estimated societal costs of motor vehicle accidents. One study, 1975 Societal Costs of Motor Vehicle Accidents, by the U.S. Department of Transportation, estimated the costs of accident investigations, losses to others, and traffic delay and legal and coroner costs (2, p. 25). Updating the 1975 data and using 1978 accident counts yields an estimate of about $7 billion for noninternalized annual accident costs.

DELAYS TO NONMOTORISTS

The highway system creates delays for nonmotorists. The most obvious example of this is pedestrians waiting for an opportunity to cross the street. Other types of nonuser delays exist, which include the possibility of increased damage incurred in a fire due to fire trucks delayed by congestion. The main thrust of this analysis, however, is directed at the largest delays--those incurred by pedestrians and bicyclists waiting at crossings.

Several studies have found that pedestrians value their travel time two to three times more highly than do motorists (3, p. 24). Pedestrians are more exposed to the weather, more threatened and intimidated by vehicles, and, in some cases, are limited in physical ability.

The amount of pedestrian delay is directly related to the traffic volume of the highway system. On the Interstate system and other limited-access freeways, there is no opportunity for pedestrian crossing except at underpasses, overpasses, or specific pedestrian bridges or tunnels. On the primary and other federal systems, the delay is at traffic lights or unsignalized intersections. Urban areas with high traffic and pedestrian volumes experience the highest nonuser delays.

Vehicle size has an impact on the delay experienced by pedestrians. A truck whose place in the traffic queue could be occupied by three cars is contributing three times as much to pedestrian delay as one passenger automobile. Total delay costs should be attributed to vehicle classes in proportion to the space they occupy.

Not enough information is available to estimate the value of nonuser delay. One study (3, p. 24) estimates 1978 pedestrian travel-time values of 20 cents/min for the central business district and 15 cents/min for other locations. None of the literature, however, estimated the number of people delayed by traffic nor average time of delay. Without these other values, the total nonuser delay due to traffic volumes cannot be estimated.

VISUAL EFFECTS

Highways can create negative visual effects for users and nonusers of the system. Litter and the use of adjacent land for billboards are dependent on traffic volume. Trash along the roadway from vehicles is a function of traffic volume, the existing surroundings, and the level of control and enforcement. Billboards are a function of traffic volume, since the advertiser is out to reach as many people as possible and carefully assesses possible locations for this attribute.

Although heavy vehicles such as trucks may well be more significant in the traffic stream in blighted, littered areas, they are not, in general, the cause of the litter or billboards. Trucks can cause unusual amounts of litter when states do not have laws requiring a cover for loads that can blow out of the truck (4, p. 21).

Estimated values for society's or the individual's perception of visual effects are available.

DISRUPTION OF NEIGHBORHOODS

Increasing traffic volume creates neighborhood disruption. This manifests itself in many ways: reduced neighboring, reduced community cohesion, disrupted living patterns, and reduced efficiency of community facilities. Reduced community cohesion is caused when traffic volumes on unlimited-access highways create disruption of residents' ability to meet and associate freely. The traffic reduces opportunities to meet casually, and as traffic becomes greater, it discourages outside activities for children and adults (5, p. 71). These reduced opportunities reduce the efficiency of community facilities. Parks and playgrounds become inaccessible. Stores lose customers and may go out of business. Getting to and from school becomes more difficult and dangerous.

Large volumes of heavy vehicles in the traffic stream create more than ordinary disruption of neighborhoods. Trucks are intimidating in residential neighborhoods. In sum, they create additional traffic burdens in neighborhoods.

It is impossible to estimate the value of neighborhood disruption due to highway traffic. In a pure experiment, two neighborhoods, otherwise identical but for traffic levels, would show differing property values as the cost of neighborhood disruption. Some studies have taken this approach, but the other factors inherent in the real world have so muddied the waters that the results are not sufficiently clear (6, p. 33).

TRAFFIC VOLUME IMPACT ON RARE OR UNIQUE RESOURCES

The term "rare and unique resources" includes the following: archaeological and paleontological resources, historic properties, wilderness areas, and national parks. Conflicts may arise between the use of highway systems and damage to rare or unique areas or resources. Popular national parks may be inundated with traffic, which lessens the enjoyment of the area for all. Wilderness areas lose their remoteness by popular use. Paleontological sites are picked over and archaeological sites are destroyed when disturbed. Historic districts lose atmosphere when the streets are packed with traffic.

It may be the case, in specific situations, that heavy trucks are the prime cause of loss of ambiance to a historic district, but in general terms the impacts discussed in this section are not due to differences in vehicle weights. Truck and bus size has a visual barrier effect, which reduces the visibility in a historical district.

There is no direct way of estimating the cost to society imposed by automobile tripmakers on rare and unique resources. These resources are of different values to different people and estimation is extremely difficult under these conditions. Methods of estimating some of these values have been attempted in past studies (7).

ECOLOGICAL IMPACTS

Traffic volumes on the highway system can create an unattractive habitat to wildlife and plants. Greater traffic increases the chances of vehicle-animal collisions. It appears that many species become adjusted to some aspects of traffic volume. A case has been cited of elk being unconcerned with traffic until a vehicle stops on the side of the road (8). Some potential impacts have been predicted but not documented and others may exist that we know nothing about (9, p. 43).

Ecological impacts are not sensitive to vehicle class except that heavy trucks may cause additional noise and vibration. Truck size has no effect on ecological impacts.

While there is a value to these impacts on the ecology, it is practically impossible to develop a reasonable cost estimate for SRMC user charges of ecological impacts.

WATER AND SOIL POLLUTION

Water pollution is significantly influenced by highway runoff. Substantial amounts of oil and grease are leaked onto the roadway and part of this is washed off in rainstorms. Road salt in winter creates a large amount of troublesome runoff. If the storm sewers lead into streams or rivers, the highway contributes to pollution directly. If the sewers lead into a municipal sewer system, the runoff is treated. In heavy rainstorms, however, the additional load on the sewer system may cause the dumping of untreated municipal waste directly into streams. With an estimated one-fifth of an average city's total land area dedicated to transportation uses (mostly streets and highways), a heavy rain could quickly overload a combined sewer system (10, p. 115).

Besides impacts on flowing surface water, highway pollutants find their way into the groundwater. This is considered by some as the more important of the two impacts. The severity of groundwater impacts is not known due to lack of knowledge about salt and other contaminants in groundwater (11, p. 86).

Soils are also affected by concentrations of toxins and heavy metals. Asbestos, lead, acids, copper, zinc, cadmium, iron, nickel, chromium, and other traces can be found in the soil (12, p. 68). Greater traffic flows mean higher concentrations of these toxins near the roadway.

Those vehicle classes with larger engines, more tires, and brakes are contributing greater amounts of pollutants that originate from those parts. Greater distances of travel [vehicle miles of travel

(VMT)] contribute proportionally larger amounts of pollution and make greater use of roads cleared with road salt in winter snow.

There is no way to estimate the value of water pollution spillovers due to highway traffic.

CONCLUSION

The SRMC elements of highway use analyzed in this paper are, in many cases, not quantifiable. All the above elements are a function of traffic volumes and therefore vary with highway use. In designing a system of user charges based on SRMC, these elements should be accounted for in the variable-with-use portion of a user charge.

Most of the SRMC elements are not attributable to specific classes of highway users. The following items should be considered common costs, that is, to be shared by all vehicle classes equally: visual effects, most neighborhood disruption (other than noise and vibration), most impacts on rare and unique resources, and ecological impacts.

Heavier vehicles, in general, occasion greater costs in safety, water, and soil impacts because they tend to travel greater distances. These costs should be attributed by the VMT of the vehicle. Larger vehicles occasion greater costs in safety, nonmotorist delay, and rare and unique resources because of their size.

In all, a sum that would be a particular vehicle's short-run marginal cost as considered in this paper would be made up of components for VMT, vehicle weight, vehicle size, and a common cost spread across all vehicles equally. To this sum would be added the other SRMC costs not covered here but in other parts of the Highway Cost Allocation Study. However, as this analysis shows, there is not enough solid cost evidence to place actual values on the cost analyzed.

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Net Benefits from Efficient Highway User Charges

DOUGLASS B. LEE

The purpose of this paper is (a) to estimate what a complete set of efficient highway prices would look like in terms of dollar magnitudes and their relationships to travel by particular vehicles under particular conditions and (b) to measure the gains that would result from imposing the efficient prices instead of the ones now charged. Because the scope of this effort is large and because no comprehensive set of marginal cost highway user charges has been estimated previously, the result of the current work is still very rough. At present, the concepts and methods are at least as important as the numerical results.

Were there no constraints--no budgetary revenue requirements, not more than one level of government involved in setting charges, no concern for income transfers or indirect impacts, and all other public and private enterprises efficiently priced--on setting highway user charges, efficiency (in the allocation of highway investment resources and available capacity) would be the sole objective in designing such charges. In reality, numerous compromises must be made for numerous reasons. The issue then becomes the degree to which efficient resource allocation should be sacrificed for other purposes.

Although whether they are cost occasioned has been routinely cited as a basis for designing highway user charges, efficiency in the utilization of scarce resources has not received much attention until recently. Now, however, highway professionals and policymakers at all levels of government are increasingly interested in finding the most productive use of the nation's resources as well as in the fairness of revenue instruments.

OBJECTIVES IN HIGHWAY PRICING

Application of the economist's concept of efficiency to public policy implies that the government should seek to maximize the net social benefits resulting from the activities in which it engages. Efficient highway user charges are those that will lead to the greatest surplus of benefits over costs for a given stock of capital facilities. Investment in the highway system should follow the same criterion, namely, increase output as long as the marginal benefits exceed the marginal costs. The research reported here, however, is directed at the pricing portion of efficiency rather than the investment portion.

Administrative Costs of Pricing

For prices to serve as guides to efficient resource allocation, they must be clearly tied to use in both reality and the consumer's mind. Annual registration fees that are invariant with respect to the amount or location of travel can only serve as very crude prices at best. This need for prices to be based on the amount of travel and the specific conditions under which it is consumed make accurate pricing difficult and perhaps exorbitantly costly in many circumstances.

The orientation of this report is to estimate what the correct prices would be by cost component and to disregard the means by which the charges might be collected. Qualitative judgments are offered regarding which costs of travel are not likely to be feasibly priced, but no quantitative trade-offs between the benefits of improved capacity utilization and administrative costs of imposing ideal user charges are attempted. These questions are critical and must be addressed eventually, but the initial problem is to gain an idea of the general magnitude of efficient prices. Ultimately, the question is whether some attempt at efficient pricing will be better than the present methods for setting highway user charges, however imperfect the pricing mechanisms. Rough approximations can be improved with experience, and experience may be the most effective way to achieve accuracy.

Second-Best Conditions

Requiring that users of the highway system pay the marginal costs of their use does not necessarily lead to efficient resource allocation unless the rest of the world also prices at marginal cost. Obviously, the rest of the world does not. It is then a matter of judgment whether efficient highway prices will improve or worsen aggregate welfare, and this judgment must be based on knowledge of such things as competition in transportation and related sectors, relationships between marginal costs and prices for goods and services that are substitutes or complements for highway services, and demand elasticities and cross elasticities. The working assumption here is that highway user charges that are closer to marginal cost than present charges will improve efficiency in the economy as a whole as well as in the highway sector.

MEASURES OF HIGHWAY OUTPUT

For the purposes of designing efficient user charges, the highway system has two primary dimensions of output. One is the volume of vehicles that can be moved over the system in a given time period, and the standard unit of measure is the passenger car equivalent (PCE). Each vehicle takes up some effective amount of space, and competition for this space results in congestion. The other dimension is the transport of weight, and here the unit of measure is the equivalent single 18 000-lb axle load (ESAL). Pavement damage is thought to be related to axle weights. Thus the output of the highway system is a combination of PCE-miles and ESAL-miles, or simply PCEs and ESALs.

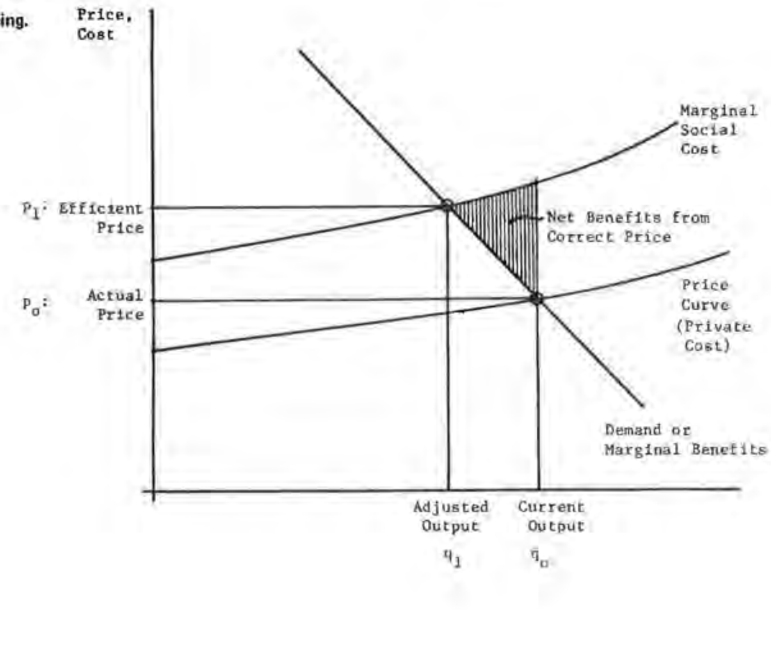
EFFICIENCY GAINS

The net benefits from more efficient prices are called efficiency gains or welfare gains. The nature of the gains depends on the output and the changes contemplated, but inefficiencies stem from either too low a price (marginal costs of some portion of consumption exceed the marginal benefits) or too high a price (users are deterred even though the benefits would exceed the costs). A generalized example is shown in Figure 1, in which the price curve lies below the cost curve. The shaded area represents the net loss from incorrect pricing, or the gains in efficiency that could be obtained by shifting from incorrect to correct pricing. In this instance, the incremental costs to society of the additional output are greater than the incremental benefits to the users. In the reverse case, where price is higher than marginal cost, the incremental benefits of greater output exceed the incremental costs.

ESTIMATION OF EFFICIENT PRICE COMPONENTS

Because efficient prices are based on charging each vehicle the costs that would be avoided if the vehicle were removed from the specific time and location where it is found operating, only variable (not fixed) costs are relevant. The variable costs listed below include those represented by public expenditures and those falling on private users and nonusers. For public costs, the price to the user is zero unless a user charge is imposed. For

Figure 1. Gains from efficient pricing.



private costs, it is the difference between social and private cost that is of interest; if there is no difference, there is no need for a price correction. The variable costs are as follows:

1. Public sector outlays (and associated costs)
   a. Pavement damage
      (1) Pavement restoration or loss of user benefits
      (2) User costs from pavement roughness
   b. Highway administration and services
2. Private user costs
   a. Vehicle interference
      (1) Delay
      (2) Accidents among vehicles
      (3) Increased vehicle operating costs
   b. Negative externalities
      (1) Air pollution
      (2) Water pollution
      (3) Noise
      (4) Visual intrusion
      (5) Danger to nonusers and property

This summary listing of variable costs is meant to be exhaustive in scope, if not in detail. If the highway system has been efficiently designed and maintained and output is subject to neither economies nor diseconomies of scale, then efficient prices to users will be sufficient to recover all the long-run costs of the system. Even though the prices are based on variable costs, under these conditions they will raise revenues that cover fixed costs as well. An important purpose of the attempt to estimate the full magnitudes of efficient prices is to assess the extent to which such prices would finance the construction and operation of the system. The results indicate that the revenues would be far greater than those raised by existing user charges.

Methods and empirical results for estimating efficient highway user charges are described in the next sections. Other references (1) provide a more detailed explanation than is possible in this brief summary.

Pavement Wear

Costs of pavement repair consist of two parts: the cost of repairing the damage to the pavement and the additional user costs to vehicles traveling over damaged pavement. An efficient design, maintenance, and operating program seeks to minimize the sum of the two costs, and correct pavement damage charges will normally include both components.

Pavement Repair

Highway pavements are designed to carry a forecast traffic volume over a lifetime of approximately 20 years. The major design consideration determining the thickness of the pavement is the expected number of axle load repetitions, measured in ESALs. Travel by various weights of vehicles can be translated into ESALs by using factors from the American Association of State Highway Officials (AASHO) Road Test, conducted in the 1950s (2). The factors embody the relationship that pavement damage on a given road increases with the fourth power of the weight on the axle. A fully loaded 72 000-lb five-axle tractor-semitrailor combination truck generates about 2 ESALs/mile of travel. Relatively, this heavy truck is wearing out the pavement at a rate about 5000 times that of the family car and about one quarter the rate of the same truck loaded to 100 000 lb. Each ESAL, however, does less damage on a thicker or stronger pavement, because pavement strength increases with the seventh power of thickness.

Incorporation of these engineering relationships into user charges that encourage efficient utilization of the highway system has several implications:

1. The charges should be high enough so that whenever a vehicle adds to the wear of the pavement, the benefits to the user (as expressed by willingness to pay for the damage through user charges) are at least as great as the costs of the damage to society.
2. Fees should increase steeply with increased axle weight.
3. Vehicles that use more axles to carry the same weight should be charged less.
4. Heavy vehicles should face substantially lower charges when they travel on heavy-duty rather than on light-duty roads.

On the assumption that the amount of pavement damage done by an ESAL is constant over the life of the pavement, the repair cost per ESAL is the total maintenance and restoration cost per highway mile divided by the ESAL life of the particular pavement and discounted from the anticipated time of restoration. Thus, the repair cost per ESAL will increase the nearer the date of restoration is and will decrease the stronger the pavement structure is. Estimated ESAL-mile charges for pavement repair are given in Table 1 by functional system.

User Costs

Pavement damage leads to lower speeds and higher operating costs for all users, whether they damage the pavement or not (3). From the standpoint of the vehicle creating the damage, user costs are external, so efficient pricing requires an explicit recognition of the user costs resulting from pavement wear.

In contrast to pavement repair costs, the time between the damage and the repair increases the user cost because more vehicles have a chance to suffer the effects of lower-quality pavement before the damage is restored. Thus, the marginal cost of an ESAL depends on the strength of the pavement (thicker pavement means less damage from a given axle) and the volume of use (larger volumes mean higher user costs). As seen in Table 1, user costs per ESAL tend to be dominated by the vehicle wear component, and reduced wear from high pavement strength is partly offset by higher average daily traffic (ADT) on heavy-duty pavements.

Administration and Services

Government services provided primarily because of highway users include traffic control, courts, street lighting (part), state highway patrol, and state and federal highway departments. Only some of these costs can be plausibly argued as related to traffic volume. The few studies available place the costs at about 0.4 cent/vehicle mile on the average (4).

Vehicle Interference

As more vehicles occupy space on the same roadway, interactions among the vehicles become increasingly significant. These interactions have three effects: one is the decrease in speed below free speeds, which results in additional travel time or delay; the second is the increase in operating costs caused by congested conditions; and the third is the increase in accidents among vehicles.

Congestion

The microeconomic formulation of the congestion problem (5) is represented in Figure 2. Average variable cost (AVC) includes vehicle wear and operating costs, pavement wear, and travel time and excludes user fees. This curve corresponds roughly to the price to the user and determines the volume of travel by its intersection with the demand curve. Because average cost rises with increasing volumes, the marginal cost of additional trips at any given volume is above the average cost. The major component of the increase in average cost and hence the difference between average and marginal cost is excess travel time or delay. Drivers are assumed to know the average travel times they will face when entering a given traffic stream, but they do not consider the increase in travel time caused by their presence for other vehicles. To internalize this effect--forcing the user to balance benefit against marginal cost--requires a price surcharge or toll that varies with the level of congestion and the PCE space occupied by the vehicle.

For the volume-capacity relationships implied by the cost curves and the demand schedule shown, the correct toll is the difference between p_0 and p_2. The effect will be to reduce vehicle volume from q_1 to q_0, at which point the average cost faced by the vehicle plus the toll will exactly equal the marginal cost. All vehicles in the stream pay this toll.

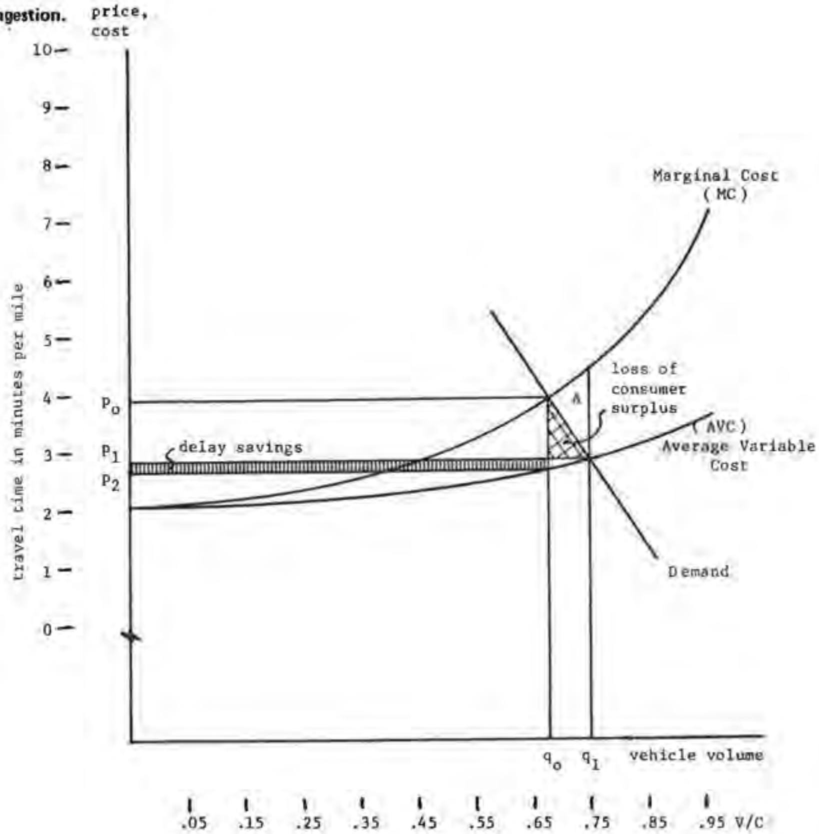
When the vehicle volume drops from q_1 down to q_0, costs are avoided equal to the area under the marginal cost curve, whereas benefits are lost equal to the area under the demand curve. The net effect is an efficiency gain represented by the three-sided area labeled A. This gain is composed of delay savings to vehicles remaining on the facility minus the consumer surplus lost by the vehicles tolled off. The first of these two components is indicated by the vertical shaded rectangle and the second by the hatched triangle. The difference between them is exactly equal to area A.

These abstract concepts can be operationalized directly. By using traffic engineering relationships based on a linear function between speed and density (6-8), average travel-time curves can be constructed for different road types. The curve for urban non-Interstate roads has been calibrated to the left-hand scale. Marginal travel times are derived from the average travel-time function. The horizontal scale has been converted to volume-capacity units and measures both volume and capacity in PCEs. Demand is given by an arc elasticity of -0.33 measured from the observed price-volume combi-

Table 1. Efficient pavement damage charges by functional system.

Functional System	User Cost (cents/ESAL-mile)				
	Pavement Repair	Vehicle Wear	Travel Time	Running Cost	Total
Interstate					
Rural	5.0	3.8	0.9	-0.9	8.7
Urban	15.0	10.6	2.4	-2.9	25.2
Arterial					
Rural	13.0	4.1	1.0	-1.1	17.0
Urban	41.0	7.6	7.0	0.3	55.9
Collector					
Rural	17.0	3.2	0.8	-0.9	20.1
Urban	40.0	6.6	6.1	0.2	52.9
Local					
Rural	31.0	2.4	0.6	-0.7	33.4
Urban	50.0	9.7	9.0	-0.4	69.1

Figure 2. Consequences of efficient pricing of congestion.



nation. This information yields a reduction in vehicle volume from 0.75 to 0.67 for the example in Figure 2, at which point the difference between average and marginal travel time is 1.02 min. By using a value of travel time of 8 cents/min ($4.80/vehicle-h), the efficient toll is 8.2 cents/vehicle mile. An estimated 30 billion vehicle miles of traffic (VMT) occurs annually on U.S. streets at a volume capacity ratio of between 0.7 and 0.8 (6,8,9), which would drop to 27 billion with the toll and produce $2.2 billion in revenues from this portion of total travel. Travel delay charges per PCE mile are shown in Table 2 for urban non-Interstate roads.

Accidents

Highway accidents cause personal injury and property damage. Costs include loss of life, loss of labor resources, medical expenditures, repair or replacement costs, loss of time, inconvenience and disruption, administration of the liability insurance system, public costs of emergency medical treatment and police, and adjudication of liability claims. So far, attempts at quantitative estimation of the relationship of these costs to congestion or particular vehicle types has not been satisfactory. More vehicles in closer proximity tend to increase the number of accidents, but if a fatality is valued in the $300 000 range (10), the benefits of reduced speed in reducing fatalities outweigh the costs of more accidents for at least some speed and volume ranges. Much accident data are available, but they are generally unsuitable for estimating the marginal costs of vehicles in connection with congestion.

Vehicle Operating Costs

Vehicle interference from congestion causes increased fuel consumption from forced speed changes and increased tire and vehicle wear from speed changes and braking. At speeds of more than approximately 45 mph, reduced speed tends to reduce fuel consumption and tire wear per vehicle mile, but it is not apparent what the net effects are if the speed reductions are the result of congestion. No quantitative estimates of changes in vehicle operating costs related to vehicle interference have been included in the figures presented here.

Negative Externalities

Highway users generate negative externalities in the form of air pollution, water pollution, noise, litter, danger to pedestrians, and other undesirable side effects. Air pollution and noise are real costs to members of society even though dollar amounts do not appear in public budgets (prevention or control costs sometimes do appear as expenditures, but these are only weakly related to damage costs). The higher the emissions rate by a vehicle is and the more sensitive and numerous the receivers are, the higher is the marginal cost of a vehicle trip. The essential characteristic of an externality is that it escapes normal market transactions, so that the valuation of negative external effects must be accomplished by political or other surrogate means. An efficient externality charge is one that encourages the producer of the externality to take the most suitable measures to reduce emissions and leaves the potential recipient to make the most suitable choices for ameliorating impacts of residual externality levels.

Methods for estimating the cost of externalities depend primarily on one or both of two strategies:

1. Estimate total expenditures made for the purpose of correcting the damage from the externality on the part of private individuals and
2. Estimate the willingness of individuals to pay for lower externality levels in surrogate (usually real estate) markets.

The aggregate-damage-cost approach has yielded the best results so far with air pollution costs (11), and the revealed-preference approach has been the most effective in evaluating noise costs (12). Air pollution costs average about 1.1 cents/vehicle mile in urban areas; there are wide variations depending on the area and the particular meteorological conditions. Noise costs average about 0.2 cent/vehicle mile in urban areas; heavy trucks create about 40 times as much damage as automobiles per vehicle mile.

Table 2. Time delay charges for urban non-Interstate highways.

Initial V/C	Average Time[a] (min/mile)	Marginal Time[b] (min/mile)	Toll[c] ($/PCE vehicle-mile)	Initial VMT	Revenues[d] ($ billions)
0.05	2.17	2.20	0.0023	15	0.03
0.15	2.23	2.30	0.0074	59	0.43
0.25	2.30	2.47	0.0138	104	1.40
0.35	2.37	2.66	0.0216	142	2.96
0.45	2.46	2.89	0.0314	111	3.31
0.55	2.57	3.19	0.0439	82	3.36
0.65	2.69	3.62	0.0601	52	2.86
0.75	2.86	4.29	0.0817	30	2.20
0.85	3.09	5.53	0.1117	52	5.09
0.95	3.50	9.58	0.1600	96	13.18
					34.83

[a]Average travel time based on linear speed-density and free speed of 28 mph = $4.29/[1 + (1 - V/C)^{1/2}]$.
[b]Marginal travel time = average time $\{1 + \{(0.5V/C)/[(1 - V/C) + (1 - V/C^{1/2})]\}\}$.
[c]Toll at the adjusted (price elasticity = -0.33) V/C and VMT (neither shown).
[d]Revenues from given toll at adjusted PCE volume.

User Charges for Prototypical Vehicles and Conditions

Of the variable costs listed earlier as relevant to the construction of efficient user charges, six have been quantified to the point of dollar estimates under some limited sets of average conditions: pavement repair, pavement user costs, administration, excess time delay, air pollution, and noise. Pavement damage and congestion delay are the costs of major significance; the others are small as per-vehicle-mile rates. Of the costs not estimated in cents per vehicle mile of travel (VMT), accidents appears to be the only category that might lead to a substantial increase in user charges if more were known about causal relationships. Other marginal costs may be large in the aggregate but small in relation to VMT.

Six vehicle types have been selected for illustration in Table 3; the salient vehicle characteristics are matched to the conditions under which they might be operated. The rural automobile causes little pavement damage because of light axle weights, it encounters little congestion so causes little delay, and the externalities it generates are easily diffused and affect few people. Such a vehicle is probably overcharged by a small amount, because fuel taxes and registration fees are largely insensitive to urban-rural locations and congestion. At the other end of the automobile scale, an urban commuter traveling during peak periods contributes noticeably to both congestion and pollution. A medium truck traveling in lightly congested urban areas incurs a mix of costs that includes damage to light pavements and negative externalities. The typical five-axle combination tractor-

Table 3. Efficient user charges for sample vehicles under specific conditions.

Vehicle Type	Location	Key Parameter	Component of Efficient Price (cents/VMT)							Existing Average User Fee (cents/VMT)
			Pavement Repair	User Costs	Administration	Excess Delay	Air Pollution	Noise	Total	
Automobile (3000-lb gross wt)	Rural	V/C = 0.05			0.3	0.3			0.6	1.3
Automobile (3000-lb gross wt)	Urban	V/C = 0.85			0.7	11.2	1.5	0.1	13.5	1.7
Single-unit three-axle truck (40 000-lb gross wt)	Small urban	V/C = 0.35 PCE = 1.2 ESAL = 0.8	25.6	7.5	0.5	2.2	0.2	0.2	36.2	4.8
Combination truck, five-axle, 3-S2 (72 000-lb gross wt)	Rural interstate	V/C = 0.15 PCE = 1.2 ESAL = 1.6	8.0	5.9	0.3	0.4			14.6	9.0
Combination truck, five-axle, 3-S2 (72 000-lb gross wt)	Urban interstate	V/C = 0.35 PCE = 1.2 ESAL = 1.6	24.0	16.3	0.3	1.4	3.0	4.0	49.0	9.0
Combination truck, four-axle (100 000-lb gross wt)	Rural arterial	V/C = 0.05 PCE = 3.0 ESAL = 27.2	408.0	95.2	0.3	0.3		0.2	504.0	5.0

Table 4. Revenues and net gains from efficient pavement damage charges.

Item	1981 $ Billions			
	Light Vehicles	Heavy Vehicles[a] Under 1.5	Heavy Vehicles[a] Over 1.5	Total
Pavement damage and user costs	0	10.1	15.4	25.4
Efficiency gains	0	0.8	4.1	5.0

[a]Vehicle classes are divided according to the average actual pavement stress applied by the typical vehicle, measured in ESAL miles per vehicle mile of travel.

Table 5. Revenues and net gains from efficient vehicle interference charges.

Item	1981 $ Billions				
	Rural Interstate	Rural Other	Urban Interstate	Urban Other	Total
Volume-capacity related costs	1.5	4.1	6.5	41.8	54.0
Congestion	1.5	4.1	4.5	33.2	
Externalities and other	0	0	2.0	8.6	
Efficiency gains	0.1	0.1	0.7	4.7	5.6

semitrailor operating entirely on heavy-duty pavements in rural areas creates damages about half again greater than its user charge payments, whereas the same vehicle operating on urban Interstates generates costs more than five times its estimated payments. Last on the list is an extremely destructive vehicle that might be a bulk agricultural hauler exempted from weight limits, a lumber truck, a coal hauler, or an illegally overloaded combination truck. The source of the damage is a very heavy load distributed on too few axles. Considerable guesswork lies behind these examples, and the specific conditions listed and implied may not be average for vehicles in the class represented.

NET BENEFITS FROM EFFICIENT CHARGES

For prices to function as guides to efficient resource utilization, the output that is priced must adjust to the point at which marginal benefits equal marginal costs. Because the existing price per ESAL seems to be below cost for medium and heavy axles, efficiency gains would be derived from reducing total ESAL output. Note, however, that it is not necessary to reduce ton mile output in order to reduce ESALs. With efficient pavement damage charges, heavy vehicles would have incentives to use more axles and stronger roads to carry the same total weights. If other constraints on efficiency were removed, it is possible that total ton miles could go either up or down while ESAL miles declined.

Similarly, efficient vehicle interference charges would be higher than current charges, in most circumstances, so reducing PCE miles of travel would result in savings in delay time far in excess of the lost travel benefits. Person trips, however, would not need to decline at all (through increased vehicle occupancy), and less-costly off-peak PCE mileage could be substituted for peak travel. Thus efficiency gains could be obtained in part from deterring frivolous travel, and the bulk of the net benefits would come from accommodating that travel in less costly ways. Efficient prices would encourage users to find those ways least disruptive to themselves.

Revenues from efficient user charges and net benefits were calculated by applying an estimated elasticity to each vehicle class on each system, combining all the price components into charges on the two (PCE and ESAL) dimensions of highway output. Aggregate results are shown in Tables 4 and 5. Total revenues sum to almost $80 billion, but presumably the actual total would be somewhat less because PCE charges deter some ESAL mileage, and vice versa. The revenues represent transfers, of course, and not net gains. Improved short-run efficiency is measured as something less, of the order of $10 billion annually, but this constitutes real gains in resources available that would be otherwise wasted.

CONCLUSIONS

Although the combined effect of all the components of efficient prices is subject to an additional degree of uncertainty beyond the uncertainty in the cost estimates, the total revenues raised would be more than $70 billion annually. This is more than the total expenditures for highways of $40 billion by all levels of government and more than twice the $22 billion currently collected in user charges. It is less, however, than the more than $100 billion that represents the annual cost of capital replacement to retain the full highway system as it now exists (13).

The most significant attribute of these results is that the user charges do not contain any fixed or annual components, such as registration or weight fees. Efficient prices, based on short-run marginal costs, would be sufficient to raise revenues on the current system that would cover at least a share of the fixed costs of the system without levying any access charges. Unless more revenues are desired, there is no need to allocate fixed costs of highway construction to vehicle classes for purposes of calculating highway user charges. Instead, the task is to estimate more accurately the true marginal costs of highway use and to design collection instruments that approximate the correct prices at the least cost.

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Abridgment

Maintenance Cost-Allocation Study for Virginia's Interstate Highways

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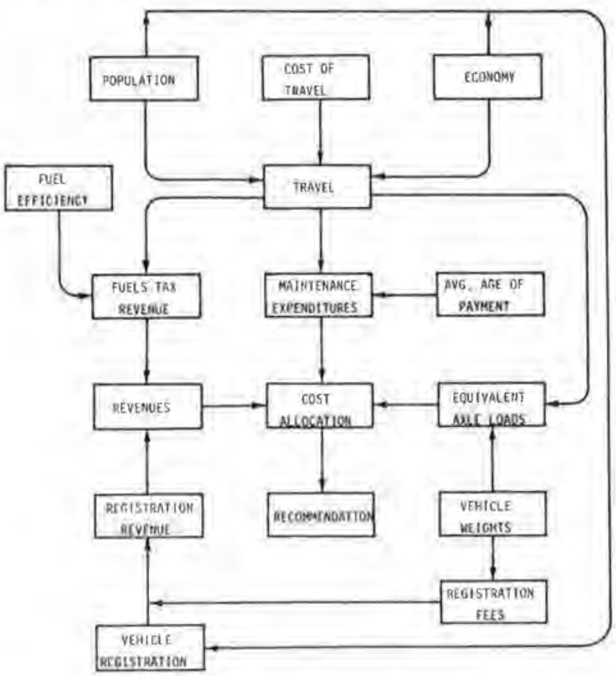
The maintenance cost responsibilities for all classes of highway users on Virginia's Interstate highways are examined. The purpose is to compare the future fuel-tax and registration-fee revenues to the future maintenance expenses contributed by each class of vehicles. The study is composed of four major steps: (a) forecasting travel on each route by each class of vehicles, (b) forecasting general and replacement maintenance expenditures on each route, (c) forecasting of fuel-tax and registration-fee revenues contributed by each class of vehicles on each route, and (d) allocation of maintenance expenditures. The allocation of general maintenance expenditures was performed by using the vehicle miles of travel for each class. The replacement maintenance expenditures, on the other hand, were divided into two categories: weight-related (allocated based on the equivalent single axle load) and environmental-related (allocated according to travel). The results show a cross-subsidy among different classes of vehicles and also among different routes. Heavily traveled routes show high revenue-to-expenditure ratios over the study period (from 1981 to 1990). Based on the present fuel-tax rate and registration fees, the revenue-to-expenditure ratio for the Interstate system in Virginia declines significantly toward the end of the decade, which suggests the need for an increase in fuel-tax rate and registration fees.

The energy shortages in the early 1970s have forced the United States to conserve energy, especially in transportation. The conservation efforts resulted in increased automobile fuel efficiency, which in turn caused a decline in fuel-tax revenue--a major source of highway funding. The decline in revenue coupled with the constantly increasing highway construction and maintenance costs have greatly decreased the ability of state highway agencies to maintain and improve the highway system.

Figure 1. Conceptual framework of study.



One of the immediate solutions to this financial crisis is to raise the highway user's tax. However, to equitably charge highway users, there is a need for a study on the revenues contributed and the costs attributable to different classes of vehicles (passenger cars and light, medium, and heavy trucks). The comparison between revenues and costs helps to formulate the tax rate for each class of vehicles so that a fair cost-responsibility scheme can be developed as a basis for future highway taxation policies.

PURPOSE

Several cost-responsibility studies have been conducted in which the total expenditures at one point are compared with the total revenues by different classes of vehicles, independent of route characteristics and of future variation in travel intensity and travel costs (1-3). Because of these shortcomings, past studies did not provide an accurate projection of revenues and highway costs and might have caused a bias in cost-responsibility assignment. In this study, the assignment of cost responsibilities was performed on a route-by-route basis for the Interstate highway system in Virginia over a 10-year period (from 1981 to 1990).

With this approach, the purpose of this study is first to formulate a taxation scheme based on their respective responsibility; second, it is to examine the future financial viability of each route. Manifestation of the former is the desired equity in taxation and of the latter is the possible innovations in highway management such as the redistribution of funds and the establishment of toll roads.

BACKGROUND

Interstate Highway System in Virginia

All major Interstate highways were considered in this study except those that are beltways around large metropolitan areas. These Interstate routes are heavily traveled by both passenger cars and trucks and were divided into two groups: (a) major through-state routes, which include I-81 (western Virginia) and I-95 (eastern Virginia) and (b) local or feeder routes, which include I-66, connecting I-81 and the Washington, DC, metropolitan area; I-64 in central Virginia, intersecting I-81 and I-95; and finally I-77, running through the southwestern tip of the state and intersecting I-81. The location of the routes plays a significant role in the forecast of travel, which will be discussed later.

Classification of Vehicles

Vehicles that use Virginia highways are grouped into four classes corresponding to the way in which traffic-volume data are maintained. The four classes are as follows:

Class 1, which includes passenger cars, panel and pickup trucks, and two-axle, four-tire trucks;
Class 2, which includes two-axle, six-tire trucks (small dump and delivery trucks);
Class 3, which includes three-axle, six- to ten-tire trucks (primarily heavy dump trucks); and
Class 4, which includes three-, four-, and five-axle combination trucks.

Buses are excluded from the study because of their extremely low volume on these Interstate routes. These classes of vehicles are used to more accurately determine the fuel-tax and registration-fee revenues and also to allocate maintenance expenses based on travel intensities and weights.

FRAMEWORK OF STUDY

The framework of the study is illustrated in Figure 1; it includes four major tasks: travel forecast, maintenance-expenditure forecast, revenue forecast, and cost-allocation analysis.

As shown in Figure 1, travel is a function of the state population, state economy, and travel cost. The influence of travel cost on trailer trucks, however, is assumed to be negligible since (a) the travel cost incurred to trailer trucks is more likely to be passed to the users of the commodities being transported and (b) the shift in transport mode and/or changes in demand due to increased travel cost may not be realized at the route level.

The forecast of travel in conjunction with the age of the pavement is then used to forecast maintenance expenditures for each route. Two other uses of the travel forecast are the estimation of fuel-tax revenues and the equivalent single axle loads (ESALs). The former is also a function of the fuel efficiency of each class of vehicles, whereas the latter is a function of vehicle weights. The second component of revenues--registration--is a function of registration fees and vehicle registration. Registration fees in Virginia are based on the vehicle gross weight for vehicles not designed or used for transportation of passengers. Vehicle registration was determined as a function of the population and the economy. From these estimated parameters, the cost-allocation analysis was performed. In the following section, a detailed description of each task is presented.

DESCRIPTION OF TASKS

Travel Forecast

Multiple linear regression analysis was applied to forecast the average daily vehicle miles of travel (VMT) by each class of vehicles on each route. The data set used includes the values of a number of independent variables from 1970 to 1979. The VMT for class-1 vehicles is assumed to be a function of the average household income, the number of households in the state, and the automobile operating cost per mile. These variables were selected based on the hypothesis that the majority of vehicles in this class are automobiles and the travel characteristics are more or less in the category of personal travel. For classes 2 and 3, the independent variables are the same: total state population, total state personal income, and truck operating cost per mile. The truck operating cost per mile was used because the travel by these classes is more local (short distance) in nature and the majority of these trucks is privately owned. Finally, the variables used to forecast travel of class-4 vehicles are the state population and the total personal income since the travel of heavy trucks is assumed to be more related to the state's economy.

In the modeling process, I-81 and I-95 were considered as the major routes in the state because they are more frequently used for all trips. It is therefore hypothesized that the travel on I-81 and I-95 would have an effect on the travel on other routes. Thus, VMT on I-81 and I-95 was used as the independent variable in the equations for other routes. The results have shown that truck travel (classes 2, 3, and 4) on I-81 and I-95 indeed affects truck travel on other routes. The same phenomenon did not occur for class-1 vehicles because the travel of this class is too highly correlated to household income and number of households in the state.

The forecast of the state total personal income was performed by using an annual growth rate of 10.5 percent starting in 1980 (4). The projected values for the state population were adopted from a study done by the Virginia Department of Planning and Budget (5).

Forecast of Maintenance Expenditures

The maintenance expenditures are divided into two classes--general maintenance and maintenance replacement--according to the classification of the available data. General maintenance includes those activities that are performed every year or those that are more related to weather and environmental conditions. Maintenance replacement, on the other hand, includes the major maintenance activities that are related to travel intensity and age of the pavement.

According to historical data (6), the price index of highway maintenance increases at approximately the same rate as that of the consumer price index of overall goods (CPIOG). It is therefore hypothesized that future highway general-maintenance expenditures depend on the value of CPIOG. The forecast of general-maintenance expenditures is performed on a per-mile basis for ease of computation. Percentage of the replacement expenditures is in the pavement-related work. It is therefore hypothesized that the maintenance-replacement expenditures are functions of the total truck travel (i.e., classes 2, 3, and 4) and the age of the pavement.

In formulating the equations for maintenance-replacement expenditures, several forms of the regression model (including linear and nonlinear) were attempted and the best-fit models were selected. This trial-and-error process was used because the available data did not show a consistent pattern of expenditures among the routes.

Forecast of Revenues

The two sources of revenue used in the study are fuel-tax revenues and registration-fee revenues. Fuel-tax revenues are computed based on the forecast VMT, the average fuel efficiency of each class of vehicles, and the state fuel tax per gallon of fuel. The projected fuel efficiency for class-1 vehicles ranged from 15.5 miles/gal in 1980 to 25.6 miles/gal in 1990. The average fuel efficiency for all trucks was assumed to increase 1.4 percent per year (7). This average figure was adjusted for classes 2, 3, and 4 vehicles by using the estimated percentages from past data (7).

The registration-fee revenues for each class of vehicles were estimated as the product of the number of registered vehicles and the fees per vehicle, which are based on their size and weight.

Expenditure Allocation

Many different techniques have been used to allocate highway maintenance expenditures to vehicle classes (1,8,9). A common problem that exists in these techniques is the estimation of the proportion of maintenance expenditures that is related to environmental damage and the proportion that is related to traffic. The Joint Legislative Audit and Review Commission of the Virginia General Assembly (1) used a split of 77 percent and 23 percent as weight-related and environmentally related, respectively. The Federal Highway Administration (9), on the other hand, used a split of 70 percent and 30 percent as traffic-related and non-traffic-related, respectively. For this paper, 70 percent of the replacement-maintenance expenditures were assumed to be traffic-related and allocated according to the relative weight of each vehicle class by using ESALs. The remaining 30 percent of the replacement expenditures--which are assumed to be common to all vehicles--were allocated according to VMT of each vehicle class on the route.

The general-maintenance expenditures were treated as common to all vehicle classes and allocated according to VMT. This is because a large fraction of the activities are related to the environment and weather instead of to vehicle weight. Thus the cost responsibility of each vehicle class was estimated based on the use of the highways.

Revenue Attribution

The two major sources of revenues considered, as mentioned previously, were fuel-tax revenues and registration-fee revenues. Since the VMT by each class of vehicles on each route was determined, the amount of fuel consumed is obtained by dividing the VMT by the corresponding average miles per gallon. The fuel-tax revenue attributed by each class is simply the amount of fuel consumed multiplied by the fuel-tax rate. The tax rate was held constant during the analysis period for the purpose of assessing the adequacy of future fuel-tax revenues.

The attribution of registration-fee revenues by each class of vehicles on each route was estimated as the product of the registration-fee revenues per VMT for that particular class and the VMT of that class on the route being considered.

Based on the developed equations and procedures, revenues and maintenance expenditures for each route were estimated for the period from 1981 to 1990. The following section will present the results of the study.

RESULTS OF STUDY

Travel

Travel increases by about 67 percent in 10 years on most of the Interstate highways in Virginia by all classes of vehicles (from 20.2 million VMT/day in 1981 to 33.6 million VMT/day in 1990). The largest shares are carried by class-1 and class-4 vehicles. I-64, I-81, and I-95 remain the most heavily traveled routes, followed by I-495, I-66, I-77, and I-85. The travel of heavy trucks (class 4) in Virginia is primarily conducted on I-81, I-95, and I-64 in that descending order. Those routes constitute approximately 87 percent of the total travel by class-4 vehicles on the Interstate highways in Virginia. Class-1 vehicles dominate the travel on all the Interstate highways; percentages range from 49 to 91 percent of all the travel on the route. The continued growth in population and in total personal income in Virginia in addition to the decrease in the number of persons per household are the main forces behind the sustained growth in travel.

Expenditures

The projected maintenance expenditures for the system (excluding urban beltways) increase at an annual rate of 10 percent. Class-1 vehicles, according to the model allocation procedure discussed earlier, produce the most costs; percentages range from 57 percent in 1981 to 62 percent in 1990; class-4 vehicles follow with percentages ranging from 36 to 32 percent in 1981 and 1990, respectively. Class-3 and class-2 vehicles contribute only a small share, approximately 3 and 4 percent of the total maintenance expenditures, respectively. However, this picture is not consistent over all the routes of the system. Trailer trucks (class 4) produce more total maintenance costs than class-1 vehicles on I-81, I-85, and I-495 according to the cumulative 10-year expenditures shown in Table 1. This class of vehicles comes close to producing the same costs as class 1 on I-77. In spite of this variation in cost distribution among classes, I-64, I-81, and I-95 generate most of the costs (79 percent) of the system (see Table 1).

Revenues

Consistent with expenditures, class-1 and class-4 vehicles are the predominant generators of revenue and provide the highest fuel-tax and registration revenue, respectively. Registration revenue makes up approximately 18 percent of the total revenue, which is structured on the gross weight of the vehicle in Virginia. Besides, the annual increase in revenue, whether fuel-tax or registration, is growing at about 3 percent under the existing tax structure, compared with 10 percent annual growth in expenses.

Similar to expenditures, trailer trucks contribute more revenue than class-1 vehicles on I-81, I-85, I-77, and I-95, as shown in Table 2. With respect to total revenue, I-81, I-64, and I-95 provide the largest amounts of revenue in that descending order (see Table 2).

Allocation Analysis

In general, the results show that the total revenue is greater than the maintenance expenses on all the routes for the study period. On the average, the ratio of revenue to expenditures varied from 1.54 to 4.11 on the different routes of the Interstate system in 1981 and will drop from 1.17 to 2.84 in 1990. Also, the revenue-to-expenditure ratio for all classes of vehicles drops from 3.07 in 1981 to 1.74 in 1990 as shown in Table 3. Classes 4, 2, 3, and 1, in that order, provide the highest percentage of revenue to expenditures. The reason for this outcome is that class-4 vehicles have the lowest number of miles per gallon of fuel and class-1 vehicles have the highest. And from the point of view of expenditure, class-1 vehicles have the most VMT on the Interstate system and therefore take a much larger share of general-maintenance expenditures, which is the major component of maintenance expenditure.

The results also show that class-1 vehicles on I-77 and I-85 and class-3 vehicles on I-495 produce revenues that are only 93, 62, and 81 percent of their contributed maintenance costs, respectively (see Table 3). There are two possible reasons for this. First, the VMT by class-1 vehicles on the first two routes and class 3 on I-495 are low compared with that for the other routes, thus causing a small contribution in gasoline-tax revenues. Second, because of the geographical location of these routes, a part of class-1 vehicles is likely

Table 1. Total 10-year expenditures by class and route.

	Millions of Dollars				
Route	Class 1	Class 2	Class 3	Class 4	All Classes
I-64	115.30	4.68	2.55	28.94	151.48
I-66	23.67	1.01	1.18	3.31	29.17
I-77	14.31	0.84	0.24	6.79	22.18
I-81	56.76	3.88	1.63	53.74	116.01
I-85	12.50	1.22	0.21	7.88	21.82
I-95	46.21	2.69	2.17	25.76	76.84
I-495	5.40	1.41	2.05	7.34	16.20

Table 2. Total 10-year revenues by class and route.

	Millions of Dollars				
Route	Class 1	Class 2	Class 3	Class 4	All Classes
I-64	171.45	11.04	3.93	53.32	239.73
I-66	35.98	2.69	2.24	7.75	48.66
I-77	13.27	1.92	0.61	20.92	36.73
I-81	95.41	13.82	5.29	213.68	328.20
I-85	7.72	1.86	0.45	21.04	31.06
I-95	122.81	12.05	6.49	95.53	237.88
I-495	38.66	3.13	1.67	7.48	50.93

Table 3. Ratios of revenues to expenditures.

Route	Year	Class 1	Class 2	Class 3	Class 4	All Classes
By Class and Year						
	1981	2.57	3.73	2.54	3.97	3.07
	1982	2.46	3.63	2.44	3.81	2.94
	1983	2.24	3.42	2.32	3.60	2.72
	1984	2.03	3.23	2.21	3.42	2.53
	1985	1.91	3.07	2.11	3.25	2.38
	1986	1.73	2.88	2.01	3.07	2.19
	1987	1.60	2.76	1.94	2.95	2.06
	1988	1.50	2.67	1.88	2.85	1.96
	1989	1.41	2.58	1.82	2.75	1.86
	1990	1.31	2.46	1.76	2.63	1.74
By Class and Route (sum of 10 years)						
I-64		1.49	2.36	1.54	1.84	1.58
I-66		1.52	2.65	1.90	2.35	1.67
I-77		0.93	2.29	2.54	3.08	1.66
I-81		1.68	3.56	3.24	3.98	2.83
I-85		0.62	1.52	2.14	2.67	1.42
I-95		2.66	4.47	3.00	3.75	3.10
I-495		7.16	2.22	0.81	1.02	3.14

to be out-of-state vehicles, whose registration-fee revenue could not be accounted for.

CONCLUSION

The study results showed that the forecast revenues collected from each class of vehicles are greater than the expected maintenance expenditures on the Virginia Interstate highway system. They also indicated that there is a cross-subsidy among the routes in the state (i.e., heavily traveled routes generate more revenue than lightly traveled routes).

In general, heavy trucks (class 4) using the Interstate highway system in Virginia contribute more revenue than other classes of vehicles. And among all classes, the revenue-to-expenditure ratios are significantly different, which suggests a cross-subsidy even between the classes of vehicles.

With the present tax structure (fuel-tax rate and registration fees), the revenues collected from the use of the state highways in Virginia are likely insufficient to pay for the maintenance expenses, much less for the construction of new highways in the next 10 years. An increase in highway user charges seems necessary in the near future to cope with the increasing maintenance cost. Manifestation of this need is the fact that the Interstate highways have had the highest revenue-to-maintenance-expenditure ratio and this ratio seems to decline rapidly in the next 10 years.

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Transit Financing and the Cities: The Record and the Views of the Nation's Mayors

LINDA GORTMAKER

Because of the concerns expressed by the nation's mayors and other elected officials about the financial conditions of their cities' transit systems, the U.S. Conference of Mayors, in cooperation with the Urban Mass Transportation Administration, conducted a survey in the fall of 1980 on the current local transit-financing situation across the nation. Although many studies have been conducted about individual systems or transit financing in general, none have provided a systematic, comprehensive view of the fiscal problems of the nation's major general-purpose transit systems. Although city governments have delegated the day-to-day operations of most urban transit systems to transit authorities, many transit agencies lack independent financial powers. The public turns to local elected officials to develop ways to raise funds for capital and operations. This study investigated these areas from the mayors' perspective: current support levels for transit; earmarked transit taxes and other financial resources; administrative and intergovernmental relationships; problems with federal, state, and local funding programs; fare policy and pricing; potential new funding options for cities and elected officials' reactions; voter acceptability of funding options; impact of Section 504 regulations; and recommendations from the cities themselves on ways to solve their transit-financing dilemmas. In this survey, 132 cities participated of a possible 139 major cities from urbanized areas that had a population of more than 200 000 plus two dozen smaller cities. Both telephone and mail-back interview techniques were used.

Mayors have long recognized that public transportation is essential to their communities' vitality and economy. As financial resources at all levels grow tighter, mayors face greater challenges in financing the capital and operating costs of their transit systems. This is made even more difficult by the soaring price of gasoline and by other factors, which in many cities have pushed riderships to their highest levels. In the context of these challenges, the U.S. Conference of Mayors, in cooperation with the Urban Mass Transportation Administration of the U.S. Department of Transportation, undertook a comprehensive survey of 139 cities to document the transit-financing performance and outlook for the 1980s of the nation's cities.

The Reagan Administration's new public transportation policy emphasizes the use of federal funds for capital expenditures for transit systems but seeks a solitary local and state role in financing operating expenses after FY 1984.

The federal-state-local partnership has characterized national public transportation policy for 17 years. Since federal operating assistance started in 1974, the federal government has worked hard, primarily with local governments, to develop public transportation financing as a joint effort. Now more than ever, the need is great for continued leadership by local elected officials in planning and implementing new state and local funding sources for transit as strong elements of that partnership. The Conference of Mayors' survey results show vital evidence of that local leadership.

CITIES: SHARING TRANSIT-FINANCING BURDEN

Elimination of the federal operating-assistance program for transit would mean a step backwards in financing policy and in the progress the nation's transit systems have made in recent years. When federal, state, and local governments initiated their fiscal support of public transit systems in the 1960s, these systems had moved from self-supporting private companies to debt-ridden operators confronted by bankruptcy in a declining industry.

Faced with the prospects of losing their transit systems, most cities elected to provide some form of fiscal support. At the federal level, priority was given to replacing capital equipment that had been allowed to wear out; the local governments were to pick up the operating deficits. In the mid-1970s, that federal policy began to provide support toward operating costs, reflecting the growing needs of transit and the federal policy decision that there should be assistance to keep fares from becoming too great a burden on individual passengers, many of whom are elderly and have low income levels.

As the gasoline shortage of the 1970s and skyrocketing prices pumped riders into buses and rail systems, cities around the country initiated programs to further upgrade their transit systems, and, not surprisingly, public transit's share of local government budgets increased, even with considerable federal aid available. Thus, the importance of local fiscal contributions to transit has been increasing steadily, and in recent years local governments have become especially active in establishing local and state taxes for transit support and other financing innovations.

The Conference of Mayors' survey of the mayors of 139 cities included all major cities from urbanized areas that had a population of more than 200 000 and two dozen smaller cities (1). The public turns to mayors and other local elected officials to develop ways to raise funds for capital and operations. The Conference of Mayors' survey found that mayors not only take this responsibility seriously but have made great strides in recent years in the area of transit financing. According to the survey, the following facts were observed:

1. Despite the fact that in almost 80 percent of the cities the transit agency is not a formal part of city government, 62 percent of the cities currently contribute some local funds to transit;
2. Almost half the cities responding reported that they have state or local tax sources earmarked specifically for transit capital and/or operating funds, and 21 more said they are planning to establish such a tax within the next two years;
3. Of the cities responding, 66 percent (two-thirds) reported fare increases during the first nine months of 1980; between 1979 and the first nine months of 1980, 80 percent of the systems reported they had a fare increase; and
4. When asked to rank in priority 10 local transit-financing issues, mayors gave highest priority to developing new local tax revenues.

In a separate survey taken during April 1981 (2), the Conference talked to mayors' offices in 100 cities to assess the specific impact of the Reagan Administration's proposal to drop public operating assistance after FY 1984. Although the cities in the earlier transit-financing study and the April survey were not precisely the same, almost all large cities participated in both, and the April survey results were overwhelming.

Cities predicted steep fare increases, ridership decreases, and reduced services if the Administration's proposal were adopted for future years. The proposal recommends that public transportation operating assistance, some $1.1 billion in FY 1981, be phased out over FY 1983 and 1984. Cities would receive sharply reduced funds to assist in operation of transit systems during those years and none at all after FY 1984.

Although local governments, as the Conference transit-financing survey shows, already bear the major burden of paying for their systems, dire consequences are predicted if the federal role is eliminated, as summarized below:

Consequence	Cities Responding (%)
Substantial fare increases	46
Moderate fare increases	20
Significant ridership decreases	65
Reduction in services	57

Significantly, the impact of the proposed elimination reflected no geographic or city size boundaries. One major northeastern rail system city saw a 40 percent fare increase over the current level of 65 cents. Another medium-sized city in the Rocky Mountain region foresaw a fare increase to $0.80 or $1.00 over the current level of $0.40. A Great Lakes university town looked for a doubling of fares, and a midwestern industrial city saw similar fare increases.

Significantly, fare increases are no guarantee to cities of an increase in revenues. Indeed, they could have the opposite effect, decreasing revenues by driving people back to their automobiles. The example of one Pacific Northwest city was instructive: a fare increase instituted a year ago resulted in a 10 percent decrease in ridership. One city estimated that a 33 percent fare increase yields a 6 percent ridership decrease.

Public transportation is particularly important to the nation's low-income urban residents; they often have no alternative transportation. Therefore, the impacts of eliminating operating assistance would hit them disproportionately. From a Northern California city came the comment that ridership would probably remain about the same on regular routes because poor residents must use public transit, and they would have to absorb higher fares. The elderly are similarly affected; one city estimated that 70 percent of its elderly population use the public transportation system.

Although cities have been developing their own local resources to pay for transit, the message from this survey seemed clear: A continued federal role in some form of operating-assistance program will be necessary to prevent significant transportation problems in cities.

LOCAL FINANCING AGENDA FOR 1980s

As Congress and the Administration grapple with the future of public transportation programs, cities across the country face the hard, more immediate task of raising revenues--at both state and local levels--to meet rising transit operating deficits. Following is a more detailed summary and brief analysis of what these results mean for mayors and cities as well as a description of the approach used in conducting the survey.

Major areas the Conference covered in its survey include the following:

1. Current support levels for transit;
2. Scope of earmarked transit taxes and other financial resources;
3. Administrative and intergovernmental relationships;
4. Problems with federal, state, and local funding programs;
5. Fare policy and pricing;
6. Potential new funding options for cities and elected officials' reactions;
7. Voter acceptability of funding options;
8. Impact of regulations of Section 504 of the Rehabilitation Act of 1973; and
9. Recommendations from the cities themselves on ways to solve their transit-financing dilemmas.

The strategy adopted was to contact the mayor of each city included in the study directly to obtain views and information on the major general-purpose transit system serving the area. In order to do this, a survey technique was used to elicit factual information on the transit systems and attitudes and views on key issues. Specifically, these steps were followed: (a) Key issue areas were identified; (b) a survey instrument covering key issue areas was designed; (c) the population to be surveyed (i.e., urbanized areas) was identified; (d) the survey instrument was pretested and necessary modifications were made; (e) advance-mail surveys were sent to selected cities with instructions on how to complete the quantitative questions and arrange for telephone interviews covering the attitudinal portion of the survey; (f) the telephone interviews were conducted; (g) review of survey responses was conducted and, where necessary, follow-up telephone calls were made; (h) codings were prepared for computer analysis, including hand-coding for open-ended questions; (i) surveys were processed and computer outputs and tabular presentations developed; and (j) results were analyzed and a final report was prepared.

A total of 139 cities were selected for participation in the survey and 132 agreed to participate; the survey was conducted during August-October 1980. In four of the cities, officials were asked to complete questions for two transit systems; these included San Francisco, Detroit, Newark, and Washington, D.C. This brought the total number of transit systems selected for the survey to 143.

CURRENT SUPPORT LEVELS AND TAXES

In conducting this study, one of the first questions asked of mayors' offices was whether the city contributed to the general-purpose transit system serving their area. Of the 132 cities participating in the study, 82 (62 percent) said they were currently contributing some local funds; of these 82 cities, 67 percent (55 cities) were from urbanized areas that had populations of 500 000 or less.

While governments at all levels are facing increasing constraints on their budgets in general and transit funding in particular, cities already appear to be making steady progress in developing local and state revenue sources as the prospect of a changing federal role for operating subsidies looms ahead. Of 101 cities responding, 46 (46 percent) reported that they had state or local tax sources earmarked specifically for transit capital and/or operating funds. Almost half the 46 cities were from urbanized areas that had populations of 750 000 and more. Fifty-five cities reported they had no earmarked transit taxes in place at the present time, but almost half (21) of 54 cities responding said they were planning to establish such a tax within the next two years.

The cities reporting earmarked taxes were further asked to indicate the type of tax being earmarked. Of the 46 cities reporting earmarked taxes, 22 cities use the sales tax, 8 cities use a gasoline tax, 11 cities use property taxes, and the rest use other forms such as utility, employer, vehicle, and oil-company profits taxes, which suggests considerable variation.

ADMINISTRATIVE AND INTERGOVERNMENTAL ENVIRONMENT

The increasingly fragmented nature of local governments across the country is symbolized in the relationships between general-purpose transit systems and city government. Questions on this relationship were postulated in the survey, and 130 cities responded. Of the 130 cities, 101 (80 percent) said that the transit agency was not part of city government; almost 40 percent of the 101 cities are in urbanized areas that have populations of less than 200 000. In terms of the larger cities, only about 14 percent of those cities where the transit agency was reported to be part of city government were from urbanized areas of 750 000 or more population.

Cities were also asked about their transit system's fiscal and tax powers. Of 100 systems responding, only 25 (one-fourth) possessed independent taxing or other fiscal capacities. Of those 25 systems, 18 identified taxing power; some systems had more than one power. Eleven agencies have taxing power based on property tax; 6, based on sales tax; 1, vehicle tax; 2, income tax; and 2, other forms of tax. In addition, of those 25 cities with financial powers, 7 can issue bonds, 4 can set fares, and 3 possess other miscellaneous powers.

Perhaps even more significant is the fact that at least three-fourths of the cities responding to this survey question indicated that the major general-purpose transit system lacks any power to develop new local revenues. When regional transit authorities are established by law or referendum, the power to levy some type of tax is frequently part of the legislative package, and the coming decade may see more of these arrangements.

FUNDING PROGRAM PROBLEMS: FEDERAL, STATE, AND LOCAL LEVELS

Cities are experiencing severe financing problems with their transit systems despite a variety of federal, state, and local programs designed to help out with both operating and capital expenditures. To determine where present programs might be improved for greater efficiencies and economies, the Conference of Mayors included a section in the survey designed to identify those parts of the transit-financing process with which cities may have had particular problems or where they have faced major bottlenecks in implementing transit-financing plans.

In general, very few problems were noted with state or local transit-funding programs, a reasonably predictable result since participants in surveys are more inclined to be critical of programs away from home. In terms of federal programs, the extent of problems identified varied by program type. Demonstration (Section 6) and planning (Section 8) grants showed fewer problems; more complaints were noted in the capital and formula grant programs, especially in the areas of regulations and program administration. On balance, however, the number of complaints seemed relatively small.

PRESENT FARE POLICIES AND PRICING

A transit system's fare policy provides the means to raise additional revenues. Transit systems can charge different fares for peak periods, weekends, or for special users as a means of increasing revenue and better links to costs. Despite these options, the majority of transit systems reporting in this study use flat fares and show no variations in response to base and peak periods.

Of 112 transit systems responding to this particular question, close to 60 percent use a flat fare (64); two-thirds of these 64 flat-fare systems were from medium-sized or small cities (urbanized areas of 500 000 and less). About one-third (35) of the systems reported a combination of flat and zone fares, and only 10 percent (11) of the systems reported using a zone fare. (Almost three-quarters of the systems with zone fares are from urbanized areas of 750 000 or more.)

In terms of fare variations over time, of 106 systems responding, close to 80 percent show no variation throughout the day, and only 3 percent reported variations between weekdays and weekends or holidays.

An important source of revenue is fare increases, and this study shows that cities seem to be doing their share. Of 106 systems responding, two-thirds reported fare increases in 1980 (covering only the first nine months of the year). Between 1979 and the first nine months of 1980, almost 80 percent of the systems reported that they had had a fare increase:

Most Recent Fare Increase	Cities Responding (%)
1979	13.2
1980 (first nine months)	66.0
Total	79.2

FAREBOX AND OPERATING EXPENSES

Cities were asked to report the relationship between farebox revenues and operating expenses in 1980. Of 90 systems reporting, 30 percent (27 systems) reported a farebox-to-operating-expense ratio in the range of 40-50 percent, and 13 percent (17 systems) were in the range of 50 percent and more.

Developing a fair and equitable policy for setting fares can be a challenge, and some cities have tried to make their fare structures sensitive to certain inflationary factors, such as labor wages, especially in California where this is mandated by law. When cities were asked if they would be willing for their transit systems to tie labor wage increases to the farebox, 71 percent (66 of 93 systems responding) said no.

The study also found that general-purpose transit systems develop estimates of average revenue (fare) per passenger. Of the 113 systems responding to a question on this issue, 88 percent said they prepare average revenue estimates. In response to a question on how they prepared these estimates, 60 of 92 systems (65 percent) said they use a simple equation of total revenue divided by unlinked passenger trips, a method that underestimates average revenue per passenger by ignoring transfers.

In terms of their estimates of average revenue per passenger, for approximately 90 systems responding to the conference study, the median was 26 cents in 1978, 27 cents in 1979, and 31 cents in 1980. This represents an increase of 14 percent from 1979 to 1980 and an average annual rate of about 9 percent since 1978.

TRANSIT PASSES

The use of special employer transit passes to pay for fares has now become an established trend in all city sizes, especially since the long gasoline lines in the summer of 1979 when many transit systems across the country witnessed dramatic surges in ridership. Of 113 systems responding to questions on use of special passes, the Conference's study shows that 81 percent said they use special transit passes, almost half of which are monthly passes. In addition, almost 60 percent of the systems responding use some type of employer ticket purchase program, almost 80 percent of which provide partial or full subsidies to employees.

LOCAL FINANCING CHALLENGE

Cities can choose from a variety of approaches in developing a workable, successful plan to meet their operating deficit. This study examined how transit systems forecast what their operating deficit will be and looked at what minimum share cities are willing to pledge from farebox revenues. In addition, mayors' offices were asked to assess voter reaction to new ways to raise local and state revenues for transit.

Future Needs and Programs

A substantial proportion of the nation's large transit systems are planning means for dealing with their operating deficit problem; a substantial number are even developing five-year planning horizons. Of 90 systems responding to a question on this subject, 70 percent (63) said they prepare projections of their operating deficits. Of these 63 systems, 61 identified the actual period. Of considerable interest is the fact that 44 of the 61 systems (72 percent) covered the period through 1984-1985.

The median of forecasts of the ratio of systems' operating revenues to operating deficits indicates that transit systems expect operating revenues to be a decreased share of support relative to operating deficits.

Farebox Attitudes

Even in the face of anticipated tighter financial conditions, mayors indicated in the survey that farebox revenue should cover a reasonable portion of operating deficits. Of 90 cities responding, almost 95 percent (85 cities) said they felt that there should be a minimum share of operating expenses for which farebox revenues should be responsible. Specifically, cities were asked to indicate what that share should be. For 72 responding cities, the median (minimum) share was about 40 percent.

When the minimum shares cited by the cities were compared with their reported percentage ratio of farebox revenues to operating expense, the medians showed relatively close correspondence--36 and 38 percent, respectively. This suggests that cities feel that their transit systems are very close to the desired minimum, and detailed review of the farebox/expense responses shows that up to a ratio of 40 percent, most (70-80 percent) of the systems responding felt they were above the desired minimum.

Funding Options and Voter Acceptability

This study attempts not only to show what current financial conditions are for the nation's transit systems but also to identify attitudes about what might be realistic, politically feasible alternatives available to decisionmakers at all levels for improving the situation. The mayors participating in the study were asked to indicate what transit funding sources would be most acceptable to their local voters. Of 94 mayors' offices responding, general fund appropriations and fare increases were considered to be most acceptable to voters. The least acceptable were property, payroll, and parking taxes, and a lottery.

TRANSIT-FINANCING AGENDA FOR 1980s

As the cities and other units of government struggle to pay for their transit systems in the coming decade, mayors find that pinpointing their needs and setting priorities are two of their most important responsibilities. To determine what the nation's mayors believe the major transit-finance issues and needs will be in their communities over the next five years, the Conference study asked mayors' offices to rank 10 issues in order of importance.

Of 109 cities listing a first-priority rank, 30 gave first priority to developing new local tax revenues. In addition, 23 cities gave first priority to securing operating funds for expansion of system routes. Eighteen cities gave first priority to improving present service levels. Below is a summary of what cities rank as the top three issues, combining some of the individual issues listed in the original survey into broader categories:

	Number of Cities Ranking Issue		
Issue	First Priority	Second Priority	Third Priority
Increased revenues: fares and/or local tax	34	8	14
Increased funding for improved service levels and/or route extensions or additions	41	44	37
Capital for system expansion and/or replacement	14	28	25

The above tabulation makes it quite clear that increased revenues and funding for service improvements and expansion represent important local considerations.

Approaches and Recommendations

To achieve these goals, mayors indicated their willingness to push for new taxes at the local level, want more support from state governments in terms of financial resources and legislation for taxes, and want more flexibility and predictability in federal funding and programs. Although it is recognized that there is a continued need for a federal operating assistance program of some kind, the area in which cities seem to feel free to ask for more federal funds is in capital improvements, which the Reagan Administration has indicated is its own priority as well.

Special Needs and Issues

Two issues--serving the needs of the elderly with more routes and service quality and serving the needs of the disabled with a fully accessible transit system--were ranked as the two lowest priorities by cities in the Conference survey. However, this did not indicate an unwillingness to serve special groups. In terms of special services provided to the elderly and handicapped by the general-purpose transit agency, of 110 responding systems, 93 (85 percent) indicated they were providing service, and almost all systems provided some type of fare subsidies to these groups. These services were often in addition to special transportation services being provided to the elderly and handicapped (and other special groups) by the cities, frequently in the form of a social service agency transport system, although sometimes as a special service contracted to the transit agency.

Almost all of the cities participating in the Conference study said their transit agency is preparing a plan for compliance with the U.S. Department of Transportation's regulations concerning Section 504 of the Rehabilitation Act of 1973. A number of cities predicted future difficulties. Of 93 systems reporting, more than half said they saw no problem in complying with Section 504 regulations, but one-third said they would have to discontinue special services because of compliance. When the 504 regulations are lifted this summer, however, compliance efforts may take new directions.

CONCLUSIONS

On the progress in local transit financing, there should be no debate. There will be considerable discussion, though, in coming months on the future of the federal role in transit operations. The federal role might remain constant or grow somewhat, and initiatives were taken by the Conference and other interest groups last spring to develop a new approach for federal transit funding--the block grant. Mayor Lionel Wilson of Oakland, California, who testified for the Conference in the Senate in May, said the block-grant approach could "guarantee flexibility at the local level with assurance at the national level that the federal dollar is spent wisely." The block-grant approach, which would include a bus program, rail program, and discretionary program for various construction and major investments, is being developed by Congress at this time but will more likely be finalized as an option later in 1982.

No matter what form future federal funding takes, the need for increased local funding for transit will become greater in the next decade because rising costs are sure to outpace any federal role. Local officials will assume an even larger share of the responsibility for meeting these costs.

In deciding how to meet its transit system's operating deficit, a city faces a variety of choices that require careful consideration of both supply and demand issues. On the supply side, one way to close the revenue-cost gap is to lower the level of service and thereby reduce total costs. However, here the revenue impact is uncertain. Some ways to lower service levels would be to drop underutilized routes and/or to reduce service quality by implementing longer headways or cutbacks in maintenance. These choices are usually difficult to achieve and have dire consequences for the mobility of citizens and the economy of the city.

Alternatively, communities can develop financing strategies. These include (a) new sources of revenue such as a tax increase or earmarking or (b) increased fares. Fares, however, cannot rise to unreasonable levels. If they do, it can discourage transit use, especially for those who can least afford to pay. In terms of increased taxes or other similar revenue producers, cities in the Conference study have already shown considerable progress in this area and plan to increase their efforts, even if federal operating support is continued.

How cities balance all these alternatives and how they resolve these issues will determine the future of transit for the next decade. One point is clear: Though strong federal and state assistance will be required, cities will continue to have the leadership role in transit financing.

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Options for Financing a Regional Transit Authority

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Transit service stoppages for lack of funds and eleventh-hour makeshift financial solutions have become all too common in recent years. Regional taxes dedicated to transit service subsidization are increasingly popular and may be necessary for continued operation in many U.S. metropolitan areas. Although these taxes are relatively new, they are under active consideration in many areas in response to rapidly increasing transit deficits and the current administration's proposed reductions in federal operating subsidies. This paper compares the efficiency and equity of various taxes for these purposes, including motor fuel, real estate, sales, wage and income taxes as well as fare increases. Data on the tax levels required and resulting burdens by income class are reported for the Pittsburgh region. Tax payments per trip are also estimated by income class as an indication of the distribution of net benefits. Broad-based wage or income taxes seem to be the most desirable sources, coupled with close attention to potential reductions in transit expenses. Sales taxes are also an acceptable tax source, although they have a smaller tax base and a slightly more regressive effect than wage or income taxes.

Government assistance for transit service burgeoned in the past decade. In 1970, total subsidy for all modes of public transit was $541 million in the United States. By 1978, subsidies had increased to $5.264 million, representing more than a fivefold increase in real dollars (1,2). Funding the capital requirements and operating deficits of existing and desired transit services has become both a substantial undertaking and a continuing problem in many metropolitan areas. Transit service reductions or stoppages for lack of funds have occurred in several areas recently, including Chicago, Birmingham, and Boston. Eleventh-hour makeshift solutions such as special state appropriations or loans have become all too common in the past few years.

The rapid increase in the level of subsidy has been accompanied by major changes in the sources of subsidy funds. Prior to 1973, no funds for operating assistance were provided by the federal government. By 1978, federal grants for operating assistance totaled $567 million for the 26 largest metropolitan areas, or 10 percent of total operating revenue in these areas. Revenue from regional taxes and counties also increased, with a 180 percent increase in real dollar contributions from 1974 to 1978. This represents an increase from 25 to 31 percent of operating subsidies. Although contributions from state and local governments increased in dollar amounts from 1974 to 1978 in these large metropolitan areas, the real value of these contributions declined. These changes for 26 large metropolitan areas are generally indicative of the nation since these services represent 92 percent of the total national operating deficit. Assistance for capital investments such as new vehicles, exclusive rights-of-way, and other facilities has also increased dramatically in the period from 1974 to 1978, but there has not been a major shift in the source of funds. Throughout this period, the federal government has provided matching funds to the level of 80 percent of the cost of capital investments, and virtually all transit agencies have taken advantage of this funding opportunity (2).

The current transit funding situation in the United States is marked, then, by rapidly increasing subsidy amounts, increasing reliance on federal and regional taxes for operating subsidies, and continuing reliance on the federal government for the bulk of capital funds. However, the federal government is not only unwilling to substantially increase operating subsidies, but has proposed elimination of all federal transit operating subsidies. Coupled with rapidly increasing deficits, many transit systems are faced with financial crises.

By and large, states seem to be unwilling or unable to assume a larger role in transit funding. Accordingly, regional taxes will become increasingly important as a source of funds for transit service. Based on the principle that the beneficiaries of services should assume their costs, regional financing for transit operation is sensible since the benefits of transit are predominantly regional in nature.

While regional funding is one revenue option, we emphasize that enacting new taxes or increasing existing taxes should certainly be avoided unless these changes are necessary to achieve public objectives. Transit service reductions, cost reductions, or private operation may provide more desirable alternatives to increased transit subsidies in any particular case and should always be carefully considered. The current remarkable increase in transit operating and capital costs coupled with the stagnation of operating revenues must be curtailed at some point in the future. Otherwise, no financing scheme will be adequate. Although cost reduction is extremely important, analysis of the possibility or desirability of service and cost reductions is beyond the scope of this paper. However, the costs of the taxes discussed below can certainly be used to weigh the relative merits of service reductions and tax increases for such analysis.

In this paper, we shall examine a number of state and regional financing sources. We are particularly interested in regional funding because it may be the most promising method of providing additional operating funds for transit. Our intent is to quantitatively assess the equity and efficiency impacts of a variety of potential regional funding sources, including the possibility of major transit fare increases. Our assessments will be based on an analysis of taxes for the Pittsburgh metropolitan region, but we believe that this analysis and our general conclusions with regard to specific tax types are applicable to most metropolitan areas. In the second section, we describe the existing service and funding of the Pittsburgh transit system. The third section considers the potential of various taxes to yield sufficient revenues. The fourth section reports the incidence of current and potential funding sources. The distribution of transit benefits and tax payments is examined in the fifth section. Difficulties in managing a dedicated transit tax are noted in the last section.

CURRENT FINANCING OF PITTSBURGH TRANSIT SYSTEM

The Port Authority of Allegheny County (PAT) was formed in 1964 and immediately assumed transit service in Allegheny County by purchase of existing transit companies for $43 million. At the time of its formation, there was considerable interest in maintaining the system throughout the county region; the City of Pittsburgh occupies only 8 percent of the land area of this region. Consequently, funding and operation of the PAT system were always organized on a countywide rather than citywide basis. According to the annual reports for PAT, Allegheny County guaranteed the debt service for the bonds issued by PAT to purchase the assets of private companies in 1964. Since 1964, PAT has maintained the bus, trolley, commuter rail, and inclined-plane service that it assumed at its formation and has expanded bus service into suburban areas.

For the first three years of PAT's existence (1964-1967), fares and other service revenue provided the bulk of operating revenue. In each year, however, deficits were incurred and were financed by grants from Allegheny County. The source of these funds has been a countywide real estate tax. In 1967, the Commonwealth of Pennsylvania initiated a program of providing operating subsidies for mass transit. In 1973, subsidy funds for operating expenses were made available from the federal government. These new subsidy programs were fortuitous for PAT since PAT's deficit was outstripping the subsidy funds available prior to their enactment. Thus, PAT has received operating subsidies from the county in which it operates, the state, and the federal government.

Table 1 shows sources of operating revenue from 1970 to 1979. During this period, the fare revenue as a proportion of expenses dropped from 79 percent in 1970 to less than 46 percent in 1978. Subsidy received from Allegheny County increased in dollar amount from $3.8 to $6.7 million but decreased as a percentage of operating revenues from 10 to 8 percent. The subsidy funds from the state and from the federal government showed significant increases; the state funds provided 27 percent of all operating expenses in 1978, whereas the federal government provided 16 percent. During this same period, operating expenses more than doubled, representing a 27 percent increase in operating expenses in real dollars. All these trends are consistent with national patterns.

As with other transit systems, PAT has been more dependent on the federal government for capital subsidy funds than for operating funds. As of 1978, 59 percent of PAT's capital expenditures had been financed by grants from the federal government, 12 percent from the Commonwealth of Pennsylvania, and the remaining 29 percent funded by grants from Allegheny County. During the period 1964-1978, the total capital expenditure was $295 million. The amount of capital expenditure and capital grant revenue received varies each year but has tended to increase over time. In 1978, capital grants received amounted to $33 million or 45 percent of all revenue.

CURRENT AND POTENTIAL REVENUE SOURCES AND YIELDS

There are a variety of regional taxes that could be used to fund transit subsidies. General sources currently used in particular metropolitan areas include wage, sales, income, and real estate taxes. Motor fuel taxes or vehicle toll revenues have also been used to subsidize transit. Finally, fare and other service revenues also represent a regional base for transit funding.

The benefit principle of taxation suggests that a particular service should be paid for by those who

Table 1. Sources of funding for PAT transit system operating revenue.

Year	Fare Revenue (%)	Other Service Revenue (%)	Allegheny County (%)	Commonwealth of Pennsylvania (%)	Federal (%)	Total Revenue ($000 000s)
1970	79	3	10	8	-	37.2
1971	73	3	14	10	-	41.2
1972	54	2	11	33	-	56.3
1973	61	2	9	28	-	48.2
1974	55	3	6	36	-	56.9
1975	51	3	9	26	11	62.8
1976	51	2	9	27	11	68.8
1977	48	2	9	28	13	72.8
1978	46	2	8	27	16	79.1
1979	44	2	9	28	17	93.1
1980 (first six months)	44	2	9	28	16	48.0

Notes: Annual revenue is reported on a calendar-year basis until 1979; data for 1979 include the first six months of 1979 plus one half of FY 1980 revenue. Note that the timing of subsidy payments within a fiscal year may affect the reported subsidy percentage from one year to the next, even without a change in the overall level of subsidization. Data for FY 1980 are preliminary.
Source: PAT annual reports.

use or benefit from the service. In the case of transit service, this principle would imply that all transit expenses should be paid by those who directly or indirectly benefit from the service. In the absence of indirect benefits, this suggests that fare revenues should be sufficient to cover transit costs. However, benefits of transit services may also accrue to nonusers, for example, by reducing the overall level of congestion for commuters. It might be argued that these indirect benefits that accrue to nonusers suggest that households in areas served by transit should provide subsidy funds.

Unfortunately, identifying the extent to which individual taxpayers receive any such nonuser benefits is quite difficult. One possible approach would be to determine whether such nonuser benefits resulted in increases in property values in the areas served by transit. Special taxes might then be imposed within the areas surrounding transit services. However, there are no reliable means to attribute real estate values or value changes to transit services. Empirical studies suggest only a weak relationship, if any at all, between real estate values and transit service, particularly bus service (3).

Regardless of the distribution of benefits among different groups, it is clear that nearly all the user and nonuser benefits from transit service accrue within the region served by the transit service. Accordingly, the benefit principle would suggest that regional taxes or fare revenues should fund the service. It is difficult to extend the principle to the level of charging for individual nonuser benefits, and the expense of current transit services generally precludes operation from only fare revenues without service cutbacks. The general presumption in favor of regional financing is quite clear under the benefit principle, which indicates that examination of regional sources is worthwhile.

If enacted, regional transit taxes might be expected to replace existing sources of subsidy as well as to accommodate increased transit deficits. Table 2 reports the tax rates that would have been required to replace various categories of subsidy funds in 1978. Required revenue yields range from $13 million, to replace federal operating subsidies alone, to $74 million, to replace all federal, state, and county operating and capital subsidies to transit. For example, $19 million in revenue is required to replace federal and county operating subsidies in 1978. This could be accomplished by a 0.53 percent sales tax, a 0.26 percent wage tax, a 0.21 percent income tax, or a 0.35 percent real estate tax imposed on residents of Allegheny County. Alternatively, a $0.03/gal motor fuel tax could be imposed. Other desired revenue yields can be obtained by proportionally increasing or decreasing these rates.

The fare increases necessary to replace subsidy funds reported in Table 2 require a strong qualification. These fare increases are derived by assuming either no patronage decline with increased fares or, alternatively, transit expense reductions that are directly proportional to patronage declines. Actually, patronage and transit expenses would be expected to decline with fare increases, but transit costs would decrease by a much lower percentage. Assuming a transit fare elasticity of -0.3 (6) and no reduction in costs with patronage reduction implies that a fare increase of 183 percent is required to replace federal operating subsidies. The actual fare increase required would be somewhere between 36 percent (reported in Table 2) and the 183 percent increase required without any cost savings. Thus, the fare increases reported in Table 2 are underestimates of the actual required fare increases to replace subsidy amounts.

Of course, levying any of the taxes reported in Table 2 may result in a decline in the total tax base just as transit patronage might be expected to decline with fare increases. For example, an increase in the motor fuel tax within Allegheny County might induce residents to purchase motor fuel outside the county. Similarly, regional sales taxes may be avoided by purchasing outside the county. Thus, all the tax rates reported in Table 2 are underestimates of the actual tax rate to yield the desired revenue target. However, the possibilities of substitution, causing a decline in the tax bases, due to the tax rates reported in Table 2 are likely to be smaller than the decline in transit patronage due to fare increases.

Obviously, the tax rates required to raise particular revenue targets depend crucially on the magnitude of the tax base. Thus, the required income tax rate is less than half of the sales tax rate in all cases. To replace all subsidy funds, the required tax rates are appreciable increases on existing taxes. For example, the required regional gasoline tax of $0.10/gal would be only slightly

Table 2. Required regional tax rates to achieve possible subsidy targets in 1978.

Item	Subsidy Target: Federal Operating Subsidy	Federal and County Operating Subsidy	Total Operating Subsidy	Total Subsidy	Tax Base ($ billions)
Revenue required ($000 000s)[a]	13	19	41	74	–
Regional sales tax (%)[b]	0.37	0.53	1.12	2.08	3.56
Regional wage tax (%)[c]	0.17	0.26	0.55	0.99	7.45
Regional income tax (%)[c]	0.15	0.21	0.46	0.83	8.91
Regional property tax (%)[d]	0.24	0.35	0.76	1.37	5.40
Regional gasoline tax (cents/gal)[e]	1.9	2.7	5.9	10.6	–
Fare increase (%)[f]	36+	53+	114+	206+	0.036

[a]PAT annual reports.
[b]Based on sales tax collections from firms located in Allegheny County tabulated by Pennsylvania Bureau of Research and Statistics. Data exclude untaxed sales and may include some sales by outlets located outside the region. Sales tax collections are based on fiscal years. Calendar-year figures reported here are the average of the two relevant fiscal years.
[c]Regional wages and incomes as reported in income tax returns (instituted 1972) and tabulated by the Pennsylvania Department of Revenue. The wage tax considered in this analysis is based on the wages of residents of Allegheny County; an alternative scheme would be to levy the wage tax by place of employment or on all those who work in Allegheny County. For the regional income tax, taxable income is defined to be identical to taxable income under the state individual income tax.
[d]Pennsylvania State Tax Equalization Board, annual certification, as reported in 1979 (4).
[e]Volume sales of gasoline estimated as the total state sales in 1978 (5) multiplied by the percentage of vehicles registered in Allegheny County in 1978.
[f]Increase assumes no patronage decline with fare increases, thereby underestimating the required fare increase.

less than the $0.11/gal state tax that was imposed on motor fuel sales in 1978. The required sales tax would be one-third of the current 6 percent sales tax, whereas the required income tax rate would be nearly two-fifths of the state income tax rate in 1978. Although these tax rate increases are substantial, only two revenue sources in Table 2 would be unlikely to yield sufficient revenue to replace operating and capital subsidies. These are the transit fare increases and the motor fuel tax for which a substantial diversion of motor fuel purchases outside the county might be expected.

In addition to the adequacy of the yield from a potential tax source, the ease of administration of the tax is also a concern. In Pennsylvania, income and sales taxes are collected by the state, so any regional taxes might simply be included in the state reporting and collection process. Wage taxes might be collected at the workplace, as they are currently for local jurisdictions, or filed with the state income tax returns. Real estate taxes are collected at the local level and additional levies would not be administratively burdensome. However, no administrative structure currently exists to collect motor fuel taxes at the county level. Imposing a special surcharge within the region would require additional reporting by firms that retail motor fuels since they currently do not report sales by county. Thus, on the criterion of administrative ease of collection, the various tax sources in Table 2 are relatively equal, with the exception of the motor fuel surcharge, which would require additional accounting and reporting.

INCIDENCE OF CURRENT AND POTENTIAL TAX SOURCES

In addition to sufficient yield and administrative ease in collection, there are several other considerations that can be examined when evaluating a tax to fund a particular service. The traditional public finance literature proposes the ability-to-pay principle in addition to the benefit principle. Under the ability-to-pay principle, the revenue target or total revenue necessary to fund a public good or service is set by a broader decision process. Taxes imposed to yield this revenue target should ensure that the contribution of each taxpayer is in accord with his or her ability to pay. Under the principle, taxpayers with equal capacity should contribute equal amounts, whereas those with greater capacity should pay more. In the transportation literature, it is often argued that public transportation provides substantial benefits to the poor although it may be a rather blunt instrument for this purpose (7,8). If providing these benefits to the poor is a goal of public transit, it may be argued that the funding sources should be based on the ability to pay. This argument would suggest, for example, that a broad-based income tax with perhaps a progressive rate structure would be an appropriate source of revenue. The primary justification for this type of tax would be that the resulting tax burdens would be equitable.

While the distribution of tax burdens among particular groups such as the elderly and minorities is of concern when designing new taxes, the most common concern in the evaluation of the equity of a particular tax source is the income incidence. Although there is some debate as to what income base (e.g., current income, permanent income, wealth) to consider when measuring burden, current income is the most common base, given the data problems with alternatives.

In Table 3, the distribution of payments among income classes for various tax sources in 1978 is reported. The table provides the distribution of payments for the major revenue sources to the state's General Fund as well as current and potential regional (county) revenue sources. The distribution of payment is very similar for the state individual income tax and the current Pennsylvania sales tax. Adding clothing to the Pennsylvania sales tax base has little impact on the distribution of payments. Since it is difficult to determine the distribution of payments by income class for the state corporate net income tax, the distribution is evaluated under two assumptions. First, if the tax is assumed to be borne by the owners of capital, the distribution of payments is assumed to be similar to the distribution of net profits income. Note that 63 percent of net profits income is in the income class of $25 000 and more. If the corporate income tax is assumed to be passed on to consumers, the distribution of payments is assumed to be similar to the distribution of the sales tax. The distribution of payments of the gasoline tax is similar to that for the individual income and sales tax although a higher percentage of gasoline tax payments comes from the lower-income groups.

In the case of the regional tax sources, the distribution of payments among income classes is similar for an income tax and a wage tax. The real estate tax has a higher concentration of payments in the lower-income groups when compared with the income and wage taxes. The distribution of fare revenues is particularly interesting. In essence, the distribution of transit fare payments is equal across our income classes. As a result, the highest-income category (with incomes of more than $25 000) contributed only 16 percent of fare revenues, whereas the minimum contribution of this high-income class is 30 percent for the other tax sources reported in Table 3.

The distribution of the burden of potential tax sources by income class is reported in Table 4 for 1978. Each entry in this table represents the average ratio of tax payments to income within each income category. In contrast to the contribution proportions in Table 3, the ratios in Table 4 reflect the actual burden experienced by an average household in each income group. Any concentration of tax payments among the lowest-income households in an income class is reflected in Table 4 but not in the aggregate measures of Table 3. Thus, Table 4 represents a more accurate description of the distribution of household burdens than does Table 3. For comparison purposes, the burden of a hypothetical wage tax (at a 2 percent rate) and a sales tax without a clothing exemption (at the current Pennsylvania rate of 6 percent) is also included in this table. By comparing the relative burdens across income classes, the regressiveness or progressiveness of the various general tax sources may be assessed. The real estate tax is the most regressive tax appearing in Table 4; the lowest-income category has an average burden eight times larger than that of the highest-income category. The income tax in Pennsylvania is a flat rate, so the burden of the tax equals the tax rate for each income category. The wage tax is relatively progressive, although there is a reduction in the burden of this tax in the highest-income category. The effect of withdrawing the clothing exemption from the current state sales tax would be to make the sales tax slightly more regressive.

The average burdens reported in Table 4 deserve several caveats. First, the burdens were calculated on the basis of current income. Since public assistance payments are known to be underreported, current income for the lowest-income groups may be underestimated. As a result, the tax burden may be overestimated. The net effect on the distribution

Table 3. Distribution of payments for current and potential state and regional financing mechanisms.

Revenue Source	Percentage of Payments per Income Level: Less Than $6000	$6000-9999	$10 000-14 999	$15 000-19 999	$20 000-24 999	$25 000 and More
State						
Individual income tax[a]	6.0	8.1	13.6	17.0	16.0	39.2
Current PA sales tax[b]	5.5	7.6	13.4	17.9	16.5	39.2
PA sales tax without clothing exemption[b]	5.6	7.6	13.3	17.7	16.4	39.3
Net profits[c]	3.8	5.7	9.2	9.6	8.7	63.0
Gasoline tax[d]	6.4	9.2	18.5	20.0	15.6	30.4
General revenue[e]	5.7-5.3	7.8-7.4	13.5-12.7	17.6-16.0	16.4-14.8	39.2-43.8
Regional						
Individual income tax[f]	5.4	7.1	11.5	15.6	15.6	44.8
Wage tax[f]	4.4	7.3	12.2	17.1	17.2	41.8
Real estate tax[g]	8.0	9.6	15.2	21.7	15.6	29.8
Fare revenue[h]	17.0	16.6	19.5	15.2	16.1	15.7

[a]Since the income tax was a flat 2.2 percent in 1978, the distribution of payments is the same as the distribution of taxable income. There are some exemptions for income among the lowest-income categories in the Pennsylvania tax, but their effect is minor. In 1977, the state individual income tax rate was 2.0 percent. The effective rates for those with incomes below $6000 ranged from 1.97 to 1.99 percent as a result of the special provision for low-income households (9). A progressive income tax enacted in 1972 was found to be unconstitutional by the State Supreme Court, and the current flat tax was enacted subsequent to that finding.

[b]This distribution of taxable consumption by income class was obtained by using a simulation model developed by the Pennsylvania Tax Commission to examine the current sales tax and the tax without the clothing exemption. This analysis is based on U.S. Department of Labor Statistics (10). We assume that consumption patterns in Pennsylvania are similar to those of the New England region. For this analysis, income was inflated to 1978 dollars. The underlying assumption is that the relationship between taxable and nontaxable consumption is not affected by inflation.

[c]The distribution of net profits income by income class was obtained from a summary of 1978 individual income tax return data from the Pennsylvania Department of Revenue. Since it is difficult to determine the incidence of the state corporate net income tax, we evaluate the incidence under two assumptions. If the tax is paid by the owners of capital (assuming that none of the tax is shifted to consumers), the distribution of the tax payments is considered to be the same as the distribution of net profits income by income class. If it is assumed that the tax is shifted forward to consumers, the distribution is assumed to be the same as that for the sales tax.

[d]The distribution of gasoline expenditures by income class was derived from U.S. Department of Labor Statistics (10). The original data reported expenditures on gasoline in the New England Region for 1972-1974. Assuming that the distribution of expenditure remained constant from 1973 to 1978, the distribution was developed by inflating 1973 income ranges to 1978 levels. When the income ranges from the Consumer Expenditure Survey were different from those used in this analysis, we interpolated to make the results compatible.

[e]The individual income tax, the general sales and use tax, and the corporate net income tax accounted for 73 percent of total general fund revenue for Pennsylvania in 1978-1979. Of the 73 percent of the general fund, the individual income tax accounted for 36.4 percent, the sales and use tax accounted for 43.9 percent, and the corporate net income tax accounted for 19.7 percent. By applying these weights, the distribution of payments to the general fund was derived. A range is provided because the distribution of payments of the corporate net income tax varies depending on the assumption made concerning who pays the tax. In the first case, it is assumed that the tax is shifted to consumers and therefore the distribution is similar to the distribution of payments of the current sales tax. In the second case, we assume that the tax is paid by the owners of capital and therefore that the distribution is similar to the distribution of net profits income.

[f]The distribution of taxable income under the Pennsylvania individual income tax for Allegheny County is based on summary individual income tax return data for Allegheny County provided by the Pennsylvania Department of Revenue. The distribution of wages by income group is based on a summary of individual income tax return data on compensation.

[g]The distribution of real estate taxes paid by income class is based on data from the Bureau of the Census (11). For this analysis, income is inflated to 1978 dollars.

[h]Calculated by us from the Household Travel Survey conducted by the Southwestern Pennsylvania Regional Planning Commission, 1977-1978.

Table 4. Distribution of burdens of current and potential state and regional financing mechanisms.

Revenue Source	Mean Tax per Income Level: Less Than $6000	$6000-9999	$10 000-14 999	$15 000-19 999	$20 000-24 999	$25 000 and More
State						
Individual income tax[a]	0.022	0.022	0.022	0.022	0.022	0.022
Current PA sales tax[b]	0.030	0.016	0.015	0.015	0.014	0.013
PA sales tax without clothing exemption[b]	0.036	0.018	0.018	0.017	0.017	0.015
Regional						
Individual income tax (at 2 percent rate)[c]	0.02	0.02	0.02	0.02	0.02	0.02
Wage tax (at 2 percent rate)[d]	0.004	0.009	0.015	0.017	0.017	0.014
Real estate tax[d]	0.165	0.066	0.045	0.037	0.032	0.028

[a]The current Pennsylvania individual income tax is at a flat rate of 2.2 percent.

[b]The current Pennsylvania sales tax is 6 percent. In this analysis, we computed the sales tax paid by households included in the Consumer Expenditure Survey given the definitions of taxable consumption under Pennsylvania law (see note b, Table 3).

[c]The burden of a flat regional individual income tax is simply equal to the tax rate.

[d]The burdens of a regional wage tax of 2 percent and the real estate tax are calculated from household data provided by the Bureau of the Census (11). For this analysis, income was inflated to 1978 dollars.

of the burden among income classes would depend on the distribution of unreported income among these classes. Second, the burdens reported in Table 4 reflect the initial rather than the ultimate burden of tax payments. State and local tax payments represent a deduction for federal income tax purposes, and the progressive nature of the federal income tax results in an ultimate burden that is more regressive than that reported in Table 4. Since the higher-income classes generally have a higher marginal tax rate, an equal state or local tax deduction results in greater tax savings for high-income households relative to low-income households.

By using the data reported in Tables 3 and 4, the distribution of the average burdens and payments may be calculated for the various potential taxes discussed earlier. Table 5 reports these distributions for a revenue target of $19 million in 1978, which would be sufficient to replace all federal and county operating subsidies.

The burdens and payments reported in Table 5 permit comparisons of different tax sources within any one income class. For taxpayers with incomes between $10 000 and $15 000 in 1978, the individual income tax results in the lowest average payment ($21), whereas the sales tax represents the lowest average burden (0.0013). The wage tax would result in the lowest average payment and the lowest average burden to the lowest-income class. Thus, the wage tax has the most progressive impact of all the sources listed in Table 5, although there is a slightly lower burden on the highest-income class compared with the middle-income classes for this tax source.

Table 5. Average payments and burdens per household to replace federal and county operating subsidies.

Revenue Source	Income Class: Less Than $6000	$6000-9999	$10 000-14 999	$15 000-19 999	$20 000-25 000	More Than $25 000
Individual income tax (0.21 percent)						
Burden[a]	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021
Payment ($)[b]	11	17	21	30	49	104
Sales tax (0.53 percent)						
Burden[a]	0.0027	0.0014	0.0013	0.0013	0.0012	0.0011
Payment ($)[b]	11	18	25	35	52	91
Wage tax (0.26 percent)						
Burden[a]	0.0004	0.0012	0.0020	0.0022	0.0022	0.0018
Payment ($)[b]	9	18	22	33	54	97
Real estate tax (0.35 percent)						
Burden[a]	0.0057	0.0023	0.0016	0.0013	0.0011	0.0010
Payment ($)[b]	16	23	28	42	49	69
Fare increase (53 percent)						
Payment ($)[b]	33	40	36	30	50	37

[a]Income, sales, wage, and real estate tax burdens calculated as proportional to existing tax burdens (Table 4).
[b]Average taxpayer payments are calculated as proportional to the ratio of the percentage of payments by tax source by income class (Table 3) to the percentage of households in each class as given by Bureau of the Census (11) with incomes inflated to 1978 dollars.

Table 6. Tax payments per trip for potential regional tax sources to replace federal and county operating subsidies.

Revenue Source	Income Class: Less Than $6000	$6000-9999	$10 000-14 999	$15 000-19 999	$20 000-25 000	More Than $25 000
Income tax	0.06	0.08	0.11	0.19	0.19	0.53
Wage tax	0.05	0.08	0.12	0.21	0.20	0.49
Sales tax	0.06	0.08	0.13	0.22	0.19	0.46
Real estate tax	0.09	0.11	0.14	0.26	0.18	0.35

Note: Each entry represents the total local tax contribution for each income class divided by the number of transit trips made by each income class. Fare payments and state and federal contributions are excluded. Transit trips for each income class are calculated as total trips (103 million) times the percentage distribution of trips by income as indicated by the Household Travel Survey conducted by the Southwestern Pennsylvania Regional Planning Commission, 1977-1978. Total tax payments by income class are calculated as $19 million times the appropriate payment percentage distribution as shown in Table 5.

DISTRIBUTION OF BENEFITS AND TAX PAYMENTS

The incidence estimates presented in the previous section are only one side of the equity issue in transit finance. As noted earlier, policymakers may be interested in the relationship between the benefits received and the tax payments by income group as well as the distribution of tax payments in relation to the ability of households to pay.

Unfortunately, identification of the distribution of transit benefits is not an easy task. Transit riders obviously benefit from the improved service and lower fares made possible by subsidies. Owners of real estate may benefit from the improved access to their property provided by transit service. In addition, transit service may provide a variety of indirect social and environmental benefits such as reduced congestion, improved air quality, and increased mobility to the elderly and handicapped. Because of the difficulties associated with measuring these indirect benefits, we have restricted our attention to the direct benefits to transit riders. These are likely to represent the largest category of benefits, since environmental and other indirect benefits were found to be small in several studies (12-14). Even when restricting our consideration to direct benefits, we must make the simplifying assumption that the distribution of benefits in each income class is equal to the distribution of trips. In fact, we expect that some trips are valued more than others, but because of data limitations we cannot properly weigh each trip by its actual value.

The tax payments per trip for each income class under the four alternative regional taxes are reported in Table 6 for 1978. Assuming that the distribution of benefits is identical to the distribution of trips, these figures represent the relative level of benefits from regional tax payments within each income class. Fare payments and transit tax payments made through the state and federal governments are excluded from Table 6.

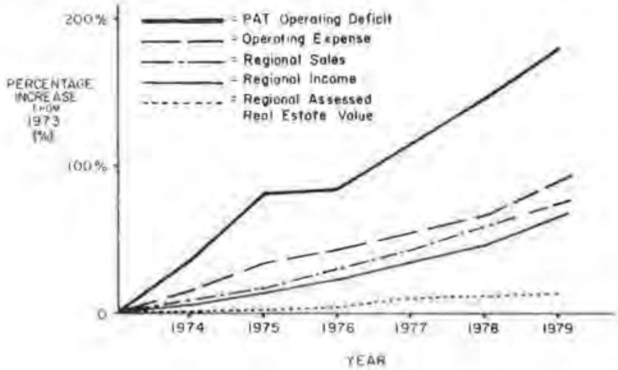
With the inclusion of direct benefits to transit riders, the net distributional impact of the Pittsburgh transit service is quite progressive. For example, under a wage tax, a household with income less than $6000 would make a $0.05 tax contribution per trip, on average, whereas a household with an income of more than $25 000 would pay $0.49 per trip, on average. While each of the tax sources reported is progressive, the real estate tax is less progressive than other tax sources. We should note, however, that these figures represent tax payments per trip by income class rather than the average tax payment per trip for households within each income class. As noted earlier, average burdens based on individual household data rather than aggregate data for the income class are more indicative of the progressiveness of tax sources. Given the household burdens reported in Table 4, we expect that net benefit calculations by using household data would show the sales tax to be more regressive relative to the income and wage taxes.

MANAGEMENT OF DEDICATED TAXES

A desirable feature of a dedicated tax for transit subsidies would be to match over time the revenues received with the need for transit subsidy funds without continual tax rate changes. For the transit service offered in Pittsburgh in the mid-1970s, this would not have been possible; the increase in the transit service deficit was much greater than the increase in any of the tax bases discussed above. Throughout the past 10 years, tax rates would have had to have been adjusted upwards to match revenues with the increase in required subsidies.

From 1973 to 1978, operating expenses for transit services increased by slightly more than 70 percent

Figure 1. Percentage increases in regional tax bases, transit expenses, and transit deficits since 1973 in Allegheny County.



[Figure 1 (data from PAT annual reports, Pennsylvania Bureau of Research and Statistics, and Pennsylvania Department of Revenue)]. During the same period, service revenues increased much more slowly than expenses. Consequently, the operating deficit increased at a much faster rate than expenses, with a total increase of nearly 150 percent during this five-year period. During the same five-year period, the tax bases of the wages and income each increased by approximately 50 percent, whereas sales increased 60 percent and assessed real estate value increased only 15 percent. Thus, the revenues from a dedicated transit tax at a given tax rate would not have kept pace either with the increase in transit expenses or with the increase in the transit deficit. For example, a wage or income tax imposed to cover the transit service deficit in 1973 would have had to triple by 1978 to continue to cover the deficit.

Of course, this increase in the tax rates could be alleviated or avoided by different transit operating policies. Fare increases, cost controls (such as wage reductions), or service cutbacks could reduce the deficit for transit services. However, patronage levels have not been increasing rapidly (if at all), so fairly severe service cutbacks or cost savings would have been necessary to restrain deficit increases to the growth in the regional tax bases.

CONCLUSIONS

We have examined a variety of potential regional tax sources for transit subsidy funds from the standpoints of sufficient yields, administrative ease, conformance with the ability to pay and the benefit principles of public finance, and the difficulties in managing revenues over time. We found that regional tax sources are viable alternatives to state and federal subsidies. From the standpoint of equity, several of these tax sources would be more desirable than the property taxes currently used for the local share of subsidy funds in Allegheny County. By and large, we have concluded that a broad-based wage or income tax would be the most preferred source on which to base a dedicated tax. These two taxes are relatively easy to administer and are somewhat more progressive than the other alternatives considered. Sales taxes are somewhat more regressive and have a smaller tax base than these two options. Motor fuel taxes would be difficult to administer and have an insufficient tax base. Motor fuel taxes and to some extent a regional sales tax to fund transit subsidies may result in significant amounts of sales diversion to other counties.

While the analysis in this paper related to a single metropolitan area, the conclusions are likely to be applicable to a wide variety of urban areas. Regional wage and income taxes seem to be the tax sources that deserve greatest attention. One problem with any dedicated tax is that the growth in revenues will not keep pace with the current rate of increase in transit deficits. Either relatively frequent increases in tax rates or controls on deficit increases would have to be undertaken to match revenues to deficits over time.

Of course, the problem of financial management is part of a broader investment problem with regard to transit. Fare revenues will never be sufficient to cover PAT transit operating expenses as transit service is currently operated. Before imposing or increasing a dedicated transit tax, decisionmakers should carefully consider the benefits and costs of particular system configurations and fare structures in order to reduce the necessary level of subsidy.

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Applying S-Index to Transportation Financing Alternatives

STEVEN M. ROCK

A one-number measure of the progressivity of a funding source has recently been developed by Suits. This paper applies the measure to various transportation financing alternatives. This S-index can range from +1 (indicating maximum progressivity) to -1 (maximum regressivity). The index can be calculated for any funding source by ranking families by income and noting the cumulative percentage of burden associated with the cumulative percentage of income. By using data from the Bureau of Labor Statistics Consumer Expenditure Survey, the index is calculated for a number of currently used or proposed household-based transportation funding sources. Subject to certain qualifications, the results suggest the general redistributive impact of alternative financing sources. In particular, it was found that most household-based sources are regressive. The most regressive alternatives were a household tax, cigarette tax, lottery, and public transit fares. Least regressive sources were parking, income, and stock-transfer taxes.

In a 1977 article, Daniel Suits (1) presented a one-number measure of the burden of a funding source. Called the S-index, it summarizes the incidence (that is, who pays) of a financing alternative or combination. The result indicates the degree of progressivity or regressivity of the source. It is the purpose of this paper to discuss the index and its application to transportation financing alternatives.

In recent years, the issue of increased funding for transportation has become more critical. Transit systems and highway funds, for example, have reached crisis stages in many regions. A number of important considerations surface in this area: legal, political, and economic. Notably absent from most discussions of transportation finance is the concern for how different income groups would be affected by the employment of different funding sources. The question to be explored here is how financing alternatives differ in terms of progressivity.

Suits' index is related to the Lorenz curve of income distribution and the resulting Gini concentration ratio. The former is a graphic description of a society's income distribution, comparing population percentiles with the percentage of total income received. It illustrates the equality or inequality of the distribution of income under various alternatives. The Gini ratio summarizes this in a number that can vary between 0 (complete income equality) and +1 (complete income inequality).

To apply the S-index, families are ranked from lowest to highest income, and the accumulated percentage of tax burden associated with the corresponding accumulated percentage of income needs to be obtained. The resulting data can be plotted as in Figure 1. A funding source whose burden is always proportional to income would lie coincident with the diagonal (45°) line. A source lying below the 45° line indicates that the percentage of tax burden borne by low-income groups is smaller than their share of total income; hence, it is a progressive source such as the federal income tax (e.g., the dashed line in Figure 1).

A source lying above the 45° line indicates the opposite, a regressive source. The percentage of tax burden imposed on low-income families exceeds their percentage share of income (e.g., the dotted line).

The S-index is defined in terms of K (the area of triangle OAB) and L [the area OABC (or OABC')] contained between the curve and the horizontal axis OA:

$$S = (K - L)/K = 1 - (L/K) \quad (1)$$

For a proportional tax, the curve will be coincident with the 45° line, so L = K and S = 0. A progressive source, such as the dashed line, lies below the diagonal, so L < K and S > 0. In the limiting case of maximum progressivity, L = 0 and S = 1. With a regressive source above the 45° line, L > K and S < 0. In the limiting case of maximum regressivity, L = 2K and S = -1. Thus, the index varies between -1 (absolute regressivity) through 0 (proportional) to +1 (absolute progressivity).

For numerical calculation, K is a triangle with base and height of 100; therefore, it is defined as follows:

$$K = 5000 \quad (2)$$

An approximation to the value of L, for 10 population deciles ranking families from the 10 percent with lowest income (decile 1) to the 10 percent with highest income (decile 10), is as follows:

$$L \approx \sum_{i=1}^{10} (½)[T_x(y_i) + T_x(y_{i-1})](y_i - y_{i-1}) \quad (3)$$

where $T_x(y_i)$ is the accumulated percentage of total burden for given tax x, associated with the accumulated percentage of income y represented by population decile i.

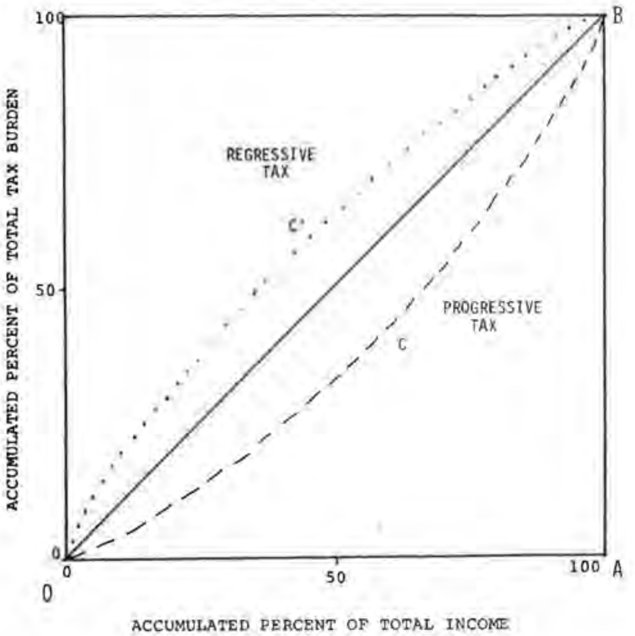
Suits' analysis was both criticized and broadened in two subsequent comments. Davies (2) raised three concerns, but only the third related to the S-index itself. First, the data generally used to calculate the S-index rely on one year's family income. Optimally, data on permanent (lifetime) income would permit a more accurate measure but such data are seldom available. Second, the value of in-kind transfers needs to be monetized and included with income. A third problem is that the index is an average over the entire income spectrum. The resulting aggregation could mask portions of the income distribution where a tax is regressive and another portion where it is progressive.

Kienzel (3), by using different assumptions of incidence, showed that the S-index is sensitive to these alternatives. Although both Davies and Kienzel recognize the drawbacks and ambiguities in Suits' analysis, this does not diminish its usefulness as a tool in tax-policy analysis. Even with the potential biases, the S-index can be an important addition to public finance issues, because it is the best (and only) summary measure available of the relationship between tax burden and income.

ANALYSIS

It will be assumed that the basic groups benefiting from the use of transportation funding sources will be the same. In fact, since funding mechanisms may affect the relative price of transportation modes, the groups benefiting from the subsidy may not be independent of the subsidy source. However, such a change will likely be small. Therefore only the difference in groups paying for the sources will be examined, by comparing the differential tax incidence of one source with that of another source. Musgrave and Musgrave (4) suggest that this concept offers the best approach for tax-policy analysis, since actual tax-policy decisions usually involve issues such as comparing alternative ways of raising revenue.

Figure 1. Tax burden versus income.



Calculation of incidence will depend on the extent to which the initial distribution of burdens differs from the final distribution. If adjustments by consumers or firms are made in response to tax changes, these should be determined. For example, consumers may alter the amount and/or location of durable goods purchases due to a change in the state or local sales tax. A series of studies have examined the shifting and incidence of local taxes to determine the impact of competition from firms in areas not subject to the taxation. In one of the most recent and most comprehensive, Mikesell (5) found less than complete shifting to the consumer. However, his estimates suggest that approximately 90 percent of the burden is shifted in the form of higher prices. In a second study, Sidhu (6) also concluded that proximity to a political border reduces the ability of sellers to shift tax burdens. Unfortunately, these empirical works did not try to determine who bears the unshifted portion of the burden or which income classes are affected and by how much.

Many of the funding sources suggested for transportation (7) are taxes levied on households' consumption, income, wealth, etc. The conventional wisdom [although not unanimously (8)] suggests that incidence lies with the consumer on the basis of expenditures, ownership, or tax payments. The incidence of other potential sources (e.g., property tax, corporate income tax, payroll tax) is more controversial, particularly if they are levied initially on businesses. The final incidence of such sources depends on changes in wages, prices, and profits as a result of the tax. Data on the shifting of tax burdens are scarce and there is little consensus on the result. For this reason, the taxes levied primarily on households will be studied.

The data analyzed by Suits and Kienzel were developed by Pechman and Okner (9) and are inadequate since all sales and excise taxes are lumped together as well as personal property and all motor vehicle taxes. What is necessary are data on detailed spending patterns and tax payments by families in different income brackets for funding sources currently used or proposed. Such data are provided by the Consumer Expenditure Survey (CES) of the Bureau of Labor Statistics (10).

Calculating the incidence of each tax or fee requires that relevant expenditures be noted by income level. A convenient breakdown available from the CES data necessary to calculate the S-index is to arrange families by population decile from the 10 percent of families with the lowest income (decile 1) to the 10 percent of families with the highest income (decile 10). For four selected deciles (1, 4, 7, 10), gross expenditure or ownership is noted in Table 1 (10). Each figure represents the average expenditure on an item by a family in a particular decile. It is seen that decile-1 families spend an average of between \$823 and \$1407 on goods subject to sales tax, whereas a decile-10 family spends between \$6847 and \$8676. For reference, the average incomes for families in the four deciles reported are \$1559, \$7063, \$13 466, and \$31 974, respectively. It is noted that since taxes on expenditure items are generally proportional to spending, the S-index for both expenditures and taxes on expenditures would be the same.

The data necessary to calculate the S-index by using Equations 1, 2, and 3 require the accumulated percentage of both income and each funding source represented by each population decile; these are presented in Table 2 (10). It is seen that although decile-1 families account for 10 percent of the population, they account for only 1.31 percent of the income but pay 2.6-3.2 percent of total sales tax collections, a regressive result. The decile-2 row considers both decile-1 and decile-2 families, which represent 20 percent of the population, 4.07 percent of the income, and about 7 percent of sales tax collections, etc. The S-index results are displayed in Table 3. The sources are ranked from the most progressive (stock-transfer tax) to the most regressive (household tax).

There have been few other studies that have applied S-indices to various taxes by using a compatible data set. However, the comparisons that are available (e.g., all sales and excise taxes and income taxes) generally support the findings in Table 3. The results of these comparisons are shown below (1,3,13) together with estimates for selected business-based taxes. The wide range for such taxes as corporate income or property levies illustrates the uncertainty and variance as to final incidence.

Source	S-Index
Individual income tax	+0.17 to +0.19
Corporate income tax	+0.03 to +0.36
Property taxes	-0.07 to +0.23
All sales and excise taxes	-0.15 to -0.16
Payroll taxes	-0.13 to -0.17
Personal property and motor vehicle taxes	-0.09 to -0.12
Lottery	-0.20 to -0.40

QUALIFICATIONS

Some qualifications need to be made to the above analysis. The data reflect spending patterns and thus incidence in 1972-1973. If the distribution of these spending patterns has changed, tax incidence could change. The omission of in-kind transfers in income and the use of a single year's income can be criticized, as suggested by Davies. Although no data are readily available to correct the latter problem, the CES data do include the value of food stamps in the definition of family income. Although not included in income, data on food received from welfare organizations and medical care paid by others are reported. Since these amounts were small (average of \$5 and \$21 reported per family, respec-

Table 1. Yearly expenditures on taxable goods and services and other sources.

Item	Expenditure ($) by Decile			
	1	4	7	10
Taxable goods[a]	1407	3262	5139	8 676
Taxable goods [b]	823	2201	3723	6 847
Gasoline	98	270	449	561
Parking and towing	1	5	9	32
Tolls	0	2	4	8
Alcoholic beverages	33	79	127	252
Cigarettes	57	107	146	142
Gas and electric tax	135	222	320	432
Telephone	81	152	193	270
Vehicle registration[c]	10	28	40	53
State and local income taxes	7	84	263	906
Title transfer fee[d]	1	3	4	5
New-car purchases[e]	100	281	514	1 005
Used-car purchases[e]	73	191	338	407
Admissions and fees	11	26	54	116
New mortgage debt	180	410	1206	1 462
Household tax[f]	18	18	18	18
Public transportation fares	33	56	42	88
Stock ownership[g]	145	1313	2168	13 736

[a]Goods subject to general sales tax, assuming food purchased for home consumption and medicine and drugs are subject to sales tax. See paper by Rock (11) for more details.
[b]Assuming the items in note a are not subject to sales tax.
[c]Assuming a $25/vehicle fee.
[d]Based on the percentage of families purchasing a car and a fee of $10.
[e]Net outlay (excluding trade-in values).
[f]Assuming $18/family.
[g]Market value of holding.

Table 2. Accumulated U.S. income and tax burden by population decile, 1972-1973.

Item	Expenditure (cumulated percentage) by Decile									
	1	2	3	4	5	6	7	8	9	10
Family income	1.31	4.07	8.35	14.30	21.98	31.46	42.81	56.40	73.05	100.00
Sales tax 1	3.20	7.68	13.59	21.00	29.92	40.14	51.81	65.15	80.29	100.00
Sales tax 2	2.60	6.24	11.36	18.30	26.93	37.07	48.81	62.55	78.41	100.00
Gasoline tax	2.85	6.68	12.70	20.51	30.24	41.65	54.65	68.56	83.77	100.00
Parking tax	0.69	2.57	6.20	11.35	17.49	25.44	35.82	48.47	64.24	100.00
Tolls	1.14	4.39	7.92	14.48	21.96	32.41	44.13	57.46	75.11	100.00
Alcohol tax	2.87	6.69	12.86	19.72	29.54	39.62	50.65	62.99	78.11	100.00
Cigarette tax	4.85	10.86	18.26	27.38	37.70	48.66	61.10	74.69	87.88	100.00
Gas and electric tax	4.96	11.12	18.53	26.71	35.86	46.12	57.90	70.25	84.13	100.00
Telephone tax	4.75	11.20	18.67	27.53	37.29	47.79	59.11	71.08	84.23	100.00
Vehicle registration	3.03	7.58	14.39	22.73	32.58	43.94	56.06	69.70	84.09	100.00
State and local income tax	0.30	0.89	2.33	5.74	11.38	19.57	30.32	44.21	62.96	100.00
Title transfer fee	3.46	8.23	14.90	23.50	33.87	45.86	58.16	71.97	85.55	100.00
New-car tax	2.30	4.46	8.48	14.95	22.71	33.30	45.15	59.81	76.80	100.00
Used-car tax	2.76	6.86	12.71	19.89	30.80	42.65	55.35	69.90	84.71	100.00
Admissions tax	2.20	4.99	11.30	16.68	24.40	34.62	45.93	59.34	75.74	100.00
New mortgage tax	2.31	4.29	7.20	12.45	19.99	31.36	46.82	61.32	81.27	100.00
Household tax	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00
Transit fares	6.91	15.36	23.77	35.49	44.40	52.78	61.50	69.46	81.63	100.00
Stock-transfer tax	0.53	2.36	5.36	10.18	15.91	21.61	29.58	36.52	49.51	100.00

Table 3. S-index for funding alternatives.

Source	S-Index	Source	S-Index
Stock transfer tax[a]	+0.24	Gasoline tax	-0.16
State and local income tax	+0.18	Used-car excise tax	-0.17
Parking and towing tax	+0.11	Vehicle registration fee	-0.19
Tolls	-0.02	Title transfer fee	-0.21
New-car excise tax	-0.04	Utility tax	-0.22
Admissions and fees	-0.05	Telephone tax	-0.23
Mortgage tax	-0.05	Cigarette tax	-0.26
Sales tax B[b]	-0.09	Public transportation fares	-0.26
Alcohol tax	-0.11		
Sales tax A[c]	-0.13	Household tax	-0.39

[a]Based on ownership.
[b]Sales tax based on Table 1, note b.
[c]Sales tax based on Table 1, note a.

tively), these can be omitted without affecting the results. The implicit assumption was made that in response to tax changes, households would continue to buy taxable items or pay taxes in the same relative pattern that they did before. Any other assumption would vastly complicate empirical calculations. If a tax used for transportation funding is incremental to an existing source, the incidence would be essentially the same as the source to which it is attached.

Since national data were used, regional incidence could differ significantly from the reported figures due to local variations in tax rates, exceptions, expenditures, etc. The results should thus be viewed as a national aggregate. In addition, data on alcohol expenditures, public transportation expenditures, and cigarette purchases suffered from serious underreporting, according to the U.S. Bureau of the Census (12). If the degree of underreporting was related to income, the reported figures could be biased.

It is noted that analysis of who pays is one input necessary to examine the overall redistributive impact of transit services. That is, combining the profile of who pays with that of who benefits would complement and expand this research. Also, improved data and analysis on the incidence of business-based taxes would be a fruitful direction for further research in this area. Computing and comparing the S index for different localities would be an additional application.

CONCLUSIONS

The burden of increasing transportation funding through a variety of household-based sources has been examined by employing data provided by the Bureau of Labor Statistics and applying the S-index of tax progressivity developed by Suits. A number of potential sources have been compared as to incidence. Subject to certain qualifications, the analysis suggests the following conclusions:

1. Most household-based funding sources are regressive, placing a greater financing burden on the poor.
2. Choosing a new source, or replacing one source with another, has implications for the distribution of burdens.
3. Particular pro-poor sources would be parking taxes, income taxes, or stock-transfer taxes.
4. Particularly burdensome sources for the poor would be a household tax, cigarette tax, or a lottery.
5. Considering transit financing, of the sources studied, virtually all of them place less of a burden on the poor than increasing fares.

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Managing Cash in Pennsylvania Department of Transportation

JAMES I. SCHEINER

Although the benefits of cash management are well known to private industry, public agencies have lagged in the application of cash-management techniques. The near-bankrupt condition of Pennsylvania's Motor License Fund in 1979 forced the use of tight cash controls as part of an initial survival strategy. The Pennsylvania Department of Transportation (PennDOT) immediately developed a cash-forecasting methodology and inventoried its outstanding cash receivables, with particular emphasis on outstanding Federal Highway Administration (FHWA) reimbursements. At the same time, PennDOT discontinued bond sales, which had been used in the previous administration to amass $2.2 billion of highway debts. In the succeeding three years, PennDOT (a) sold no highway bonds, (b) tripled the flow rate for FHWA reimbursements and simultaneously cut FHWA receivables by almost $50 million, (c) put new state tax revenue immediately to work in support of a massive Pennsylvania highway restoration program, and (d) consistently paid all bills on time, typically within 30 days. PennDOT could not have achieved all four of these results without a tight framework of cash management. Although the circumstances of the Motor License Fund are unusual, three lessons of its cash-management experience have broad applicability: (a) cash-flow forecasting provides greater management control—deviations from the cash plan are often early warning signals of trouble; (b) if an organization cannot precisely answer the question—Who owes us how much money and when are we going to get it?—its management is deficient; and (c) large cash balances are a luxury that many transportation agencies can no longer afford—PennDOT has run a fiscally responsible highway program for three years, with an average cash balance equivalent to only two weeks' expenditures.

In private industry, cash management is a vital business function. A business adage proclaims, "The work isn't done until the money is in the bank." During periods when interest rates are at high levels, cash management takes on added significance. The difference between paying and earning interest on sums as low as a few thousand dollars can have a significant impact on a small firm's profitability.

Public agencies have not been so sensitive as private industry to the financial impacts of cash flow. Clearly, transportation agencies no longer have the luxury of overlooking this important topic. With highway programs being stifled due to declining fuel consumption and with public transit facing federal operating cutbacks, improved cash flow has become a requirement for survival.

NEED FOR CASH-FLOW FORECASTING

In 1978, perhaps no state transportation department needed cash-flow forecasting more than the Pennsylvania Department of Transportation (PennDOT). The Department had been living off massive highway bond sales for the past decade. Pennsylvania had amassed $2.2 billion of highway-bonded debt, more than twice the amount of any other state and 20 percent of the highway debt of the entire nation (1).

Bond sales were curtailed only after highway debt brought down Pennsylvania's credit rating to the lowest among the 50 states. At that time, there was a severe cash shortage in the Motor License Fund (MLF). Payment delays of several months were typical in the 1976-1978 period, as PennDOT shut off its construction program and laid off 5000 employees. In January 1979, cash-flow management was not an option, it was an imperative. PennDOT had been operating on a pay-as-you-go basis for the past three years, without even the semblance of a cash-flow-forecasting methodology.

PennDOT operates out of the constitutionally earmarked MLF, which collects highway user taxes and expends money solely for highway purposes. Although the State Treasurer pays the bills and invests idle cash and the Department of Revenue collects the taxes, the Department of Transportation is responsible for the lion's share of expenditures. Transportation, therefore, accepted responsibility for revenue and expenditure cash forecasting for the entire MLF.

PENNDOT CASH-MANAGEMENT SYSTEM

Today, PennDOT operates the equivalent of a $100 million/month to a $150 million/month checking account. Every month, revenues of this magnitude flow into the MLF, and expenditures of this magnitude flow out. There is little margin for error with cash flows this large. Despite significant uncertainties surrounding many key variables, overall tolerances for receipt and expenditure forecasts must be in the ±5 percent range in order to preclude cash shortages.

PennDOT's cash-flow-forecasting system has been highly successful. Since 1979, the Department has paid all its obligations on a timely basis (generally within 30 days) while maintaining a cash balance in the range of $25-$75 million--about two weeks' expenditures.

The heart of PennDOT's cash-management system is the monthly cash-flow forecast. This forecast provides a rolling 12-month estimate of cash receipts and disbursements, so that plenty of advance warning is available to show periods and extents of anticipated cash shortfalls. Receipts and disbursements have been broken down into easy-to-forecast categories. For example, all the Department's salary and fringe-benefit costs have been lumped into one item, irrespective of organization, because this total can be easily forecast to ±1 percent. Every forecast item is tied to an individual, who is technically responsible for the forecast's accuracy. Actual versus forecast numbers are contrasted on every monthly report, so that technically responsible individuals get constant feedback on each forecast's reliability.

Monthly forecasts for the MLF are shown in Tables 1, 2, and 3. [Tables 1, 2, and 3 were developed by the Federal Highway Administration (FHWA) for use in this paper. The source tables used by PennDOT are available from the author.] Table 1 is a rolling 12-month cash-flow forecast. The forecast is updated monthly by adding one month to the end. Although normal cash balances equal one-half of a month's expenditures, the cash balance peaks in April of each year to allow for the payment of an estimated $124 million to municipalities.

Forecasts are made by specific line items as shown in Table 2 for receipts and in Table 3 for expenditures. Individuals are assigned responsibility for each forecast category. Based on comparisons for the last month and year-to-date subtotals of actual figures against forecasts, the total fiscal-year (1981-1982) estimate is updated monthly. The updated FY 1981-1982 estimate for September and the change from August 1981 are shown in the last three columns of Tables 2 and 3.

In Table 2, the actual receipts for September were $23 million greater than the forecasts, primarily due to improved procedures for billing and collecting federal aid.

In Table 3, contracted repairs for maintenance were $8.1 million greater than forecast and construction contracts were $20 million less than forecast. Other observations on receipts and disbursements are contained in the following sections of the paper.

GENERAL OBSERVATIONS ON RECEIPTS

The timely receipt of federal aid augmentations is critical to cash-flow management. In just two fiscal years, Pennsylvania's federal collections were improved from $146 million to $380 million while federal receivables (federal money owed Pennsylvania but not paid) were reduced by almost $50 million. This was accomplished by identifying projects for which FHWA agreements or amendments were pending and then processing these in priority order, based on dollar impact. Each PennDOT unit manager was made responsible for federal-aid collections for projects under that unit's jurisdiction.

Since May 1979, there has been a continuing decline in liquid fuels tax receipts due to the drop in gasoline sales. In early 1979, Pennsylvanians were consuming motor fuel at the rate of 6 billion gal/year; by mid-1981, this rate had dropped to about 5 billion gal/year. Revenues from diesel fuel sales have fallen off far more sharply than drops in truck traffic, which suggests that better enforcement is needed in this area. Pennsylvania's Department of Revenue initiated a crackdown on truck stops that were in arrears in diesel fuel tax payments during mid-1981.

The new oil franchise tax is yielding about what had been projected--$16-17 million/month. This tax is 3.5 percent of the wholesale price of motor fuel, less taxes, to be paid by oil companies who transact the first Pennsylvania sale of gasoline or diesel for a highway purpose.

License and fee receipts have also been below expected levels, principally due to the sluggishness

Table 1. PennDOT rolling 12-month cash-flow forecast.

Item	Fiscal YTD[a]	Oct.	Nov.	1981 Dec.	1982 Jan.	Feb.	March	April	May	June	FY 1981-1982	July	Aug.	Sept.	12-Month Forecast
	Millions of Dollars														
Beginning balance	85.3	51.8	54.3	71.3	72.8	88.2	101.8	135.0	46.2	66.3	85.3	67.3	68.2	84.5	51.8
Receipt[b]															
Motor fuels (2, 3)	160.8	60.4	63.9	62.2	62.2	61.4	56.9	55.3	57.8	56.8	697.7	60.8	64.4	59.9	722.0
Motor vehicles (4, 5)	110.0	46.8	36.4	30.8	31.4	32.3	35.3	43.8	51.3	37.3	455.4	33.5	33.8	44.0	456.7
Federal and local aid receipts (6-8)	134.6	38.0	48.0	36.6	26.2	20.7	17.2	20.9	35.1	51.7	429.0	62.8	66.3	61.4	484.9
Other (9-12)	16.6	4.3	3.7	5.5	4.4	4.6	8.2	4.1	4.4	5.4	61.2	2.4	5.4	7.1	59.5
Subtotal	422.0	149.5	152.0	135.1	124.2	119.0	117.6	124.1	148.6	151.2	1643.3	159.5	169.9	172.4	1723.1
Expenditure															
Debt and local payments (1, 20-22)	52.4	19.7	9.1	34.7	17.6	22.2	14.6	136.6	24.1	37.0	368.0	23.5	12.5	15.9	367.5
Payroll and administration (2-7)	127.6	41.2	53.2	49.6	49.0	50.6	42.6	42.8	41.1	26.6	524.3	32.8	47.4	44.4	521.3
Maintenance (8-13)	155.0	59.5	46.8	27.6	21.9	16.8	13.0	13.0	21.6	40.4	415.6	54.2	41.4	44.2	400.4
Construction (14-19)	126.6	26.6	25.9	21.7	20.3	15.8	14.2	20.5	41.7	46.2	359.5	48.1	52.3	78.1	411.4
Adjustments	-6.1	-	-	-	-	-	-	-	-	-	-6.1	-	-	-	-
Subtotal	455.5	147.0	135.0	133.6	108.8	105.4	84.4	212.9	128.5	150.2	1661.3	158.6	153.6	182.6	1700.6
Ending balance	51.8	54.3	71.3	72.8	88.2	101.8	135.0	46.2	66.3	67.3	67.3	68.2	84.5	74.3	74.3

[a] YTD is year to date from beginning of fiscal year (FY). FY 1981-1982 begins July 1981 and ends June 1982.
[b] Source: PennDOT tables. Numbers refer to the line items combined for this table by FHWA.

Table 2. Evaluation of cash-receipt forecasts.

	Millions of Dollars								
	Sept. 1981			YTD (July-Sept.)			Change in Total FY 1981-1982 Estimates		
Receipt[a]	Actual	Forecast	Difference	Actual	Forecast	Difference	Aug.	Sept.	Difference
Liquid fuels tax	46.9	47.1	-0.2	143.2	141.4	+1.8	536.9	536.1	-0.8
Franchise tax (fuel)	16.6	16.3	+0.3	17.6	17.8	-0.2	162.8	161.6	-1.2
Licenses and fees	38.3	40.8	-2.5	93.9	94.4	-0.5	399.4	395.6	-3.8
Other motor receipts	4.2	4.6	-0.4	16.1	15.5	+0.6	60.2	59.8	-0.4
Federal and local aid receipts									
Construction	28.3	18.1	+10.2	73.2	60.3	+12.9	277.1	263.0	-14.0
Maintenance	24.3	13.4	+10.9	59.4	54.9	+4.5	159.6	160.4	+0.8
Other	0.7	0.6	+0.1	2.0	1.4	+0.6	5.4	5.6	+0.2
Restricted income									
Aviation	0.7	0.6	+0.1	1.0	1.5	-0.5	4.8	4.8	0
Fines, local share	0.9	0.7	+0.2	2.2	0.9	+1.3	6.5	8.5	+2.0
Federal aid, local share	7.2	2.7	-4.5	11.9	10.3	+1.6	37.2	41.0	+3.8
Refunds	0.5	0.6	-0.1	1.5	2.1	-0.6	7.2	6.9	-0.3
Total cash receipts	168.5	145.5	+23.0	422.0	401.3	+20.7	1658.8	1643.3	-15.6

[a] Source: PennDOT Table 1, as modified by FHWA; line item 1, "Beginning Balance", is not included here.

Table 3. Evaluation of expenditure forecasts.

	Millions of Dollars								
	Sept. 1981			YTD (July-Sept.)			Change in Total FY 1981-1982 Estimates		
Expenditure[a]	Actual	Forecast	Difference	Actual	Forecast	Difference	Aug.	Sept.	Difference
Debt service	11.7	11.6	+0.1	39.9	39.9	0	166.7	166.8	+0.1
State police	11.0	11.0	0	22.0	22.0	0	110.1	110.1	0
Other departments	2.8	2.4	+0.4	8.5	5.5	+3.0	33.1	35.2	+2.1
Payroll	28.1	24.9	+3.2	87.1	80.0	+7.1	332.2	330.0	-2.2
Travel and subsistence	0.6	1.0	-0.4	1.7	1.9	-0.2	7.5	6.7	-0.8
Communications, professional, and other services	1.3	1.6	-0.3	5.4	7.3	-1.9	21.3	23.3	+2.0
Utilities and rentals	1.0	1.4	-0.4	2.9	3.7	-0.8	20.5	19.0	-1.5
Contracted repairs (maintenance)	42.0	45.9	-3.9	109.5	109.2	+0.3	265.8	273.9	+8.1
Contracted maintenance services	1.0	0.6	+0.4	3.4	2.1	+1.3	13.7	14.1	+0.4
Materials, winter traffic	-	-	-	0.1	0.1	0	17.7	17.7	0
Maintenance materials	12.7	9.1	+3.6	32.9	24.6	+8.3	67.6	73.6	+6.0
Equipment fuels, supplies, and parts	2.5	2.3	+0.2	7.2	6.8	+0.4	30.1	29.8	-0.3
Miscellaneous equipment and supplies	0.6	0.4	+0.2	1.9	1.2	+0.7	5.0	6.5	+1.5
Engineering, planning, and research contracts	0.9	1.5	-0.6	3.7	7.8	-4.1	15.9	14.8	-1.1
Right-of-way claims	2.0	2.3	-0.3	5.3	2.5	+2.8	14.5	14.2	-0.3
Railroad and utility work	0.6	0.7	-0.1	2.9	2.1	+0.8	8.1	10.0	+1.9
Construction contracts	22.5	30.1	-7.6	71.1	81.3	-10.2	280.0	260.0	-20.0
Capital outlay	3.3	6.6	-3.3	14.0	13.0	+1.0	30.8	30.9	+0.1
State highway and bridge authority	29.6	29.6	0	29.6	29.6	0	29.6	29.6	0
Municipal (fuels tax)	0.2	1.2	-1.0	1.3	3.3	-2.0	149.9	149.4	-0.5
Municipal (fines and penalties)	-	-	-	-	-	-	8.3	7.8	-0.5
Federal aid, local government	5.8	3.3	+2.5	11.2	10.9	+0.3	38.0	44.0	+6.0
Total payments and expenditures	180.2	187.5	-7.3	461.6	459.9	+6.7	1666.4	1667.4	+1.0
Add vouchers payable (beginning)	15.3	-	-	21.3	-	-	-	21.3	-
Less vouchers payable (ending)	-27.4	-	-	-27.4	-	-	-	-27.4	-
Total cash payments	168.1	187.5	-19.4	455.5	454.9	+0.6	1666.3	1661.3	-5.0

[a] Source: PennDOT Table 3, as modified by FHWA.

Table 4. Pattern of contract expenditures for highway projects.

	Cumulative Percentage of Total FY Expenditure Through:											
Type of Contract	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
Maintenance												
FY 1979-1980	9	21	32	42	56	66	74	77	80	82	89	100
FY 1980-1981	11	24	40	57	68	79	83	85	88	90	94	100
Two-year avg	10	23	36	50	62	73	79	81	84	86	92	100
Construction												
FY 1979-1980	9	20	29	39	51	61	69	72	78	81	90	100
FY 1980-1981	12	18	31	39	46	58	63	68	72	80	89	100
Two-year avg	11	19	30	39	49	60	66	70	75	81	90	100

of new-car sales. Pennsylvania's inauguration of staggered vehicle registrations and four-year driver's licenses with photographs had beneficial cash-flow impacts during the implementation periods of these programs.

"Other motor receipts," which account for about $60 million annually, include fines, vehicle safety inspection sticker sales, and interest income. With high interest rates and quicker turnaround of federal funds, interest income is now approaching $15 million annually.

GENERAL OBSERVATIONS ON DISBURSEMENTS

The three largest disbursement categories--payroll, construction contracts, and maintenance contracts--account for well over half the total MLF expenditure.

The payment schedule for debt service is not subject to change. The MLF payment schedule for State Police, however, may be adjusted from month to month as long as the total amount is paid by the end of the fiscal year.

Payroll is the largest single cash-disbursement item; it accounted for $330 million in the 1981-1982 fiscal year. For the past three fiscal years, the Department has held payroll to about 4 percent average annual growth in order to provide as much money as possible for road contracts.

Comparison of actual versus forecast for other disbursement items provides an independent management check on the pace of key activities. All cases of unusually low or high payments are investigated. Claim settlements can have significant disruptive effects. The Department's Chief Counsel provides immediate input to the cash-forecasting system on major cases and negotiates payout schedules based on the Department's fiscal capabilities.

Forecasts for the construction and maintenance contract payments rely on the Department's new computerized project management system (PMS). This system is extensively described, including its cash-forecasting modules, in a paper by Kutz and Zeiss (2). The computer generates payment forecasts for each of the Department's 11 engineering districts, with past forecasts checked against actual data. Where the correlation has been poor, the technically responsible individual may override the District's forecast until the situation can be corrected.

The "vouchers payable" entry represents the Department's "float"--checks authorized for payment but not yet paid. Although there have been short periods when the MLF's cash balance has dropped below the "vouchers payable" amount, the Department has never had to delay a payment since the advent of cash forecasting in April 1979.

Table 4 shows the pattern of contract expenditures for both maintenance and construction projects through FYs 1979-1980 and 1980-1981. Pennsylvania's expenditure pattern, which may be typical for snowbelt states, shows that 66-79 percent of maintenance contract expenditures are incurred in the July-December period. Construction contract expenditures are more uniformly spread, with about 60 percent incurred in the July-December period.

CONCLUSIONS

Each state has unique financial arrangements for supporting transportation needs. Some states have earmarked transportation funds, whereas other states get appropriations from general funds. Practices to reserve state funds for projects and to account for federal aid differ considerably from state to state. There are three basic lessons of PennDOT's cash-management experience, however, that have broad applicability.

First, regardless of the financial situation, cash-flow forecasting is an excellent tool to gain greater management control. Deviations from expected cash performance are often early warning signals of problems that merit top management attention.

Second, the flow of federal reimbursements is critical to cash performance. These reimbursements are not automatic nor are they always prompt. Management should know precisely what federal reimbursements are outstanding and when they are scheduled for collection.

Third, Pennsylvania has shown over the last three years that it is possible to run a fiscally responsible highway program with minimum cash balances. Cash cushions can be converted into additional road projects but only after establishment of tight cash-management controls.

REFERENCES

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Abridgment

Subjective Perception of Car Costs

WERNER BROG

The costs involved in owning and using cars are very incompletely perceived by car owners, since they are frequently consciously or unconsciously repressed. In order to be able to empirically study this phenomenon more or less reliably, a very special methodological design is needed. In-depth interviews and interactive measurement methods, in particular, are especially promising to study the perception of car costs. By using these methods, it can be proved that there is a tendency to underestimate the out-of-pocket costs involved in using cars, a fact that has already been demonstrated in a number of studies. Simultaneously, it can be shown that the extent to which it is known what the expenditures are for other items in the car budget is even more limited. Furthermore, many car owners so thoroughly repress some of the costs involved in using their cars that they refuse to acknowledge certain items, even after they have been reminded of these categories of expenditure and admitted that they had forgotten these costs.

Since the energy crisis of 1974-1975, at the latest, when the price for gasoline was continuously rising, the question of the extent to which the costs involved in owning and running a car influenced mode choice was posed increasingly often (1). However, it quickly became clear that car owners are poorly informed about the actual costs involved in owning and using their cars. This has been demonstrated by a number of studies (2-4), which show that car owners not only frequently underestimate the amount they spend on their cars, but that they also tend to either ignore or minimize certain types of expenditures (e.g., for repairs, depreciation in car value, and parking fees). Often, only running costs were considered when calculating car budgets, i.e., the price paid for gasoline and oil, etc. But even when only these running costs were considered, they were frequently underestimated (5). Furthermore, a number of factors suggested that when operating expenses for cars increase, most car owners respond by trying to reduce their running costs (6) and that fixed expenditures for maintaining cars are less closely scrutinized.

This insight seemed to suggest that it might be advantageous to critically examine the perception of all expenditures related to ownership and use of cars. A study of this sort also seemed to be necessary because econometric-oriented planning models frequently focus mainly on out-of-pocket costs.

However, a study of the perception of the car budget is methodologically problematical (7). One of the reasons for this is the fact that actual expenditures are all too often repressed or minimized. Thus, a methodological design had to be used that could break through subjective barriers. It was also necessary to compare cost estimates with comparative data that were as objective as possible. Therefore, in the study presented here (8), special instruments were designed to examine a sample of 600 car drivers in the Federal Republic of Germany. The study was sponsored by the German Automobile Club (ADAC).

METHODOLOGICAL DESIGN

Personal in-depth interviews had to be used in order to identify perceived car costs and determine objective car costs as precisely as possible. In these interviews, different methods were used to deal with various questions.

Questions pertaining to purchase and use of cars were posed directly. Since the study for the most part dealt with behavior that had occurred within the last 12 months, it was assumed that answers to factual questions would be more or less precise since the recall period was not that long. (This naturally did not apply to questions likely to elicit emotional responses.)

However, during specific "critical" parts of the interview, it was necessary to ensure that the presence of the interviewer did not result in biased responses that could not be corrected later. This was done either by using scales or lists of various sorts so that the memories of the respondents would not be overly taxed when several responses were called for or by using questionnaires in which the respondents would note their answers in their own words, i.e., without the intervention of the interviewer. These instruments were used when individuals were asked to list the types of expenditures involved in the upkeep and use of their cars, responses that could easily be influenced by interaction with the interviewer.

Different categories of expenditure had to be standardized because so many different types of costs are involved in estimating the car budget. This was done by using sets of cards on which different items of expenditure were precisely defined and differentiated from other types of expenses. Since the order of the cards could be changed at will, it was possible either to arrange expenditures in the chronological order in which they had arisen or to list items in order of importance.

Projections, for alternative behavior, for instance, are always methodologically difficult to study. In other surveys, the Institute for Empirical Social Research had already developed instruments (interactive measurement methods) (9) in which individuals not only answered prepared questions but also participated in creating situations that were as realistic as possible.

In this study, these interactive measurement methods were applied by having the households play a car budget game. The respondents used chips to depict their monthly net incomes and to represent the amounts spent on precisely defined categories of expenditure. Four types of car expenditures were differentiated (developed and used by the ADAC):

1. Fixed costs (car taxes, insurance payments, inspection fees);
2. Costs for running the car (gasoline, oil, washing and polishing costs, etc.);
3. Repair costs and maintenance costs (oil change, repairs, etc.); and
4. Loss in value of car (car depreciation).

In its final form, the interview consisted of nine different parts:

1. Number of cars in household;
2. Number of kilometers driven per year;
3. Perception of car costs;
4. Controlled analysis of different items of expenditure;
5. Car purchase: (a) purchase of extras for car, (b) degree to which informed about insurance and manner in which decision made which car insurance to buy, (c) reasons for buying gasoline at particular station, (d) manner of dealing with repairs of different sorts, (e) degree to which informed about

the car market and manner in which decision made which car to buy, (f) degree to which one is informed about the depreciation of cars, and (g) car maintenance;

6. General attitudes toward informing oneself of different car-related expenditures;
7. Household game to measure sensitivity to increased car-related costs;
8. Sociodemography; and
9. Interviewer and interview.

The respondents estimated their car budgets in four different stages; in each successive stage, they had more information than in the preceding stage:

1. The respondents were asked to "spontaneously" estimate their car-related expenditures,
2. The respondents carefully considered whether their spontaneous estimate had really taken all different kinds of costs into account,
3. The interviewer used the card sets to remind the respondents of the various categories of expenditure, and
4. The household made its estimate by using any bills and receipts that might have been kept (it was forbidden to use such bills and receipts in the previous three stages).

The most important section of the final part of the interview was the use of the household game. This game was needed since it would not otherwise be possible for the interviewer to check and evaluate the accuracy of the responses. However, by using the game, the interviewer became familiar with the circumstances of the households and the attitudes of the respondents toward different questions pertaining to cost. Since it could be assumed that the respondents had gone through an intensive learning process in the different stages of the study, it was assumed that the final budget estimates would include all the different types of car expenses that were not being repressed, ignored, or rationalized. To a large extent, the interview situation used ensured that the results of measurement would be accurate. This would not have been so had conventional survey instruments been used.

ESTIMATING TOTAL CAR BUDGET

The monthly car expenditures for owning and using cars were grossly underestimated by the car drivers who were interviewed. Although two out of every three respondents claimed to have a good or very good knowledge of their car expenditures (Table 1) when estimating their car budgets, 56 percent of the respondents were forced to increase their total car budgets between the first and the last estimates. The final car budget estimate for every third respondent was more than 20 percent higher than the first, spontaneous estimate. Every fifth person was forced to increase the final estimate by 40 percent or more (Table 2). But a certain relationship between the degree to which a person is informed and his or her self-evaluation could be identified.

Although the value of almost all cars depreciates (with the exception of certain classics), only one-third of all the respondents spontaneously quoted this item as a part of the car budget. Since a person has to be somewhat familiar with economic thinking in order to realize that the value of a car depreciates each year, many car drivers forget this item. However, even after the respondents were reminded that their cars were worth less each year, 13 percent of the respondents had no idea whatever how much the value of their cars depreciated each year. The average car budget is underestimated by about 30 percent per year due to the fact that car depreciation is often ignored.

The car budget as estimated by the respondents accounts for an average of 17 percent of the net income of the households interviewed. This is only slightly less than the households paid for rent (including heat, gas, electricity, telephone, and television fees) or groceries (excluding alcohol, cigarettes, etc.), for which the average household spent 21 percent of its monthly net income. A comparison of these figures with the figures quoted in government statistics (10) shows (with the exception of the car budget) that these figures are similar to the national statistics for Household Type 2 (four-person household with average income), which is most similar to the type of households included in the sample.

The car-related expenses, which were higher than those quoted in the government statistics, were a result of the methodological contents of the survey; in the government statistics, the proportion of the monthly net income spent on cars (about 14 percent) does not include depreciation of the cars but does include the purchase price.

On the other hand, the instruments used in this survey not only included the depreciation value of the cars (as far as possible) but also reminded the respondents of the different types of expenditures related to car use. As a result of these survey techniques, the respondents increased their estimates from an average of 300 German marks per month in their first estimates (14 percent of their monthly net income) to an average of 365 German marks per month (17 percent of their monthly net income); this latter figure is much more realistic than the first one. However, in fact, the average household included in the survey spent an average of 20 percent of its net monthly income on its car budget. This was caused not only by the fact that the depreciation value of the car was so frequently

Table 1. Precision of car budget estimate.

Precision of Estimate	Cost[a] (%)				
	Total	Fixed	Repair	Operating	Depreciation
Very precise	18	18	9	13	10
Rather precise	50	59	49	62	25
Less precise	27	17	28	18	13
Not precise	5	3	6	3	4
No response	-	3	8	4	13
Not exposed to this cost	-	-	-	-	34

[a]Base (B) = 600.

Table 2. Self-evaluation of precision of estimate.

Increase in Estimate (%)	Respondents by Type of Estimate (%)				
	All (B = 585)	Very Precise (B = 104)	Rather Precise (B = 299)	Less Precise (B = 157)	Not Precise (B = 25)
None	44	58	41	39	44
<20	21	18	21	23	16
20-40	14	9	15	18	8
40-60	8	5	8	10	8
60-100	9	7	9	7	13
>100	4	2	6	3	11
Avg	22	15	24	22	29

ignored but also by the fact that many were unwilling to acknowledge certain categories of expenditure. (The latter categories are dealt with later in this paper.)

ACCURACY OF ESTIMATES

The extent to which estimates for the total car budget and for different categories of expenses are considered to be accurate is an important factor in determining the subjective perception of car costs. As Table 1 shows, individuals are surer of what they spend on some items than on other items. Thus, although two out of every three car drivers believe that they can estimate what they spend on their entire car budgets accurately or very accurately, three out of every four car drivers believe that they can estimate their fixed costs and running costs accurately or very accurately. In regard to the rarer repair costs, there was much less confidence in the estimations, although even here, three out of five car drivers thought that their estimates were either accurate or very accurate. However, whenever possible, these subjective evaluations had to be compared with actual facts. One indication of whether these subjective evaluations were likely to be more or less objectively valid was whether or not the respondents kept a record of their expenses, i.e., an account of running costs and whether this was examined from time to time.

However, it is important to identify the reasons why a record of car expenditures is maintained if the control function of this record is to be evaluated. Thus, the fact that four out of every five keep their bills and receipts tells one nothing about the actual reasons why these documents are kept. When asked whether they saved their bills and receipts, 126 out of a sample base of 600 (21 percent) said that they did not. Out of the base of 600, 474 (79 percent) said that they did keep bills and receipts, as follows:

Type	Percent
All car expenditures	28
Specific expenditures	72
Fixed costs	88
Running costs	33
Other costs	88

Of the same size base, the following reasons for keeping bills and receipts were given:

Reason	No. Responding	Percent
Own records	241	40
Internal Revenue Service	238	40
Reclamation	187	31
Insurance	152	25
Business	28	5
Other	49	8

When asked whether they kept an account of their car costs, 478 out of the base of 600 (80 percent) said that they did not. Out of the base of 600, 122 (20 percent) said that they did keep an account of their car costs for the following reasons:

Reason	Percent
All car expenditures	50
Specific expenditures	50
Fixed costs	70
Running costs	78
Other costs	77

Reasons given for keeping an account of car costs were as follows:

Reason	No. Responding	Percent
Record of gasoline consumption	49	8
As personal record	46	8
Business	24	4
Other	20	3

Among those who kept their bills and receipts, a larger-than-average number either drove a great deal, owned a new car, used their cars predominantly for business purposes, or were self-employed; i.e., they were precisely those for whom car costs do not play a particularly large role and for whom saving bills and receipts is less for control purposes than for tax purposes.

The same applies to those who keep an account of their car expenditures. A relatively large number of those referred to above also keep a record of their car expenses. (Among those who use their cars primarily for business purposes, every third person keeps an account of his or her expenses.) However, an account of gasoline and oil expenses is usually kept for business purposes rather than for personal reasons. Only 8 percent of all car drivers (14 percent of the unemployed) keep a record of their car-related expenditures for personal reasons.

The car budget estimates used in the survey made it seem sensible to use only the first, spontaneous estimate and the final estimate. The in-between stages were primarily of methodological value; i.e., they were to help the respondent to calculate his or her actual car-related expenses. Estimation errors thus refer to the difference between the initial and the final estimate. Since it did not seem to make much sense to categorize errors in estimation in all too precisely differentiated subgroups, increases in expenditures were depicted only in intervals of 20 percent.

In the final estimate, the total car budget was an average of 22 percent higher than in the first, spontaneous estimate. However, for different groups, there are considerable differences between the first and the final estimate. This is especially apparent if one classifies people according to whether or not they are employed and what their occupations are. While those who are self-employed underestimate their expenditures by an average of only 16 percent and blue-collar workers underestimate their expenditures by only 13 percent, those who are unemployed underestimate their expenditures by an average of 29 percent (Table 3).

Since the first and final estimates differ so radically for different groups, it makes sense to use averages for purposes of comparison. While the first and the final estimates were the same for 44 percent of the respondents, every fifth car driver increased his or her first estimate by 40 percent or more. The difference between the first and final estimates was least pronounced for those who used their car predominantly for business purposes, those who drove new cars, and those who were self-employed (Table 3). These are precisely those who keep an account of their car expenses relatively frequently.

Although these accounts are rarely kept for personal reasons, keeping track of expenses causes one to have a (subjectively) more accurate record of expenditures. This is shown in Table 4. Only every second person who keeps an account of his or her expenses increases the estimate, and by an average of only 15 percent. Those who do not keep records of their expenditures increase their initial estimates by an average of 25 percent. The relationship between number of kilometers driven per year and the precision of the budget estimates is equally understandable (Table 4).

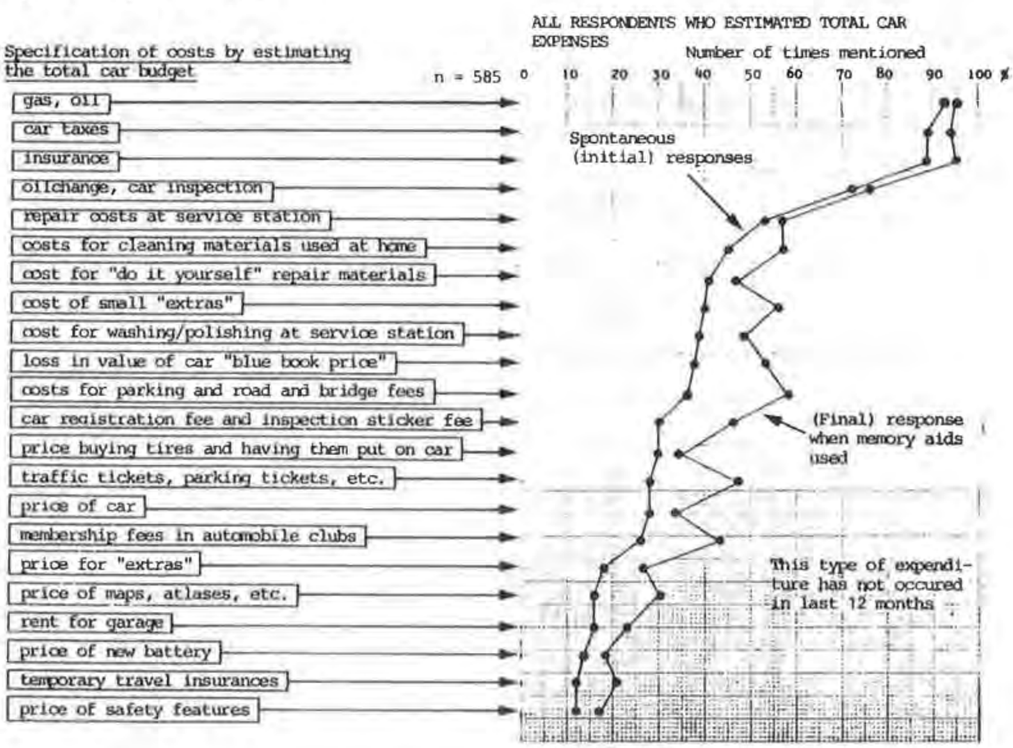
Table 3. Effect of employment status and type and use of car on estimate of total car costs.

Increase in Estimate (%)	Percent of Total Respondents (B = 585)	Employment Status (%)					Primary Use of Car (%)		Type of Car (%)	
		Unemployed (B = 63)	Blue-Collar Worker (B = 42)	White-Collar Worker (B = 287)	Civil Servant (B = 52)	Self-Employed (B = 111)	Business (B = 98)	Private (B = 487)	New (B = 246)	Used (B = 339)
None	44	28	45	45	41	52	53	42	50	40
<20	21	23	32	19	18	24	21	21	15	24
20-40	14	22	16	14	11	9	10	16	13	16
40-60	8	13	2	8	8	7	6	8	8	8
60-100	9	5	5	9	18	6	7	9	10	8
>100	4	9	-	5	4	2	3	4	4	4
Avg	22	29	13	22	28	16	17	23	20	22

Table 4. Effect of keeping account of car costs and yearly mileage on estimated total car costs.

Increase in Estimate (%)	Percent of Total Respondents (B = 585)	Account of Car Costs Kept (%) (B = 118)	Account of Car Costs Not Kept (%) (B = 467)	Mileage Driven per Year (%)		
				>20 000 km (B = 150)	10 000 to 20 000 km (B = 295)	<10 000 km (B = 140)
None	44	52	42	46	43	44
<20	21	21	21	26	21	16
20-40	14	12	14	12	14	16
40-60	8	10	8	4	8	12
60-100	9	4	10	10	7	8
>100	4	1	6	2	6	4
Avg	22	15	25	18	22	25

Figure 1. Perception of car costs.



DIFFERENT PERCEPTIONS OF DIFFERENT TYPES OF EXPENSES

Even more interesting than those categories of expenditure that were simply underestimated were those types of costs that were totally forgotten, repressed, or rationalized and the changes that resulted in the first and in the final estimates when people were reminded of these expenses. It becomes clear how car costs are perceived when one notes the difference between those costs that occur spontaneously to respondents and those costs that the respondents totally ignored until they were reminded of them by the interviewer. Figure 1 shows the differences in the perception of various types of costs. Respondents have a fairly good idea of their out-of-pocket costs, of major expenses, and of running costs. Gasoline, tax, and insurance costs are fairly well perceived, as are repair and maintenance costs. Ninety percent of the respondents who had had such expenses recalled them.

Larger purchases, such as tires, batteries, or the car itself, as well as minor expenses such as car washing and waxing costs, were somewhat more poorly perceived. Each fifth respondent had to be reminded of these expenses by the interviewer.

Expenditures for fees of various sorts were frequently repressed or forgotten. Each third respondent who had had to pay parking fees, parking tickets, speeding tickets, membership fees in automobile clubs, registration fees, or inspection fees had to be reminded of these items. These expenses were forgotten more quickly than expenditures that pertained directly to car use. This also applied to the purchase of such "extras" as slipcovers.

However, although it is perhaps understandable that the respondent could forget minor expenses, it is somewhat odd that every twentieth car owner had to be reminded of the cost of taxes and insurance for the car. (The remainder of this group had had these costs paid for by a third party.)

The proportion of these car owners can also be found in that group for whom there was no difference between the first and final estimates of the total car budget. This means that here too almost every twentieth respondent had to admit that a category of expenditure had been forgotten and yet refused to increase the estimate for the total car budget. In this group as a whole, the cost for specific items resulted in a 15 percent increase in costs, but this was not reflected in an increase in the total car budget, a particularly clear example of the subjective process of repressing certain types of car expenses.

To summarize, one can say that for the majority of car drivers, (a) specific types of car expenses are partly repressed, especially fees, extras, car depreciation, etc.; (b) even when respondents acknowledged that they had forgotten certain categories of expenditure, this did not necessarily induce them to increase the total car budget; and (c) even when the car budget was radically increased, not all categories of expenditure were taken into consideration.

Thus, almost all those who used cars showed that they were extremely poorly informed of the costs involved in using their cars. The problem is even greater than the above discussion would suggest.

INFORMATION ON PRICES AND COST CONTROLS

In the broadest sense of the term, only approximately every second car driver is price conscious, i.e., selects that product deemed to be less expensive. When the value of the product increases, the respondents do show a stronger tendency to do comparative shopping. When making minor purchases, only 14 percent of the respondents did comparative shopping and 11 percent were influenced by "tips," test results, or suggestions made by friends or acquaintances. However, when the purchase price of the product to be bought increased, 47 percent of the respondents did comparative shopping and 29 percent of the respondents were influenced by brand names. When buying tires or batteries, for instance, two out of every five respondents were influenced by tips or by test results (Table 5). However, when the respondents selected their insurance policies, price was not the most important factor considered. Every fifth respondent did not know how high insurance payments were and only approximately every third person kept track of price developments for the different insurance companies. Out of a base of 600, 80 percent knew what their insurance payments were. The degree to which people keep informed about reports on insurance companies is as follows:

Degree	Percent
Not at all	63
Only for own company	8
For other companies also	28
No response	1

The insurance company was chosen because of the following reasons:

Reason	Percent
Accidental	29
Low costs	31
Large returns	7
Good benefits	14
Serious company	11
Suggestion	7
Acquaintances/friends work there	6
Other	6

As might be expected, the most comparative shopping was done and the most detailed scrutiny of information sources took place when it was decided to purchase a new car. Of the respondents, 44 percent decided where to buy their cars only after they had compared various offers. The other respondents either knew in advance where they would purchase their car or else selected their car more or less accidentally. This is obviously caused by the fact that most of those who wish to buy a car have some idea of what they are looking for--type of car, manufacturer, size, etc. Other respondents bought their cars where they did because they were regular customers at that dealer.

Although cost is relatively important when it is decided where to buy gasoline, it is not the only factor taken into consideration. However, one can assume that price has become more important in recent years as the price of gasoline has soared. Of a base of 600, 57 percent of the respondents regularly patronize the same gasoline station and 43

Table 5. Purchase of equipment.

	Type of Equipment		
Response	Tires, Batteries, Headlights, Headrests (%) (B = 261)[a]	Radio, Slipcovers, Fire Extinguisher, First Aid Kit (%) (B = 175)	Soap, Wax, Spark Plugs, Defrost Spray, Windshield Wiper Blades (%) (B = 443)
Shopped at given store, service station because			
Always go there	21	14	29
Close to home/work	8	5	16
Cheap	54	67	39
Other	15	11	12
No response	2	3	4
Comparative shopping			
Took place	46	47	14
Did not take place	53	51	86
No response	1	2	-
Influenced by brand			
No	59	65	82
Yes[b]	39	29	11
No response	2	6	7

[a] Respondents who had bought at least one article in this category themselves within the last 12 months.
[b] Influenced by specials, test results, suggestions, etc.

percent do not. Reasons for selecting a gasoline station are as follows:

Reason	Percent
Price	41
Near home	26
Good service	15
On way to shopping	3
Other	6
No response	21

Of 600 respondents, 80 percent knew gasoline prices exactly and 20 percent could not remember them. Respondents who inform themselves about gasoline prices in their communities do so with the following frequency:

Frequency	Percent
Regularly	13
Occasionally	18
Only in passing	36
Hardly ever	32

Nevertheless, the expenditures for operating the car account for only 40 percent of the costs involved in using cars. And the perception of other expenditures is even worse than that for operating costs, for instance, the perception of repair costs, which account for 19 percent of the car budget, and the perception of fixed costs, which account for 27 percent of the car budget. The depreciation in the value of the car, which accounts for an average of 14 percent of the yearly car budget, is usually either partly or totally repressed.

The assumption that radical increases in operating costs for cars would lead people to be more aware of car-related costs could not be justified in this study, with the exception of the purchase price of the cars.

Nevertheless, as inaccurate as the perception of the car budget might be, car-related costs are still comparatively well accounted for in the household budget in contrast to other categories of expenditure.

A detailed study (11) of total household budgets showed that there were even worse errors in the perception of the total expenditures for the household. In Munich, for instance, only 2 percent of all households kept a regular account of their expenditures and only every sixth household (18 percent) could precisely account for income and expenditures. Approximately every fourth household (23 percent) knew precisely what they spent for at least some categories of items, whereas 38 percent of the households could more or less correctly reconstruct their household budgets--with some effort. Every fifth household (21 percent) could do no more than roughly estimate its expenditures, even with great effort.

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A Decade of Change for Mass Transit

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The transit industry in the United States was transformed during the decade of the 1970s. This transformation consisted of changes in institutional structure; changes in the amount, type, and location of transit service; and changes in cost levels and in the means by which costs were financed. The purpose of this paper is to examine the nature and extent of these changes, with particular emphasis on changes in levels of service, costs, and financing. Variations in these trends among different transit systems are highlighted, and causes of the variations are analyzed by a range of statistical methods. Although the econometric results are not entirely conclusive, they suggest that various aspects of the current transit program may encourage cost escalation and thus hamper the effectiveness of government subsidies to transit.

The transit industry in the United States underwent a revolution during the decade of the 1970s. Unlike most other industries, however, the transit revolution resulted not from technological change but rather from shifts in public policy. The most important aspects of transit's transformation were changes in the institutional framework of the industry, accompanied by a broadening of the perceived objectives of transit; changes in the amount, type, and location of transit service; and changes in the costs of transit and in the means by which these costs were financed. The purpose of this paper is to examine the nature and extent of these changes with particular emphasis on changes in levels of service, costs, and financing. Variations in these trends among different transit systems are highlighted, and causes of the variations are analyzed by a range of statistical methods.

NATIONWIDE TRENDS

There were significant differences among cities along virtually every dimension of change in mass transit during the 1970s. Nevertheless, an examination of nationwide aggregate trends is useful for identifying the most important, overall shifts in the industry. The changes focused on here are institutional changes, service-level changes, and changes in costs and financing.

Changes in Institutional Framework

Changes in the institutional structure of the transit industry during the 1970s represented the culmination of trends that had been initiated in the 1960s. In both decades, the proportion of the industry that was publicly owned increased substantially. The percentage of public systems increased from 5 to 15 percent between 1960 and 1970 and from 15 to 55 percent between 1970 and 1980. Moreover, this increasing number of public systems provided a larger and larger proportion of the nation's transit service: from 36 percent of total vehicle miles in 1960 to 68 percent in 1970 and 93 percent in 1980 (1, p. 43). Thus, transit in the United States has been transformed from a primarily privately owned industry to one that is now overwhelmingly public. Related to this development, consolidated metropolitanwide transit agencies have become increasingly common. Although such regional authorities have enhanced the possibilities for comprehensive planning, service coordination, pooling of overhead costs, and regionwide financing, they have eliminated most competition within the industry. Some observers blame public ownership and lack of competition for the rapidly rising costs and subsidy requirements of transit during the 1970s, which are documented in subsequent sections of this paper (2, pp. 42-49; 3, pp. 109-113).

Increasingly viewed as a public service to be provided by local government agencies, transit has been run less and less to maximize profits or even to minimize losses. Rather, transit operators have been charged with the responsibility for achieving a wide range of social, economic, and environmental goals such as pollution abatement, congestion reduction, energy conservation, central-city revitalization, traffic safety, and improved mobility for the poor, the elderly, and the handicapped (4, pp. 171-203; 5, pp. 1-12, 32-36). Political considerations have supplanted market competition as the guiding force for determining service policies, fare structures, and operating procedures. In some instances, the resulting political bargains may have led to inefficiency. For example, suburban portions of regional transit districts have received additional service in return for their political support and financial contributions to regional systems (6). Unfortunately, these suburban services have usually been either lightly patronized (as with bus routes) or extremely expensive to run (as with commuter rail) and in both cases have entailed large operating subsidies per passenger (7).

Finally, public ownership and government subsidization have been accompanied by numerous regulations, many of which have accelerated cost increases. These include the Section 504 regulations of the Rehabilitation Act of 1973, which mandate full accessibility of transit vehicles and stations for elderly and handicapped users; Section 13(c) of the Urban Mass Transportation Act of 1964 and the Davis-Bacon Act, which have increased the power of transit labor unions; Section 401 of the Surface Transportation Assistance Act of 1978, which requires that transit vehicles and other capital equipment be manufactured in the United States; and a host of environmental regulations (5, pp. 31-46, 80-134).

Changes in Service Level

In light of the dramatic changes in the institutional structure of the U.S. transit industry, it is somewhat surprising to see how little the overall level of transit service changed from 1970 to 1980. According to the American Public Transit Association (APTA) (1, p. 58), total vehicle miles of operation (excluding commuter rail) grew from 1.9 billion to 2.1 billion, an increase of only 11 percent. There was much variation among transit modes, however. For example, vehicle miles of trolley coach service decreased 61 percent, vehicle miles of streetcar service decreased 42 percent, and vehicle miles of rail rapid transit service decreased 6 percent (in spite of new systems in San Francisco and Oakland, Washington, and Atlanta). The overall increase in service was due solely to the 19 percent expansion of bus operations. Changes in ridership roughly paralleled these changes in service levels. Trolley coach passengers declined 45 percent, streetcar passengers declined 53 percent, and rail rapid transit passengers declined 10 percent. In contrast, bus ridership increased 18 percent (1, p. 55).

The allocation of transit service within metropolitan areas also changed. Although statistics on this shift are not shown here, various studies indicate that an increasing proportion of transit service is being provided in relatively low density, suburban portions of urban areas (2, pp. 279-284; 6, pp. 548-549; 8, p. 23). As transit routes have been extended in an attempt to capture the patronage of an ever more suburbanized population, service frequencies have been reduced in central-city areas. This shift in service policy has been partly responsible for the decreasing load factors and increasing trip lengths on transit over the decade of the 1970s.

Although transit service has been decentralized within urban areas, it has become ever more concentrated during peak commutation hours. In 50 large U.S. cities, for example, the average ratio of peak-hour to midday buses in service increased from 1.80 in 1960 to 2.07 in 1980 (9, p. 49; 10, pp. C2-C27). Peaking has been even greater for rail rapid transit. For the seven U.S. systems that reported these data, the ratio of peak to midday cars in service averaged 2.98 in 1980 (10, pp. D2-D5). As the degree of peaking has increased, so has the extent to which transit vehicles, capital infrastructure, and transit workers are underutilized during off-peak hours. This has exacerbated the decline in the industry's productivity and has contributed to the escalation of transit costs.

Changes in Costs and Subsidies

Of all the changes in U.S. transit, the burgeoning of transit costs and subsidies has surely been the most dramatic trend. As shown in Table 1 (1, 11), total operating expenses have skyrocketed for all modes of transit. Between 1970 and 1980, total costs increased 387 percent for bus and streetcar service, 138 percent for rail rapid transit, and 228 percent for commuter rail service. Of course, these

Table 1. Trends in U.S. transit operations and finances, 1970-1980.

Statistic	Bus and Streetcar 1970	Bus and Streetcar 1975	Bus and Streetcar 1980	Rail Rapid Transit 1970	Rail Rapid Transit 1975	Rail Rapid Transit 1980	Commuter Rail 1970	Commuter Rail 1975	Commuter Rail 1980
Operating expense[a] ($ millions)	1,303	2,500	5,049	613	1,085	1,458	297	571	973
Operating revenue ($ millions)	1,323	1,483	1,957	384	491	717	188	283	436
Operating deficit ($ millions)	-20	1.017	3.092	229	593	741	109	288	537
Operating revenue/operating expense	1.02	0.59	0.39	0.63	0.45	0.49	0.63	0.50	0.45
Vehicle miles (millions)	1,476	1,567	1,710	407	423	385	N.A.	N.A.	164
Cost per vehicle mile ($)	0.88	1.60	2.95	1.51	2.57	3.79	N.A.	N.A.	5.83
Revenue passengers[b] (millions)	4,358	4,245	4,926	1,574	1,388	1,420	295	260	285
Cost per passenger ($)	0.30	0.59	1.02	0.39	0.78	1.03	1.01	2.20	3.41
Average fare[c] ($)	0.30	0.35	0.40	0.24	0.35	0.50	0.64	1.09	1.53
Operating subsidy per passenger ($)	0.00	0.24	0.62	0.15	0.43	0.52	0.37	1.11	1.88

Note: N.A. = not available.
[a]Excluding depreciation.
[b]Also defined as linked passenger trips.
[c]Average fare was calculated as the ratio of passenger revenue divided by revenue passengers, excluding transfer passengers.

Table 2. Trends in transit subsidies by level of government, 1970-1980.

Type of Subsidy	1970 Amount ($ millions)	1970 Percent of Total	1975 Amount ($ millions)	1975 Percent of Total	1980 Amount ($ millions)	1980 Percent of Total
Operating						
Federal	0	0	408	21	1324	30
State	30	9	549	29	992	23
Local	288	91	944	50	2062	47
Total	318		1901		4378	
Capital						
Federal	133	67	1287	80	2787	81[b]
State and local[a]	67	33	322	20	647	19
Total	200		1609		3434	
Operating and capital						
Federal	133	26	1695	48	4111	53
State and local	385	74	1815	52	3701	47
Total	518		3510		7812	

Note: Commuter rail as well as rapid transit, streetcars, trolley buses, and motor buses are included in these statistics. The capital subsidy amounts do not include the special Congressional appropriations for the Washington subway system.
[a]The state and local portion of capital subsidy financing was estimated on the basis of statutory matching rates for different segments of the transit capital program.
[b]The overall federal matching rate for capital subsidies in 1980 exceeded 80 percent due to the 85 percent matching rate on Interstate transfer funds.

figures do not control for changes in the amount of service provided, so they could be misleading. Operating costs per vehicle mile also increased rapidly, however: 235 percent for bus and streetcar and 151 percent for rail rapid transit. Due to declining load factors on all modes, cost escalation is calculated to be slightly greater on a per-passenger basis: a 240 percent increase in operating cost per bus and streetcar passenger, a 164 percent increase in cost per rail rapid transit passenger, and a 235 percent increase in cost per commuter rail passenger.

Growth in Operating Deficits

Perhaps the most striking trend in these operating and financial statistics is the sharply increased unprofitability of bus and streetcar services relative to rail rapid transit and commuter rail. In 1970, bus services in the United States were actually profitable in aggregate, whereas rapid transit and commuter rail covered less than two-thirds of their operating costs from passenger fares. By 1980, bus services covered only 39 percent of their operating costs from the farebox, a lower percentage than either of the other modes. This reversal stems both from the rapid increase in bus costs--as noted above--and the much slower increase in bus fares relative to fares on other transit modes. Between 1970 and 1980, average bus fares rose only 33 percent, whereas rapid transit fares rose 108 percent and commuter rail fares 139 percent. The resulting increase in operating subsidy per bus rider was $0.62 compared with a $0.37 increase in subsidy per rapid transit passenger. The increase in subsidy per commuter rail passenger was even larger ($1.24), which arises from the greater average length of commuter rail trips.

The sudden escalation of operating deficits from bus service has been attributed to two factors (2, pp. xxxiii-xxxiv). First, federal operating subsidies per rider have been larger for all-bus systems in low-density urban areas than for multimodal systems in dense urban areas. Because the Section 5 subsidy allocation formula is based primarily on population and population density instead of ridership, transit-oriented cities with rail systems received substantially less subsidy than they would have if the formula had distributed funds strictly in proportion to ridership. Second, most rail rapid transit service is located in urban areas whose state and local governments have experienced the most severe budget crises. The greater scarcity of federal as well as state and local government operating subsidy funds in cities with rail transit has led to larger fare increases and service cutbacks.

Growth of Government Subsidies

The overall increase in government subsidies to mass transit from 1970 to 1980 is depicted in Table 2 (1,11,12), which also disaggregates subsidies by level of government and by operating versus capital purposes. The total operating and capital subsidy to transit in the United States multiplied by more than 15-fold over the decade, from $0.5 billion to $7.8 billion. The rate of increase was greater for capital subsidies than for operating subsidies

(17-fold versus 14-fold), but operating subsidies nevertheless exceeded capital subsidies in 1980, accounting for 56 percent of the total subsidy.

Another notable trend in Table 2 is the increased federal role in transit finance. Growing from $0.1 billion in 1970 to $4.1 billion in 1980, federal assistance rose from 26 to 53 percent of the total subsidy. Finally, one important trend not shown in the table is the increasingly widespread use of regionwide taxes earmarked for transit. Virtually no major city had adopted this financing mechanism by 1970--primarily due to the much smaller need then for transit subsidies. By 1980, however, 15 of the 26 largest U.S. metropolitan areas relied primarily on earmarked transit taxes for the local share of subsidy financing (11). Gortmaker, in a paper in this Record, states that of 101 cities surveyed by the U.S. Conference of Mayors in 1980, 46 percent had either state or local taxes dedicated for transit, and 21 percent had plans for implementing such taxes by 1982.

Impacts of Subsidies

In many ways, these nationwide trends in the transit industry have been disappointing. Some might argue that the 11-fold increase in transit subsidies from 1970 to 1980 has simply inflated costs instead of providing more, better, or cheaper service for transit users. There may be some validity to this viewpoint in light of the mere 11 percent increase in vehicle miles of service provided and the even smaller, 6 percent increase in ridership. Declining productivity and increased unit costs may have been partly responsible for the suprisingly small impacts of subsidies on output and use levels. Operating costs per vehicle mile increased 205 percent for the industry as a whole over the decade, and operating costs per passenger increased 222 percent (1, pp. 47, 58). Even controlling for the 112 percent general rate of inflation in the economy, these increases were substantial; in constant, inflation-adjusted dollars, costs per vehicle mile and per passenger increased 44 percent and 52 percent, respectively. At the same time, output per transit worker declined 18.4 percent, from 13 600 miles per employee in 1970 to only 11 067 miles per employee in 1980 (1, pp. 58, 66). This decrease in labor productivity was detrimental to transit budgets--especially in conjunction with rapid increases in salaries and fringe benefits--because labor costs typically account for 70-80 percent of total operating costs (6, p. 544).

Capital costs in the transit industry have also increased rapidly. For example, construction costs for the new Washington, D.C., subway system have averaged about $90 million/mile, almost the same as the $89 million/mile cost of the new Atlanta subway (13,14). In contrast, San Francisco's Bay Area Rapid Transit (BART) system, which was built in the late 1960s, cost $23 million/mile, roughly a fourth as much (15). Similarly, the capital cost of purchasing a new bus increased more than fivefold between 1970 and 1981--from less than $30 000 per bus to more than $150 000 per bus (16).

Because costs have increased so much, transit subsidies have not produced substantially more transit service to the nation. Until recently, however, they have been successful in keeping down fares. From 1970 to 1980, the average fare for the transit industry as a whole rose only 36 percent, from $0.28 per linked trip (including transfer charges) to $0.38 per linked trip (1, p. 60). Given the 112 percent general rate of inflation in the United States over this period, the real transit fare (in inflation-adjusted, constant dollars) actually fell by 34 percent. This decline in real transit fares--in conjunction with an increase in automobile user costs over the same decade--makes the small increase in transit ridership all the more puzzling.

Incentives for Cost Escalation

There is good reason to question whether the very design of the transit subsidy program is responsible for small ridership gains and rapidly increasing costs. Shifting the transit tax burden to the federal level of government has sharply reduced the proportion of transit costs directly relevant to local transit decisionmakers. As a result, when weighing the costs and benefits of proposed capital projects, for example, local officials have an incentive to consider only the small, local share of costs and thus may decide to undertake projects whose benefits fall far short of total costs yet exceed local costs. Similarly, urban areas receiving relatively generous federal operating assistance (50 percent in many cases) have initiated or maintained highly unprofitable routes and types of services that local officials probably would not have been willing to support on their own.

This impact of federal involvement has been compounded by the adoption in numerous areas of state and local taxes earmarked for transit. Most such taxing arrangements automatically yield a growing tax revenue stream over time even if statutory rates remain constant. This also has reduced the need for local transit authorities to eliminate highly unprofitable services, to bargain for moderate labor wage settlements, and to increase the productivity of their operations. Finally, none of the federal or local subsidy programs have made funding levels contingent on performance standards, cost control, ridership gains, or the achievement of social, environmental, or economic goals. Only a few states have begun to tie subsidy payments to performance indicators, but even these have set aside only a small fraction of the total state subsidy to reward efficient systems.

Determining the nature and extent of the subsidy program's impact on transit costs and performance during the 1970s is essential to improving the program. Subsequent sections of this paper examine the variation among cities in the changes in costs, service levels, and ridership from 1970 to 1979 and seek to identify the cause of the variations and, in particular, the degree to which differences in institutional and financial arrangements can explain the variation.

VARIATIONS AMONG CITIES IN TRANSIT TRENDS

Although most transit systems have conformed to the general directions of the nationwide aggregate trends documented above, there have been significant differences among cities in the magnitude of financial and operating changes over the decade. To examine variations among cities, this section reports changes in key variables for each of 34 individual bus systems. The difficulty of obtaining consistent data for the entire decade accounts for the small size of the sample. As a whole, however, the group represents a cross section of the industry. The sample systems cover virtually the entire spectrum of size and type of system, type of urban area, geographic location, cost and service level, fare policy, and perhaps most importantly, institutional structure and subsidy financing arrangement.

The data used for the analysis were derived from four sources: Transit Operating Reports for 1970, 1975, and 1979 compiled for each system by APTA,

Table 3. Trends in operations and finances of 34 bus systems, 1970-1979.

Bus System	Fleet Size (1979)	Change in Operating Cost ($/bus hour)	Ratio of Operating Subsidy to Operating Cost		Change in Subsidy per Passenger[a] (cents)	Change in Average Fare[a,b] (cents)	Change in Vehicle Hours (%)	Change in Total Riders[a] (%)	Change in Riders per Bus Hour[a]
			1970	1979					
Los Angeles	2604	+21	0.04	0.57	+35	+2	+61	+84	+6
New York	2500	+19	0.00	0.37	+28	+17	-11	-16	-3
Chicago	2420	+31	0.00	0.48	+24	-4	-34	+32	+43
Philadelphia	1552	+15	0.02	0.39	+17	+7	-10	+2	+6
Minneapolis[c]	1069	+15	0.00	0.67	+36	-6	+49	+62	+4
St. Louis	1058	+20	0.00	0.77	+64	-23	+12	+47	+8
Cleveland	1011	+21	0.00	0.74	+46	-12	-13	+13	+11
Baltimore[c]	969	+14	0.00	0.46	+26	+7	+22	+3	-8
Atlanta	921	+16	0.00	0.76	+51	-9	+44	+33	-3
Miami	654	+15	0.00	0.53	+35	+9	+36	+21	-4
Denver	631	+21	0.00	0.80	+95	-10	+215	+185	-3
Portland (OR)	540	+19	0.18	0.70	+67	+2	+124	+123	0
Buffalo	538	+14	0.00	0.43	+26	+13	-23	-43	-14
New Orleans[c,d]	493	+15	0.22	0.51	+14	+7	-7	-15	-7
Dallas	456	+13	0.00	0.36	+22	+13	+2	-7	-3
Norfolk[c]	282	+15	0.00	0.56	+43	+10	-1	-21	-8
Louisville[c]	247	+15	0.00	0.73	+54	-7	+22	-1	-7
Sacramento	233	+19	0.33	0.77	+77	+3	+87	+73	-2
Omaha	232	+15	0.00	0.67	+53	-6	+29	+35	+1
Indianapolis[c]	232	+13	0.00	0.44	+33	+16	-8	-35	-12
Madison[c]	193	+14	0.21	0.59	+29	+2	+148	+202	+7
Syracuse	169	+12	0.00	0.53	+39	+6	-8	-25	-6
Tacoma	128	+13	0.37	0.68	+38	+5	+5	0	-1
Harrisburg	81	+16	0.00	0.61	+36	-13	+555	+873	+13
Charleston (WV)	79	+10	0.00	0.60	+47	+3	+39	+17	-4
Albuquerque	66	+11	0.22	0.75	+103	+11	+48	-2	-6
Savannah	60	+10	0.00	0.40	+21	+17	-23	-45	-12
Little Rock[c]	54	+12	0.00	0.71	+67	+4	-30	-55	-11
Wichita[c]	47	+14	0.27	0.79	+38	-12	-5	+98	+17
Dayton	45	+15	0.10	0.72	+70	+3	+34	+10	-5
Greensboro[c,d]	31	+12	0.24	0.65	+54	+15	-29	-57	-14
Binghamton	31	+8	0.22	0.45	+12	-3	-5	+43	+13
Lafayette (IN)	17	+12	0.00	0.81	+106	+5	+32	-37	-15
Spartanburg[c,d]	16	+11	0.09	0.51	+42	+25	-26	-54	-12

[a]Ridership figures reflected in these statistics include transfers, free riders, and reduced-fare passengers.
[b]Average fare was calculated as total passenger revenue divided by total passengers.
[c]Privately managed.
[d]Privately owned.

Section 15 data for 1979 obtained for each system from the Urban Mass Transportation Administration (UMTA) (17), public annual reports available for most of the systems, and supplemental, unpublished information obtained from all 34 systems. Use of this range of sources permitted cross-checking of statistical values and facilitated the identification and revision of inaccurate figures.

Table 3 displays trends in key operating and financial statistics for each of the 34 bus systems, which are listed in order of bus fleet size. All the systems experienced increases in costs and in degree of subsidy from 1970 to 1979, but increases in some cities were much larger than in others. For example, per-hour costs in Chicago rose three times as much as in Charleston or Savannah. Similarly, the subsidy ratio increased 80 percentage points in Denver but only 23 points in Binghamton. Increases in per-rider subsidies ranged from $1.06 in Lafayette to only $0.12 in Binghamton.

The statistics shown in the last four columns of Table 3 display even greater variation among cities. Not only are there differences in the magnitude of changes but also in the direction of changes. Average fares on some systems increased, whereas on others they decreased. Likewise, bus hours of service, total ridership, and load factors (riders per bus hour) rose in some cities but fell in others. Thus, the aggregate, nationwide data in Table 1 conceal some important variation. On the basis of this variation, subsequent sections of this paper explore the statistical relationship between trends in operating and financial statistics and various possible explanatory variables.

STATISTICAL ANALYSIS OF BUS DATA

Statistical analysis of the bus data is organized into three parts. The first part categorizes the 34 bus systems on the basis of eight different factors and compares the different average values of the trend variables for bus systems in different categories. The second part calculates simple correlation coefficients between the trend variables and the explanatory variables. Finally, regression equations are estimated for each of the trend variables and different groupings of explanatory variables are included in each equation.

Differences in Variable Averages by Category of System

Table 4 presents calculations of average changes in a range of operating and financial statistics for each of a variety of transit system categorizations. From a policy perspective, the first four categorizations are probably the most significant. Degree of public ownership, public management, transit tax earmarking, and federal subsidy are all aspects in the design of the transit program that can be manipulated. The last four breakdowns--by local tax effort, fleet size, population growth, and density--may contribute to the explanation of variations among cities in transit trends, but they are mostly external to the transit program itself.

The impacts of public ownership, public management, and tax earmarking are consistent with expectations. For example, publicly owned systems have had larger increases in cost per bus hour, smaller

Table 4. Average trends in bus costs, fares, subsidies, service levels, and ridership by type of system, funding, and city, 1970-1979.

Category	Number of Systems	Change in Operating Cost ($/bus hour)	Change in Average Fare (cents)	Change in Subsidy per Rider (cents)	Change in Operating Ratio[a]	Change in Operating Subsidy Funded Locally (%)	Change in Route Miles (%)	Change in Bus Hours (%)	Change in Riders (%)
Ownership									
Public	31	+15.4	+2	+46	-0.64	-8	+42	+45	+54
Private	3	+12.7	+16	+37	-0.37	-54	-17	-21	-42
Management									
Public	23	+15.9	+1	+48	-0.63	-8	+44	+52	+62
Private	11	+13.7	+6	+40	-0.59	-20	+22	+12	+12
Percent of state and local subsidy dedicated (1979)									
75% or more	12	+18.5	-4	+55	-0.72	-7	+67	+51	+52
15-75%	8	+14.6	+1	+38	-0.65	-4	-1	+76	+124
Less than 15%	14	+12.6	+10	+42	-0.51	-21	+32	+8	-5
Federal subsidy as percentage of total operating subsidy (1979)									
45% or more	17	+13.1	+3	+42	-0.63	-25	+26	+38	+49
25-45%	8	+15.9	+3	+49	-0.54	+1	+69	+47	+49
10-25%	7	+20.3	-3	+49	-0.72	+1	+49	+54	+62
Less than 10%	2	+11.6	+20	+48	-0.41	0	-48	-28	-55
Local tax effort (1976)[b]									
High	12	+15.7	+3	+45	-0.60	-2	+81	+44	+39
Medium	16	+15.9	+1	+38	-0.58	-16	+14	+12	+21
Low	6	+12.2	+6	+67	-0.75	-21	+8	+103	+124
Fleet size (1979)									
500 or more	13	+18.4	-1	+42	-0.66	-4	+43	+36	+42
100 - 500	10	+14.3	+5	+40	-0.57	-21	+70	+27	+21
Less than 100	11	+12.0	+5	+54	-0.61	-14	-19	+54	+72
Population change (1970-1978)									
+50% or more	1	+12.5	+13	+22	-0.50	-12	+36	+2	-6
+10% to +50%	8	+15.6	+4	+67	-0.66	-1	+100	+62	+40
+2% to +10%	15	+13.7	+3	+41	-0.63	-18	+14	+52	+69
-2% to +2%	6	+17.5	-3	+33	-0.56	-20	+12	+11	+38
-2% or less	4	+17.0	+5	+43	-0.60	-2	+33	-3	-9
Central-city density (1978)									
10 000 or more	6	+17.7	+8	+27	-0.52	+5	+4	-1	+2
5000-10 000	12	+16.0	-3	+46	-0.74	-16	+58	+75	+102
5000 or less	16	+13.5	+5	+52	-0.56	-16	+33	+27	+19

[a]The operating ratio is calculated as operating revenues (excluding subsidies) divided by operating costs.
[b]Local tax effort in each urban area was calculated as the ratio of local government own-raised tax revenue divided by total personal income.

fare increases, larger increases in subsidy per rider, bigger declines in operating ratios, more service expansion, and greater ridership growth than have privately owned systems. Precisely the same pattern of differences is found between publicly managed systems and privately managed systems. Similarly, systems funded primarily by earmarked transit taxes had larger cost increases, smaller fare increases, larger increases in subsidy per rider, bigger declines in operating ratios, more service expansion, and greater ridership growth than have systems with little or no funding from dedicated state and local taxes.

The differences in trends for systems receiving different levels of federal operating assistance are puzzling. In many respects they run directly counter to the hypothesis that federal aid encourages cost escalation. Although the smallest cost increase is indeed calculated for the two systems with the least federal aid, the largest average increase occurred in systems with only 10-25 percent federal funding. Because all seven of the systems in this 10-25 percent category were also in the largest fleet-size category, it seems likely that the unexpected result arises from the effects of size on costs rather than any beneficial impacts of federal subsidy on productivity. As seen further down in the table, cost increases have been much larger for big systems than for small systems. Similarly, the performance of the two systems receiving less than 10 percent federal aid may reflect more the impact of private ownership and management than of federal subsidies, since both are private. In short, it is difficult to isolate the independent effect of federal aid because of its correlations with other explanatory variables.

The differences among calculated averages for the four control categories may also be of some interest. The strongest relationship appears to be between fleet size and cost escalation, with the 13 largest systems having incurred increases of more than $6/bus hour larger than those of the 11 smallest systems. It is not clear, however, to what extent this implies diseconomies of scale. The larger cost increases in larger systems may arise from greater union power and higher costs of living in the larger cities; both factors would lead to larger wage increases for larger systems. It is debatable whether such factors represent genuine diseconomies of scale. Of course, managerial inefficiency, coordination problems, and reduced worker incentives might also account for part of the larger cost increases for larger systems, but the limited data do not permit isolation of these effects.

Local tax effort was used as a barometer of willingness to spend for local public services. It was anticipated that the greater the tax effort, the less would be the incentive for cost control and fare hikes and the greater would be the increases in subsidy, service levels, and ridership. As shown in Table 4, this expectation was not strongly confirmed, perhaps because tax effort could be differently interpreted. For example, the marginal burden of yet more taxes for transit subsidies would probably be greatest in cities with a high tax effort. Thus, one might alternatively expect greater resistance to public expenditures for transit where the local tax burden was already high. The results in Table 4 do not provide an adequate basis for choosing between the two interpretations.

Population change was included primarily to help explain changes in service levels and ridership.

Table 5. Correlations among selected operating and financial statistics for 34 bus systems, 1970-1979.

Explanatory Variable	Change in Operating Cost per Bus Hour	Change in Average Fare	Change in Subsidy per Rider	Change in Operating Ratio[a]	Change in Percentage of Operating Subsidy Funded Locally	Percentage Change in Route Miles	Percentage Change in Bus Hours	Percentage Change in Riders
Public ownership (1979)	+0.18	-0.39[b]	+0.11	-0.34[b]	+0.40[b]	+0.14	+0.18	+0.17
Public management (1979)	+0.24	-0.18	+0.17	-0.08	+0.17	+0.09	+0.18	+0.15
Percentage of state and local subsidy dedicated (1979)	+0.57[c]	-0.57[c]	+0.23	-0.35[b]	+0.16	+0.10	+0.11	+0.08
Federal subsidy as percentage of total operating subsidy (1979)	-0.42[b]	-0.04	-0.16	-0.04	-0.37[b]	+0.05	+0.02	+0.05
Local tax effort[d] (1979)	+0.34	-0.01	-0.20	+0.15	+0.34[b]	+0.19	-0.06	-0.06
Fleet size[e] (1979)	+0.71[c]	-0.10	-0.29[f]	+0.06	+0.12	-0.13	-0.12	-0.05
Population change (1970-1978)	-0.15	+0.20	+0.04	+0.04	-0.02	+0.14	+0.03	-0.03
Central-city density (1978)	+0.40[b]	+0.11	-0.34[b]	+0.09	+0.26	-0.14	-0.09	-0.02

[a]Operating ratio calculated as operating revenues (excluding subsidies) divided by operating costs.
[b]Significant at 0.05 level.
[c]Significant at 0.01 level.
[d]Local tax effort calculated as local government own-raised revenues divided by total personal income in each urban area.
[e]Natural logarithm of fleet size used for correlation analysis.
[f]Significant at 0.10 level.

Excluding Dallas, the one city in the growth category of 50 percent or more, the results are generally in the expected direction (i.e., positively correlated) but are not so strong as anticipated.

The most interesting aspect of the disaggregation by central-city density is the finding that most of the growth in transit service and ridership has occurred in low- and medium-density urban areas. In contrast, the six densest cities maintained roughly constant levels of service and ridership. Costs per bus hour have increased faster in dense areas, but this may be partly due to the correlation between density and size. Although one would expect a very significant impact of density (via traffic congestion) on speed and thus on cost per bus mile, it is not clear why density should affect costs per bus hour.

Correlation Analysis

Table 5 contains statistical correlation coefficients for the relationships between the various transit trends (column headings) and a range of explanatory variables. Both the trends and the explanatory variables are the same as those examined in Table 4 except that all the variables but public ownership and management are measured continuously rather than categorically. In general, the pattern of results is roughly the same as that in Table 4. The directions and magnitudes of relationships, however, are more readily discerned from the more compact correlation matrix.

The correlation coefficients clearly indicate that public ownership, public management, and earmarked transit taxes are all associated with large cost increases, small fare increases, large increases in subsidy per rider, large decreases in the operating ratio, large increases in the proportion of local tax funding, large increases in service, and large increases in ridership--all relative to privately owned, privately managed systems without earmarked taxes.

The results for the federal subsidy are as perplexing as they were in Table 4 and probably for the same reasons. Again, high federal ratios are associated with relatively small cost increases as well as small increases in subsidy per rider. Somewhat more in line with expectations, generous federal aid was also associated with relatively small fare increases, decreases in the operating ratio, decreases in local funding, and increases in service and ridership. With the exception of local funding, however, these associations are surprisingly weak.

A few of the relationships with the four control variables are also interesting and can be more easily seen in Table 5. The very high positive correlation between fleet size and cost increases supports the inference about scale impacts drawn from Table 4. In spite of large cost increases and small fare increases, subsidy per passenger increased the least in the largest systems. The explanation for this paradoxical result almost certainly lies in load factor differences among systems of different size. Referring back to Table 3, the reader will note that over the decade, the number of passengers per vehicle hour (a proxy for load factor) decreased more for smaller systems than for larger systems. Thus, although costs increased faster in larger systems, these costs continued to be spread out over more passengers. Load factors, which are higher in denser cities, probably explain the negative correlation between density and per-rider subsidy as well.

All the correlations with the service level and ridership variables are weak. Nevertheless, they suggest that service levels and total ridership have been declining the most (or increasing least) in dense cities with large bus systems. In contrast, service levels and ridership have been increasing the most (or declining the least) in publicly owned, publicly managed systems with dedicated state and local funding and generous federal operating assistance.

Of course, these correlations are only meant to be suggestive of the nature and extent of the relationships between various trends in the transit industry and a selection of possible explanatory variables. They obviously do not prove hypotheses about causes of the trends. Moreover, as noted in various instances above, correlations among the explanatory variables make interpreting the calculated coefficients a challenging task.

Regression Analysis

In spite of the inevitable limitations caused by the small sample size, regression analysis of the bus data yields some interesting results. Nine of the many equations that were estimated by ordinary least squares are shown in Table 6. (The overall statistics for Table 6 are given in Table 7.) The regression coefficients and t-statistics for each equation are located in the column under its dependent variable.

Cost Equations

Perhaps of greatest interest are the cost equations in the first four columns. The first version includes a dummy variable for public ownership and was estimated for all 34 systems, whereas the second version excludes the public ownership variable and was estimated only for the 31 public systems. Both equations find that percentage of state and local tax dedication is the single most significant policy variable for explaining the differences among cities in increases in per-hour operating costs from 1970 to 1979. Moreover, the estimated coefficient is roughly the same in both versions. It indicates, for example, that if one system had 10 percent more of its state and local funding dedicated for transit than another system, its per-hour cost could have been expected to increase by about $0.30-0.34/h more when other factors affecting costs are controlled for. Although not as statistically significant, the coefficients of the public ownership and management variables also have the expected signs. The first version indicates that the independent effect of being publicly owned was to increase costs by an additional $0.68/bus h; being publicly managed led costs to increase by an additional $0.33/h. When the three private systems are thrown out of the sample, however, the management variable becomes more important (causing $0.94 additional increase in cost) and more statistically significant. The federal subsidy variables, both in continuous and categorical form, display the same unexpected sign as in the earlier correlation analysis. Perhaps even more surprisingly, the coefficients for federal subsidy are not far from statistical significance. It seems unwarranted to interpret the strange result as evidence that federal subsidies encourage efficiency, but the expected contrary impact is certainly not confirmed by the regressions.

Two other variables are noteworthy. Fleet size has a significant positive effect on cost increases regardless of type of specification. The coefficient in the first equation suggests that if one system had 100 more buses than another, its per-hour costs could have been expected to increase by $0.30/h more over the decade than for the smaller system. The other variable of interest is percent of costs subsidized. Although not statistically significant, its coefficient indicates that the larger the proportion of a system's costs financed by subsidies instead of the farebox, the larger was the increase in cost, suggesting that subsidization in itself (i.e., regardless of source) may induce cost escalation.

Other Equations

Space limitations prevent a detailed analysis of the other equations. A few notable results, however, are highlighted below:

1. Public ownership is estimated to have encouraged smaller fare increases and larger increases in subsidy per rider. Public management is estimated to have encouraged larger subsidies per rider as well as service expansion. None of these coefficients, however, is statistically significant.
2. Tax earmarking evidently had a tendency to reduce fares or at least to keep fare increases small. It also encouraged larger subsidies per rider.
3. When other variables are controlled for, federal subsidies are estimated to be associated with smaller increases in subsidy per rider and less service expansion--both counterintuitive results.
4. Urban areas where local tax burdens were already high experienced smaller increases in cost, bigger fare increases, and smaller increases in subsidy per rider.
5. The greater local government expenditures per capita (a proxy for disposition to public spending), the greater was service expansion.
6. Population growth tended to promote greater service expansion but, inexplicably, smaller ridership growth (or larger losses).
7. The denser the central city, the greater was the loss (or the smaller was the increase) in service.
8. The greater the transit modal split (as represented by transit riders per capita), the greater the tendency over the decade for fares to decrease (or increase more slowly), for the operating ratio to increase, and for the subsidy per rider to increase.
9. On average, there was only a 0.25 percent increase in hours of service over the decade for every 1 percent increase in total operating costs.
10. Finally, percentage change in number of bus hours is by far the most significant variable for explaining changes in ridership, and the relation is positive, as expected. The relation between fares and ridership is negative--also as expected--but much less significant.

Limitations of Analysis

Although the preceding analysis suggests some interesting statistical relationships among various policy variables and trends in transit operations and finances, the estimates are limited in a number of ways. Due partly to the small sample size, few of the coefficients are statistically significant. A related problem is multicolinearity among some of the explanatory variables. Multicolinearity, which is especially difficult with small samples, can lead to large standard errors in coefficient estimates, which thereby are rendered less reliable. A number of potential explanatory variables were already discarded to mitigate this problem, but it seems likely that at least some multicolinearity still exists in the equations listed in Table 6.

Perhaps the most severe problem is the unavoidable simultaneity of many of the relationships. For example, one hypothesis that was being tested was whether institutional and policy variables could explain differences among cities in transit cost increases over the decade. It was anticipated that public ownership, public management, and degree of subsidy would have exacerbated cost increases. Alternatively, however, it could be argued that the direction of causation was just the reverse: that systems experiencing the largest cost increases were the most likely to need and get the largest subsidy increases and to be taken over by public agencies. Similarly, in other estimated equations, there are explanatory variables that are determinants of the dependent variable as well as functions of the dependent variable. Such relations can lead to simultaneous equations bias of the coefficients. Unfortunately, the small sample size and various other practical considerations precluded use of more refined statistical methods such as two-stage or three-stage least squares (instead of ordinary least squares) in order to alleviate this problem.

SUMMARY AND POLICY IMPLICATIONS

The transit industry in the United States experienced three significant changes during the decade of the 1970s:

1. Public ownership, public management, regional

Table 6. Selected regressions for trends in bus operations and finances, 1970-1979.

Explanatory Variable	Dependent Variable: Operating Cost per Bus Hour, Version 1: Change ($)	t-Value	Version 2: Change ($)	t-Value	Avg Fare: Change (cents)	t-Value	Operating Ratio: Change	t-Value
Public ownership (1979)[a]	+0.677	0.29			-8.41	1.05		
Public management (1979)[a]	+0.333	0.27	+0.941	0.76	+0.219	0.05	+0.001	0.02
Percentage of state and local subsidy dedicated (1979)	+0.034[b]	2.32	+0.030[c]	1.97	-0.102[b]	2.08	-0.001	0.93
Federal percentage of total operating subsidy (1979)	-0.048	1.31			-0.072	0.51		
Whether federal operating subsidy at least 45 percent of total (1979)[a]			-1.88	1.34			-0.104	1.21
State percentage of total operating subsidy (1979)					-0.007	0.07		
Local tax effort (1976)[d]	-0.068	0.27			+0.811	1.06	+0.030	1.59
Local government expenditures per capita ($) (1976)								
Fleet size (1979)	+0.003[e]	2.79						
Log of fleet size (1979)			+1.32[b]	2.46			-0.072	1.37
Percentage change in population (1970-78)								
Central-city density (1978) (000s)	-0.024	0.13						
Increase in percent of costs subsidized (1970-79)			+0.033	0.85				
Transit rides per capita (1979)					-0.012	0.12	+0.006[c]	1.97
Increase in cost per bus hour ($) (1970-79)					-0.635	0.98	-0.020	1.36
Percentage increase in total costs ($) (1970-79)								
Percentage change in bus hours (1970-79)								
Change in average speed (mph) (1970-79)								
Change in average fare (cents) (1970-79)								
Intercept	+13.82[e]	4.88	+5.98	1.43	+21.09	1.46	-0.239	0.85

[a]The indicated explanatory variables were specified as 0-1 dummy variables.
[b]Significant at 0.05 level.
[c]Significant at 0.10 level.
[d]For regression analysis, tax effort was defined to be local government own-raised revenues as percentage of total personal income in each urban area.
[e]Significant at 0.01 level.

Table 7. Overall statistics for regression equations in Table 6.

Statistic	Change in Operating Cost per Bus Hour ($): Version 1	Version 2	Change in Avg Fare (cents)	Change in Operating Ratio	Change in Subsidy per Rider (cents): Version 1	Version 2	Change in Route Miles (%)	Change in Bus Hours (%)	Change in Riders (%)
Mean	+15.17	+15.40	+2.84	-0.617	+45.5	+46.3	+36.8	+39.1	+45.5
Standard deviation	2.84	2.97	9.18	0.212	20.4	19.1	125.1	17.0	44.8
F-statistic	7.02	8.06	2.37	1.69	2.88	4.94	0.58	178.1	96.5
Probability value	0.0001	0.0001	0.473	0.1560	0.0230	0.0028	0.7638	0.0001	0.0001
R^2	0.65	0.62	0.43	0.31	0.44	0.50	0.14	0.98	0.93
No. of observations	34	31	34	34	34	31	34	34	34

consolidation, and public regulation increased.

2. Transit was increasingly dominated by bus service, with decreases in vehicle hours of service as well as in ridership for other modes of transit. Within metropolitan areas, service and ridership followed the shift of population from the central city to the suburbs.

3. Both capital and operating costs of transit skyrocketed, compelling a corresponding burgeoning of government subsidies to finance these increased costs.

Perhaps of greatest interest in this story of change is the impact of public policy. From 1950 to 1970, transit was generally expected to finance operating costs through fares, and government subsidies (both operating and capital) were minimal (2, pp. 31-47; 11; 12). Partly as a consequence of this policy, vehicle miles of transit service in the United States fell 37 percent during these two decades, and ridership fell 57 percent (1, pp. 55, 58). In contrast, government subsidies to transit increased 15-fold during the 1970s and reached $7.8 billion by 1980. Although this infusion of funds into an ailing industry has indeed reversed the declines of the previous two decades, the resulting service expansion and ridership growth nevertheless have been small (11 and 6 percent increases, respectively).

Some might argue that the very design of the subsidy program has been responsible for the disappointing yield of large transit subsidies. Although the preceding statistical analysis of bus data was not entirely conclusive, it did suggest that public ownership, public management, and tax earmarking tended to have an inflationary impact on costs during the 1970s. Moreover, one formulation indicated that the higher the percentage of costs financed by subsidies, the greater was the increase in costs, implying that subsidization in itself may encourage productivity declines and cost escalation.

These results suggest the need for more careful monitoring of transit operations and for explicitly relating levels of subsidy to output. Because most transit subsidy programs in the United States simply cover costs, whatever they happen to be, without regard to any index of goal achievement, there is not much incentive for a transit system to use subsidies efficiently. The current program fails to distribute funds among cities in a manner that rewards efficient systems and penalizes inefficient ones. Instead, distribution formulas (especially at the federal level) arise from political bargains and have little relationship either to the transportation needs of each urban area or to the performance of individual transit systems. Clearly, in the current era of fiscal austerity at all government

Subsidy per Rider									
Version 1		Version 2		Route Miles		Bus Hours		Riders	
Change (cents)	t-Value	Change (cents)	t-Value	Change (%)	t-Value	Change (%)	t-Value	Change (%)	t-Value
+4.80	0.29								
+7.93	0.89	+2.71	0.34	+3.21	0.06	+2.61	0.37		
+0.098	0.91	+0.138	1.37	+0.040	0.07	-0.023	0.29		
-0.298	1.09								
		-21.7[b]	2.40	-15.7	0.33	-2.36	0.37		
-2.52	1.49								
				+0.182	1.17	+0.014	0.65		
				+0.511	0.40	+0.007	0.04	-0.341	0.81
				-7.35	1.10	-0.540	0.59		
-0.694[e]	3.10	-1.26[e]	4.55						
1.65	1.15	+1.82	1.37						
				+0.056	0.99	+0.262[e]	34.3		
								+1.40[e]	14.0
								+1.87	0.22
								-1.27	1.37
+65.9[b]	2.48	+59.0[e]	3.06	-33.5	0.33	-45.3[e]	3.23	-4.42	0.32

levels, it is essential that limited public funds be spent as effectively as possible. There is no good reason for making transit the exception. Transit systems receiving public subsidies should be held accountable for achieving the objectives that are the basis for justifying such subsidies.

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