political in nature but, as has been noted, the choices made may have significant economic consequences as well.

What is urgently needed is a clearer definition of federal and state transportation investment goals. This paper has documented the change in the highway finance environment and the shift in highway program emphasis from route expansion to route maintenance. A growing problem arises from the inability of the existing federal-aid highway program to adapt to the changing highway investment environment.

Although the potential of FAHP to influence highway investment decisions has always been present, it has taken shrinking highway revenues to dramatize the issue. Now, because the important link between federal transportation policy and the characteristics of grant programs to implement that policy, a renewed effort is required to realign the provisions of FAHP.

The Interstate system is now largely in place, and the role of the federal government in highway finance is changing. For the past 2 decades, the federal government has played a dominant role in influencing highway capital investment, leaving route maintenance as a strictly state and local issue. However, it is problematic whether the growing inability of localities to maintain highways financed with federal funds can continue to be viewed as strictly a local issue.

Perhaps the most fundamental requirement for planning changes in FAHP is to explicitly address the link between policy and programs. Highway investment policies must be redefined in light of the current energy-conscious environment, and programs must be designed accordingly. Simplistic statements aimed directly at programs (e.g., equalizing matching ratios) are certain to continue the ad hoc development of FAHP. Certainly, matching ratios can be different for highway grant programs, but there must be a rational explicit reason related to the trade-offs between local and national investment benefits. Tradition notwithstanding, highway block grants do make sense if the main purpose of the grant program is distributive rather than allocative. Future debate in this area should recognize the critical link between policy objectives and the programs that implement policy.

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REFERENCES

1. Expected Impact of the National Energy Plan on the Federal-Aid Highway Program. Federal Highway Administration, Jan. 1978.
2. D. Kulash. President Carter's Automobile-Related Energy Conservation Proposals. Proc., 4th National Conference on Effects of Energy Constraints on Transportation Systems, Union College, Schenectady, NY, Aug. 1-5, 1977; U.S. Department of Energy, 1977.
3. Automotive Fuel-Economy Program. National Highway Traffic Safety Administration, U.S. Department of Transportation, 2nd Annual Rept. to Congress, Jan. 1978.
4. President Carter's Energy Proposals: A Perspective. Congressional Budget Office, U.S. Congress, June 1977.
5. Price Trends for Federal-Aid Highway Construction. Office of Highway Operations, Federal Highway Administration, Quarterly Publ., 1977.
6. J. S. McCarthy. State Highway Finance User Taxation in Indiana. Purdue Univ., West Lafayette, IN, Joint Highway Research Rept. C-36-73E, Oct. 1976.
7. Highway Statistics: Summary to 1975. Federal Highway Administration, Rept. FHWA-HP-HS-S75, undated.
8. L. Sherman. Impacts of the Federal-Aid Highway Program on State and Local Highway Expenditures. Massachusetts Institute of Technology, Cambridge, PhD dissertation; Office of the Assistant Secretary for Policy, Plans, and International Affairs, U.S. Department of Transportation, Feb. 1975.
9. A. L. Porter, S. Rao, and T. D. Larson. Effects of Federal Funding Policies on State and Local Transportation Performance: Preliminary Findings. Paper presented at the 57th Annual Meeting, TRB, 1978.

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Review of Road Expenditures and Payments by Vehicle Class: 1956 to 1975

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The question of whether, over the past 20 years, the payments made by road users have been sufficient to match the expenditures made on their behalf for road systems is addressed. The results suggest that, in aggregate, payments by road users have not been sufficient to meet expenditures for roads. For urban roads, payments have more than met expenditures but, on rural roads, payments have been well below expenditures. An analysis of time trends suggests that these discrepancies have grown progressively. This analysis further suggests that, if different road users are considered separately, payments by light vehicles (automobiles and light trucks) and by medium vehicles (medium trucks and buses) have been much greater than the expenditures occasioned by each. It is shown that,

for heavy vehicles (heavy trucks), payments over the 20 years were significantly greater than occasioned expenditures only for urban roads. In recent years, however, payments by heavy vehicles on both rural and urban roads (and hence on all roads) have been greater than occasioned expenditures.

Highway financing and the relations between expenditures for and receipts from roads have long been important policy issues. Legislative history since 1950 suggests that the primary concern of the U.S. Congress has been to establish an equitable way of charging road users so as to generate the revenue needed to pay for the road program. The worth of road investments has always been taken for granted, but Congress has repeatedly implied that those who benefit from roads should pay their fair share in relation to the benefits derived from and the costs occasioned by them.

This paper summarizes a study (1) of the question of whether the expenditures for the road system and the different parts of it have been matched by the payments made by users of the roads. It thus addresses the issue of whether road users as a whole or different groups of users have paid their fair shares of the expenditures as intended by Congress. We concentrate on the costs occasioned, not the benefits received, thus implicitly accepting that the congressional judgment of the worth of road investments was correct. In a companion paper (2), we have addressed the question of what, if anything, should now be done to change the basis of road charges, assuming possibly different congressional intentions in the future.

The study on which this paper is based treats the problem of equitable treatment for road users in two ways. First, we make year-by-year comparisons, over the 1956-1975 period, of expenditures made on behalf of all road users with the payments made by them, for the system as a whole, for different types of roads, and for classes of road users. This type of analysis is not new (3,4); our intention is to make more careful, comprehensive, and up-to-date evaluations. Second, and as an alternative view, we discuss the question of whether road users as a whole and classes of users have received more favorable treatment than have other industries at large. This involves regarding road users as customers of an integrated industry that includes the provision and maintenance of roads. We investigate the accounting of expenditures for and payments made by users as if the industry comprised ordinary firms, using appropriate accounting conventions. The principal difference between this approach and the pay-as-you-go approach is that differences between payments and expenditures, if positive, yield returns to the suppliers of roads or, if negative, raise the need to finance deficits. This will be referred to as the roads-as-an-industry approach.

Consideration of different classes of users raises two kinds of problems--the definition of the vehicle classes and the identification of the expenditures and payments (or outlays and receipts in the case of the industry approach) with the classes. Because of the nature of road costs, these two problems are connected. As argued in the larger study (1), it proves impossible to uniquely identify expenditures with the particular vehicle classes we would like to distinguish. Accordingly, we analyze for alternative groupings. Our interest is in three vehicle classes that seem to be relevant in terms of congressional intent:

Class	Includes	Called
1	All automobiles and light trucks that have two axles and four tires (chiefly pickups and vans)	Light vehicles
2	Buses, single-unit trucks that have more than four tires, and truck combinations that have registered gross masses less than 23.6 Mg (50 000 lb)	Medium vehicles
3	All heavy truck combinations that have registered gross masses of 23.6 Mg or more	Heavy vehicles

ANALYSIS PROCEDURES

Expenditures

All expenditures (capital outlays, maintenance, operation, and administration) on behalf of road users made by the federal, state, and local levels of government are included. The earlier studies account for only those so-called direct expenditures that are clearly earmarked for roads and for the operating costs of activities directly related to motor vehicle use. They exclude expenditures such as the proportion of state and local court system costs that are attributable to road users (e.g., traffic cases, and juvenile, civil, and criminal cases involving vehicle-related crimes such as automobile theft and drunken driving), local police department costs over and above those for the traffic police (e.g., the costs of general patrolmen, detectives, and other personnel who are not part of the traffic department, but spend some of their time enforcing traffic violations and road-related crimes such as automobile thefts and drunken driving), and a proportion of the state and local correctional institution costs of the state and local prosecution bureaucracy (e.g., district attorneys' offices). We have included estimates of these items in our expenditures.

Payments

All user payments are included--such as receipts from federal, state, and local road-user taxes that are conventionally earmarked as such. The earlier analyses included the following:

1. Federal excise taxes on the purchase of trucks and buses, gasoline and diesel fuels, tires, tubes, and tread rubber, lubricating oil, and parts and accessories and use taxes on trucks and buses;
2. State excise taxes on gasoline and diesel fuels, user taxes on heavy vehicles, vehicle registration, and miscellaneous charges; and
3. Local (municipal and county) parking fees, local fuel and other user charges, and miscellaneous imposts including fines.

In addition to these, we include the revenue from the federal excise tax on new automobile purchases (repealed in the fall of 1971), which was not earmarked for the highway trust fund, but nevertheless was a payment associated with the purchase of an automobile.

Certain payments are excluded because they give rise to an equal and offsetting expenditure and thus balance out of the accounts. Private parking and toll receipts are excluded because the expenditures on parking facilities and toll roads, which are assumed to offset these receipts, are excluded. Also excluded are private inputs to trip making such as time spent driving or truck drivers' wages.

Because we wish to follow the conventions for accounts in other industries as far as possible, two main sources of tax receipts--state and local sales taxes on motor vehicles and related purchases and local personal property taxes on motor vehicles--are excluded. Most inputs for other industries would not be subject to what are intended to be taxes on consumption. We, therefore, ignore these considerations in this analysis.

The operations of each year involving expenditures for maintenance, capital investment, and other items are regarded as being set alongside the payments by road users and representing receipts to the industry. A positive difference attracts a credit interest, and a negative difference requires an interest charge to finance the operations. We assume that both outlays and receipts are evenly spread over any year and the charge or credit is the interest on the annual balance.

The rate of interest we have selected is 5 percent. This could be argued. What is required for the industry analogy is the rate (net of inflation, already allowed for in the calculations) at which a comparable industry could borrow. The degree of risk should be similar. The road industry was, over the period, an obviously expanding industry of very low risk indeed. During most of the period, the prime rate for government bonds was a little less than 5 percent. If we allow for low but increasing inflation during the period and some premium for the assumed nongovernment, but low-risk, industry, 5 percent seems a reasonable approximation.

Expenditures Occasioned by Vehicle Classes

In attempting to identify expenditures associated with particular vehicle classes, we found that the smaller the class, the less it is possible to make an unequivocal statement on the issue. Even dividing users into only three classes, it is necessary to make alternative calculations. Thus, we present results for the following combinations of classes:

1. Light versus medium plus heavy vehicles and
2. Light and medium versus heavy vehicles.

We call expenditures identified with these classes occasioned expenditures. Expenditures that cannot be identified are called common.

Occasioned expenditures are based on an incremental approach. We begin with the idea of the provision of road services for a given vehicle class and then ask what is added to or subtracted from expenditures if other classes are permitted to use the roads or, alternatively, withdrawn. In principle, one can begin with any given class, which has its own demand for items such as route length, number of lanes, and structural strength, and consider the addition of another class that has different demands. We have, of course, no very good evidence to identify these demands, and so we have taken a rather arbitrary position. Our assumptions are given below.

We begin with the incremental expenditures associated with adding heavier vehicles to lighter ones. The latter, which are smaller and more maneuverable, can be provided with an adequately designed road for a relatively low cost per unit served. We first consider, given that a road system of the actual extent experienced was provided, the expenditures occasioned solely to serve heavier, wider, and higher and lower performance vehicle classes. This leads us to calculate

1. Structural-strength requirements,
2. Climbing-lane requirements,
3. Vertical-clearance requirements, and
4. Lane- and shoulder-width requirements.

This gives us an estimate of the savings possible if medium and heavy vehicles are excluded from the system. We assume that 3.05-m (10-ft) rather than 3.7-m (12-ft) lanes would have sufficed and 3.05-m rather than 4.3-m (14-ft) clearances. No attempt is made to estimate how extensive a system would have been demanded by the different classes of users.

It can also be argued (and will be below) that different vehicle classes cause different levels of pavement and shoulder damage. The relationship used to estimate pavement and shoulder maintenance and resurfacing expenditures by vehicle class makes these expenditures a function of axle loads and vehicle kilometers of travel by vehicle class. It is assumed that there are no common costs in this category of expenditures--that all relevant expenditures can be attributed to the respective vehicle classes.

An important element of uncertainty in calculating occasioned expenditures arises from the fact that, in the period under review, decisions about original capital construction and subsequent maintenance were taken in a rather arbitrary way. There was no attempt to optimize expenditures with respect to the factors involved. Indeed, essential elements providing the basis for such calculations only began to be available during the period--for example, the AASHO tests were not reported until the early 1960s. We cannot satisfactorily answer the question of what expenditures would have been avoided by prohibiting, for example, heavy vehicles from using the roads. It would have been possible to have selected weaker pavements and thus save capital costs. On the other hand, had an attempt been made to minimize full lifetime pavement costs, the conclusion might well have been that thicker pavements are preferable for all traffic because maintenance expenditures will be lower. This would have raised the proportion of common costs above what we have computed. We thus cannot settle the issues as to what would have been the appropriate occasioned capital and maintenance costs. The adjustments to the expenditures we have identified might have gone either way with respect to excluding a given vehicle class.

Other maintenance, administrative, safety, and law enforcement expenditures are regarded as overheads. Although there is some relationship between these costs and the extent and the use of the system (particularly items such as the costs of the equipment and bureaucracy required to enforce commercial vehicle weight laws), current data do not permit us to determine this relationship; thus, no parts of these expenditures can be shown to be occasioned by a particular vehicle class. This is not a severe problem, because these costs are a relatively small fraction of total program costs and any occasioned costs are smaller still.

In summary, the approach we use is to try to answer the question, For each of the industries (rural roads and urban roads) concerned, what was involved in expenditure terms in providing service for different kinds of customers? The service is not considered to be the best that could have been provided or the most desired; it simply happened to be how the industries were run over the time considered. As in accounting for past experiences in most industries, difficulties are encountered in assigning all expenditures to customer classes but some useful comparisons can nevertheless be made.

Structural-Strength Requirements

The structural-strength calculations for structures are based on those described in section 210 of the highway cost-allocation study (3), which developed structural cost increments for vehicles of different gross masses. That study found small differences between cost increments for different types of roads. Our three vehicle classes can be identified with corresponding mass limits, which enables us to identify the portion of total structural expenditures occasioned by heavy vehicles alone and by heavy plus medium vehicles. Current information does not enable

us to relate bridge maintenance costs with vehicle characteristics; thus, these were not assigned.

Climbing-Lane Requirements

We think that, to maintain service levels when vehicles with inferior performance are admitted to the roads, an industry would provide extra capacity. This applies to medium and heavy vehicles; they have poor maneuverability and are unable to sustain speeds on heavy grades. Had all vehicles been designed to perform as well as light vehicles, climbing lanes could have been avoided. Reductions in the number of lanes would, in principle, lead to savings in maintenance. However, we regard this latter item as negligibly small; there is no reflection of it when assessing maintenance.

Vertical-Clearance Requirements

So far as vertical clearance is concerned, the cost of grade separations and interchanges is governed by vertical height. Heights vary widely among types of vehicles, and the problem in assigning cost responsibility is one of judging sensible distinctions. We seem to be on reasonably safe ground only in distinguishing between our light vehicle class and the others. Thus, for example, buses, which are classified as medium, have more in common on this dimension with heavy vehicles than light. By using this distinction, the savings for 3.05-m rather than 4.3-m clearances was calculated, and this cost was assigned jointly to medium and heavy vehicles. This involved the following items:

1. Certain grading and drainage costs associated with construction of approaches to grade separation and of depressed road segments (because gentle approaches and smaller cross sections requiring less earthwork would have sufficed for light vehicles),
2. Certain right-of-way costs associated with depressed road segments (because a smaller cross section would have been required, resulting in a narrower right-of-way), and
3. Certain costs associated with grade separation and interchange structures (because shorter spans would have sufficed).

The significant expenditures associated with vertical clearance requirements, then, are those for constructing interchanges and grade separations because higher clearances necessitate longer and higher structures of these types.

Lane- and Shoulder-Width Requirements

If narrower lanes and shoulders had been built, some expenditures would have been avoided. Again, it is possible to distinguish only the impact of light vehicles and the others. This results in a modification of the actual 3.7-m lanes to the 3.05-m width that can accommodate vehicles of width 2.0 m (6.5 ft) as opposed to the 2.4-2.6 m (8-8.5 ft) of large trucks and buses. On parkways built exclusively for use by automobiles and other light vehicles, 3.05-m widths and shoulders 0.61 m (2 ft) narrower than elsewhere are common. These two differences occasion savings in the following capital expenditures:

1. Pavement and shoulder construction;
2. Grading and drainage;
3. Acquisition of right-of-way; and
4. Construction of structures, because all structures would have been narrower and grade separations and interchanges could have been built with shorter spans over the roadway.

The narrower lanes would have resulted in savings of about 16 percent in width, which implies a 16 percent reduction in structures, about 9 percent reduction in roadway width, and 5 percent in right-of-way width. The corresponding savings in costs are 16 percent of construction costs (because bids for construction are made in proportion to the surface area), 9 percent of grading and drainage costs, and 0 percent of right-of-way costs (because for rights-of-way, no significant impact would have been expected). On most of the rural and urban segments, the right-of-way widths are so large compared with the roadway width that there would be no savings at all. In dense parts of urban areas, up to 5 percent reduction in width might, in principle, be realized, but it is doubtful whether significant reductions in costs would have accrued.

When putting these estimates together to describe occasioned expenditures, two kinds of problems emerge: Each of the components has been estimated separately, which causes danger of double counting, and the smaller systems postulated imply differences in maintenance costs from those actually experienced. On the first issue, the procedure used is first to subtract the expenditures occasioned by climbing lanes (and resurfacing) from total capital outlay. The remaining expenditures can be identified as right-of-way, pavements and shoulders, grading and drainage, and structures. The differences in expenditures implied by each further element of saving (strength, vertical clearance, and width) are then expressed as percentages of these four categories. To estimate overall savings for each expenditure category, the three sets of individual percentages are multiplied together to form the final estimates. On the second, we were able to make no adjustments although, in principle, some small savings could have been realized, especially in maintenance attributed to heavy vehicles, because of the postulated smaller system they required. On the other hand, the narrower lanes and other reductions would have implied a smaller maintenance figure for light vehicles as well. The net effect of these omissions is to slightly bias the total occasioned costs against the heavier vehicles because, as shown below, maintenance is attributed primarily to them.

Maintenance and Resurfacing Expenditures

These are a considerably more important component of noncommon expenditures than are the capital costs. Our estimates are based on the AASHO tests of the early 1960s, subsequent laboratory studies, and reported field observations. These have generally indicated that heavier axle loads are responsible for a much more than proportionate amount of pavement damage. We measured the expenditures associated with maintaining serviceability over the period in question, identified with the maintenance and resurfacing expenditures defined above. The masses and distances run by the vehicle classes provide the basis for estimating the proportion of these expenditures to be assigned to each vehicle class. Pavement damage can be shown to be a function (greater than the fourth power, according to AASHO) of axle-load applications. This suggests that a causal and quantitative relationship exists between axle-load applications (axle kilometers of travel by various operating axle loads) and pavement damage or loss of serviceability. Thus, in principle, a function relating costs to pavement damage and axle kilometers of travel by different axle loadings can be established, and costs occasioned by vehicles that have various axle loads can be derived. [A more satisfactory way than this, in principle, to have answered the question of what maintenance expenditures were in fact occasioned by vehicle

classes would have been to sample actual experience--perhaps, for example, by relating expenditures for a cross section of roads to different vehicle mixes in a regression model. However, our inquiries showed no convincing empirical work of this kind and little prospect of satisfactorily fitting a current model without great expense (1).]

Maintenance accounted for $76 billion over the 20 years, or 27 percent of highway expenditures. It covered many kinds of operations--the repair of roadside drainage, of surfaces and bases, and of shoulders and structures, as well as traffic services and snow control. Pavement maintenance, the most important item, accounted for 40 percent of maintenance expenditures and varied considerably by road type. The heterogeneity of types of operations and their incidence argued in favor of separate treatments of the subcategories.

Examination of these activities shows that a number of them cannot be related to use of the roadway except insofar as the presence of the first vehicle on the road makes them all necessary. These include

1. Roadside and drainage--this consists primarily of mowing, seeding, and repair of the effects of erosion;
2. Snow control--this consists of plowing and salting;
3. Maintenance of structures--this consists primarily of painting and repair of the effects of weather and is not affected by use of structures by vehicles; and
4. Traffic services--this consists of signing, striping, and related operations.

To a very slight extent, ignored here, the cost of traffic services is affected by vehicle use in that use of the roadway by trucks requires the marking of truck routes, announcement of weighing stations, and so forth. No portion of these four cost items can be shown to have been occasioned uniquely by any particular vehicle class because they are equally necessary for all road users. This was, in fact, the approach adopted by the section 210 study.

Pavement and shoulder maintenance (including resurfacing) expenditures present more complex problems. Here, the indications are that different types of vehicles do cause different expenditures. In calculating them, we have to consider (a) the relationship between traffic, weather, and other forces and the physical deterioration of the pavement and (b) the relationship between the state of the pavement and the expenditures required for keeping up the road. The first has been the focus of most work to date.

The AASHO Road Test involved the construction of six test roadways and their subjection to repeated applications of six different types of vehicles. Careful measurement of pavement conditions was made, and all but the simplest maintenance activities were deferred until the pavement reached terminal serviceability and began to break up. Four important results emerged from analyses of these data:

1. The physical quality and structural soundness of a pavement decreases in proportion to the number of load applications to which it is subjected--each type of pavement can absorb some fixed number of load applications before failure;
2. For any given type of pavement, the number of load applications contained in its effective service life is inversely proportional to the mass of the load--service life decreases rapidly as vehicle masses increase;
3. The strength of a pavement, measured in terms of the number of load applications before failure, increases rapidly as pavement thicknesses increase; and
4. For different types of pavements, the rate of deterioration is, of course, different, but the general shapes of the deterioration function and the relative amounts of damage done by different load applications are the same.

Thus, for any given type of vehicle, the trend of pavement deterioration can be predicted with considerable accuracy solely on the basis of the volume of traffic that the road has carried over its lifetime. Furthermore, pavement damage increases very rapidly as vehicle masses increase.

The implication of the stability of the shape of the deterioration curves derived from the AASHO test data is that the equivalent damage factors, as shown below (1 kN = 225 lbf), will remain approximately constant over a range of types and thicknesses of pavements that includes essentially all those in service today (5).

Axle Load (kN)	No. of 80-kN Loads That Cause Equivalent Amounts of Damage
8.9 (passenger automobile)	0.0002
8.9-35.6	0.006
35.6-71.0	0.18
71.0-89.0	1.00
89.0-107.0	2.35
107.0-133.5	5.80
133.5-151.5	12.00
151.5-169.0	20.00
169.0-196.0	33.00

In other words, regardless of the strength or weakness of the roadway, most of the pavement deterioration will be the responsibility of the heaviest vehicles. The values are such that this will be true even if these vehicles represent only a very small fraction of the traffic stream.

No piece of research conducted since the AASHO Road Test has directly addressed the same question on anything like the same scale. The test results have been adopted around the world and have stood up well under the test of time. But, although the empirical work relating road use to pavement damage has yielded clear, definitive results, the relationship between damage and maintenance expenditures is much more difficult to establish. Apparently, very little attention has been devoted to this problem. One is left to hypothesize about the nature of this relationship.

The assumption made in this study is that the relationship between pavement and shoulder maintenance expenditure and damage is a very simple one. In particular, it is assumed that these costs are directly proportional to pavement damage (although this assumption must remain tentative until more research is done). Such evidence as is available suggests that this is not an unreasonable assumption. Over the long run, maintenance expenditures seem to vary directly with damage.

The measure of damage used in the pavement and shoulder maintenance cost allocation is the sum of the products of total axle kilometers of travel on each class of road in each axle-load category times the equivalence factor for that axle load. These factors are similar to those given above, but were made to correspond more closely to the available axle-load data. These were calculated directly from the AASHO Road Test results as presented in the report of that study (6). Thus, pavement and shoulder maintenance expenditures by road class are allocated in propor-

Table 1. Total expenditures and payments: 1956-1975.

	Amount ($ billion, current prices)							
	Pay-as-You-Go Approach				Roads-as-an-Industry Approach			
Type of Road	Expenditures[a]	User Payments[a]	Difference: Payments Minus Expenditures	Ratio of Expenditures to Payments	Outlays	Receipts[a]	Difference: Receipts Minus Outlays	Ratio of Outlays to Receipts
Rural	186.3	138.8	-47.5	1.34	211.8	144.3	-67.5	1.47
Urban	119.7	138.5	+18.8	0.86	128.7	158.2	+29.5	0.81
All	306.0	277.3	-28.7	1.10	340.5	302.5	-38.0	1.13

[a]Rural-urban breakdown based on splitting overhead expenses and yearly or one-time tax components between these roads in proportion to distribution of vehicle-kilometers of travel.

Table 2. Road expenditures and payments: 1956-1975.

	Rural Roads		Urban Roads		All Roads	
Year	Expen-ditures	Payments	Expen-ditures	Payments	Expen-ditures	Payments
1956	4 493	4051	2 628	3 438	7 121	7 489
1957	5 004	4486	3 008	3 790	8 012	8 276
1958	5 884	4363	3 492	3 713	9 376	8 077
1959	6 386	4951	3 785	4 158	10 171	9 109
1960	6 212	5140	3 854	4 303	10 066	9 443
1961	6 524	5459	4 189	4 625	10 713	10 084
1962	6 828	5970	4 471	5 000	11 299	10 970
1963	7 253	6422	4 690	5 310	11 943	11 731
1964	7 792	6909	4 976	5 677	12 768	12 586
1965	8 201	7087	5 192	6 101	13 393	13 188
1966	9 021	7069	5 711	6 370	14 732	13 439
1967	9 395	7214	6 096	6 780	15 491	13 994
1968	10 124	7749	6 578	7 578	16 702	15 327
1969	10 637	8409	6 868	8 532	17 505	16 940
1970	12 045	8467	7 751	9 079	19 796	17 545
1971	12 830	8866	8 579	9 974	21 409	18 840
1972	13 229	8244	8 819	9 811	22 048	18 054
1973	13 876	8757	9 017	10 920	22 893	19 678
1974	14 710	8890	9 473	10 909	24 183	19 799
1975	15 849	9456	10 321	11 571	26 170	21 027

tion to the equivalent axle kilometers traveled on them. Differences in the age and construction standards of these road classes resulted in considerable variation among them in expenditures per equivalent axle kilometer.

The resulting pavement and shoulder maintenance expenditure allocations assign a much higher fraction to heavier vehicles than was the case in the section 210 study. The staff of that study considered an approach such as ours, but dismissed it because they felt that automobiles and other light vehicles had a negligible effect on pavement performance because the road had been designed to very high standards in order to carry heavy loads. A thin pavement designed for and used by automobiles only would, they argued, require very nearly the same amount of maintenance as the thick mixed-traffic pavement. Thus, the amount of maintenance expenditures they charged exclusively to heavy vehicles was the small difference between the cost of the mixed road and the cost of an automobile-only road. To charge heavy vehicles both for construction costs and maintenance costs would, they thought, constitute double counting. Whatever the merit of this rationale, however, it reflects essentially a different interest from ours. The section 210 study was concerned with what should be allocated to different vehicle classes. We are concerned with the determination of the costs actually occasioned by different vehicle classes; thus, we can ignore the difficult question of the determination of just what an optimally designed pavement for differing vehicle classes would look like and use the AASHO-based figures to represent our best estimate of what actually occurred.

Table 3. Payments and expenditures by vehicle class: 1956-1975.

	Amount ($ billions, current prices)		
Item	Rural Roads	Urban Roads	All Roads
Light Versus Medium and Heavy Vehicles			
Payments			
Light vehicles	94.4	114.7	209.6
Medium and heavy vehicles	43.9	23.8	67.7
Expenditures			
Occasioned			
Light vehicles	0.5	0.3	0.8
Medium and heavy vehicles	43.4	18.7	62.1
Common	142.4	100.7	243.1
Light and Medium Versus Heavy Vehicles			
Payments			
Light and medium vehicles	119.7	129.9	250.6
Heavy vehicles	19.1	7.6	26.7
Expenditures			
Occasioned			
Light and medium vehicles	13.6	5.5	19.1
Heavy vehicles	20.3	6.3	26.6
Common			
All Vehicles			
Payments	138.8	138.5	277.3
Expenditures	186.3	119.7	306.0

Table 4. Payments and occasioned expenditures.

	Amount ($ billions, current prices)					
	Rural Roads		Urban Roads		All Roads	
Year	Occasioned Expendi-tures	Pay-ments	Occasioned Expendi-tures	Pay-ments	Occasioned Expendi-tures	Pay-ments
Medium and Heavy Trucks and Buses						
1957	1.40	1.70	0.50	0.60	1.90	2.30
1964	2.10	2.05	0.90	0.95	3.00	3.00
1969	2.85	3.05	1.25	1.50	4.10	4.55
1975	4.15	3.90	1.60	2.10	5.75	6.00
Heavy Trucks						
1957	0.55	0.45	0.15	0.20	0.70	0.65
1964	0.95	0.80	0.35	0.30	1.30	1.10
1969	1.20	1.25	0.40	0.55	1.60	1.80
1975	1.80	1.95	0.50	0.90	2.30	2.85

STUDY RESULTS

Road Users as a Whole

The results of the accounting for the road system as a whole are shown in Table 1 (1). Congressional objectives to achieve a pay-as-you-go system were not

achieved for the roads as a whole; expenditures exceeded payments by $29 billion, or 10 percent. A sharp distinction exists, however, between rural roads and urban roads. Whereas payments exceeded expenditures for urban roads, expenditures were about one-third more than payments in the case of rural roads. Viewing the individual components of these totals, it seems fairly clear that this rural-urban contrast should be interpreted as a distinction of between-urban use and within-urban use, rather than a rural-dwellers versus town-dwellers contrast.

If one considers the trend of events over the 20-year period, a somewhat different picture emerges (Table 2) (1). When all urban roads are taken together, payments exceed expenditures throughout the period except for a few years in the late 1950s, when there was an approximate balance. However, payments were consistently below expenditures for all rural roads taken together, and this discrepancy grew with time. For all roads in aggregate, expenditures exceeded payments in all years except the mid-1950s and the early 1960s, when there was an approximate balance.

These contrasting trends over time underline the need to present the second approach--that of regarding the roads as an industry or industries. A private industry faced with a time lag of this sort between expenditures and receipts would be forced to borrow money to make up the difference. Interest charges on these loans are real costs, because they represent the opportunity cost of other types of output foregone. Application of the industry analogy to the road system requires the computation of the finance charges incurred because of the lag between receipts and expenditures and their addition to the expenditure accounts.

The results of viewing the roads in this way are also shown in Table 1. Comparing the results of the pay-as-you-go approach with those of the roads-as-an-industry approach shows that the contrast between road types is sharper in the latter approach. For roads as a whole, outlays exceed receipts by 13 percent, rather than 10 as before. The rural roads together appear worse, and the urban roads appear better when compared with the pay-as-you-go approach. For all three road categories, the imbalances tended to get cumulatively worse.

Individual Vehicle Classes

Here, we consider three user classes. Occasioned expenditures consist of those due to climbing lanes, structural strength, vertical clearance, and lane and shoulder widths and of those due to maintenance and resurfacing expenditures. Table 3 brings together the payments and expenditure data.

In discussing all road users, we saw that urban roads were distinguished from rural roads in that urban payments exceeded expenditures in total and in most years, whereas in the rural case, the opposite was true. From Table 3 it is clear that, because of the incidence of common costs that cannot be assigned to any one class, the picture changes greatly when direct attribution to users is attempted. Total payments for all road users greatly exceed occasioned expenditures. When vehicle classes are considered, lighter vehicles paid much more than they occasioned, especially for urban roads. For heavier vehicles, there is a much closer balance. Here, occasioned expenditures just exceeded payments for rural roads, but did not do so for urban. When heavy vehicles are grouped with medium trucks and buses, so that a greater proportion of expenditures can be attributed to the group as a whole, a rather different pattern emerges, in that payments now just exceed expenditures for rural roads and, for urban, payments exceed expenditures quite comfortably. Thus, the contrast between urban and rural roads is confirmed here, but it is difficult unequivocally to assert that any vehicle class was not meeting its expenditures on a pay-as-you-go basis.

The closeness of the payments and occasioned-expenditures figures for the heavy and heavy-plus-medium categories again makes the time trend important. Table 4 compares payments and expenditures for 4 of the 20 years--1957, 1964, 1969, and 1975. For heavy and medium trucks and buses, payments in every case exceeded occasioned expenditures for urban roads and the difference tended to increase over time. There was a close and fluctuating balance for rural roads. For heavy trucks, the trend is fairly clear for both types of roads--an early position of deficit with respect to occasioned expenditures is reversed in later years, reflecting a shift in the taxation borne by that class.

As in the analysis of the road system as a whole, the discrepancies between occasioned expenditures and payments described above and their time trends can be picked up in the requirement for financing, year by year, in the industry approach. The discrepancies sharpen for this approach. The heavy-truck receipts are now clearly lower than the occasioned outlays for rural roads and for all roads taken together. For heavy and medium trucks and buses taken together, the receipts clearly exceed the occasioned outlays throughout the 20-year period for rural, urban, and all roads. For heavy trucks, the overall picture is quite similar to that for the pay-as-you-go approach except that, under the industry approach, the occasioned outlays on rural roads exceed receipts in all years except the last two. Thus, the trend toward a balance is apparent only over the past few years. When all roads are taken together, as for the pay-as-you-go approach, the heavy-truck occasioned outlays exceeded receipts during the earlier years before the picture was reversed. The only difference is that this changeover occurred later for the industry approach.

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REFERENCES

1. K. Bhatt, M. Beesley, and K. Neels. An Analysis of Road Expenditures and Payments by Vehicle Class: 1956-1975. Urban Institute, Washington, DC, 1977.
2. K. Bhatt, R. McGillivray, M. Beesley, and K. Neels. Congressional Intent and Road-User Payments. Urban Institute, Washington, DC, 1977.
3. Final Report of the Highway Cost-Allocation Study. 87th Congress, 1st Session, House Document 54, 1961.
4. Supplementary Report of the Highway Cost-Allocation Study. 89th Congress, 1st Session, House Document 124, 1965.
5. R. Whiteside, T. Chu, J. Cosby, R. Whitaker, and R. Winfrey. Changes in Legal Vehicle Weights and Dimensions. NCHRP, Rept. 141, 1974.
6. The AASHO Road Test: Report 5--Pavement Research. HRB, Special Rept. 61E, 1962.

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