Applications of Earnings-Credit and Relative-Use Methods of Highway Cost Allocation

C. A. STEELE and T. R. TODD, respectively, Deputy Chief, Economic Research Division, and Chief, Finance and Taxation Research Branch, U. S. Bureau of Public Roads

In the final report on the Highway Cost Allocation Study, the Federal-aid highway program cost responsibilities were allocated between highway users and other beneficiaries on the basis of an averaging of the cost responsibilities as found in the relative-use and earnings-credit procedures. Neither procedure is new, but the added information then available made possible much more thoroughgoing and sophisticated analyses than could be made at the time of their previous application. Although these analyses were oriented primarily toward the Federal-aid portion of the total highway program, the improved techniques developed could also be applied to similar analyses covering all road and street systems at either the National or the State level. This paper sets forth the reasons for the development of the new techniques, explains the modifications made (showing how they differ from the procedures previously used), and indicates how they may be applied in other studies.

• ONE REQUIREMENT of the Highway Cost Allocation Study requested by Section 210 of the Highway Revenue Act of 1956 was "to make available to Congress information on the basis of which it may determine . . . an equitable distribution of the tax burden among the various classes of persons using the Federal-aid highways or otherwise deriving benefits from such highways." The Congress thus requested information concerning a problem that has plagued highway tax and finance researchers for many years, and one that will probably continue to be a subject of research and discussion for many more.

It is almost universally accepted among specialists in the field of highway finance that the tax burden of supporting highways, roads, and streets should, first, be allocated between the users and nonusers, and, second, among the various classes of users. It has been customary to attempt to allocate highway cost responsibility on the basis of estimates of either benefits received or costs caused, although other bases, such as ability to pay, or some combination of bases have been tried on occasion, or at least considered. The fact that benefits received from highways frequently accrue indirectly to ultimate beneficiaries complicates the benefit-allocation analyses considerably, but it does not change the underlying concepts.

Some authorities on government and finance, though recognizing the propriety of allocating highway costs among the various classes of highway users, are convinced that nonusers should not be required to support any part of the cost of the principal road systems. It is recognized that in this complex problem, as in others of public concern, theory alone is not always right or sufficient for practical application; and that considerations of general fiscal policy, as distinguished from highway finance taken alone,

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may at times invalidate carefully worked out solutions of the allocation problem.

Other public finance theorists and practitioners would completely reject the establishment of any relationship between highway disbursements and the taxation of highway users in any form at any level. Their reasons for this attitude vary. Thus, one authority believes that centralized control should be exercised over all areas of public expenditure, and that no single area should be "untouchable" and exempt from control by having a portion of governmental receipts earmarked for it. Another objects to the allocation of such a large proportion of a jurisdiction's resources to a single function of government, while others — education and health are most frequently cited — go vainly begging for funds. A third, and he would represent a good proportion of modern economic theorists, would object because he believes that, to conserve and ration economic resources, highway financing should be approached from a pricing rather than a taxing standpoint. As Zettel said in a panel discussion of perplexing financial problems facing the State highway departments held during the 47th Annual Meeting of the American Association of State Highway Officials in October 1961:

> . . . there are some economists now who believe that the raising of the money from highway users should be entirely unrelated to highway costs. They would ration highway space, they would set prices high enough to make demand clear the market. These . . . argue that highways are badly underpriced.

Another group of economists would almost completely reject the fundamental concept that the provision of highways is a governmental function. They would treat the highway function as a public utility, to be supported wholly by charges to be levied against those who benefited from the highway network.

However, nearly all the States and the Federal Government have now embraced the philosophy of levying taxes on motor vehicles and their use and earmarking the proceeds for the support of the highway function. They have in effect voted down all the other philosophies just listed, largely because the tax-paying public has demanded more and better highways, and has clearly indicated its willingness to pay for them through imposts related in one way or another to highway use.

The Highway Revenue Act of 1956 adopted this philosophy of earmarking the proceeds of highway-user taxation for the Federal support of the highway function, thereby reversing the long-standing policy of supporting Federal aid for highways from general revenues.

COST ALLOCATION STUDY PROCEDURES

In carrying out the mandate of the Highway Revenue Act of 1956 concerning the allocation of the costs of Federal-aid highways between motor-vehicle users and others, the Highway Cost Allocation Study staff (1, p. 6) decided on the following procedure:

> First, to identify and evaluate any specific costs that may not be allocable to motor-vehicle users; second, to work out a general allocation between motor-vehicle users and others by the use of methods that have been in previous Federal and/or State studies of the problems of Highway cost allocation.

For the allocation of highway costs between motor vehicle users and others, the staff chose the "relative-use" and "earnings-credit" methods, the basic concepts of which are generally well known among those who have critically studied problems relating to highway taxation.

Recognizing that highway cost allocation is far from being an exact science, the staff of the Highway Cost Allocation Study considered that a compromise between the conflicting findings of the two studies would probably be more readily accepted than those of either alone. Accordingly, a compromise of the findings of the relative-use and

earnings-credit studies was developed and presented in the final report.

This paper is primarily concerned with describing how the relative-use and earnings-credit allocations were made. Special attention is devoted to the improved techniques applied. Although these analyses were oriented primarily toward the Federal-aid portion of the total highway program, the modified techniques employed could also be applied to similar analyses covering all road and street systems at either National or State levels. Examples of actual State-level application are cited.

SOME FUNDAMENTAL CONCEPTS

There is little room for disagreement with the position taken in the Final Report of the Highway Cost Allocation Study (1, pp. 6-7) that no adequate method of measuring the nonvehicular benefits derived from highways has been developed; and, that, in consequence, no way of comparing vehicular and nonvehicular benefits is now available. However, neither the relative-use nor the earnings-credit approach involves the direct analysis of benefits, with the result that the need for direct comparisons of the two types of benefits does not arise.

The relative-use study attempts to assign cost responsibility for each road and street system to users and nonusers in proportion to the extent to which each system renders through-traffic service, community or neighborhood service, or access service. The prosecution and findings of the study are, of course, influenced materially by the definitions and measurements adopted as representative of the three components of total traffic. Variations in defining the three components can vary the final results by a considerable degree. The division of highway service into categories of through-traffic, neighborhood, and land service suggests a parallel allocation of tax responsibility to the motor-vehicle user, to the community, and to land.

The earnings-credit method of cost allocation is based on a pragmatic rather than a theoretical approach to the problem. It combines concepts of the relative-use and standard-cost methods of allocation. Under the standard-cost concept, which was used in a 1951 highway finance study in Ohio, each primary rural and urban road system would be allocated user taxes at a unit rate — per vehicle-mile or ton-mile of travel over it — sufficient to meet its full costs.

Those portions of the costs of other systems not covered by this procedure would need to be met from the property taxes and other general revenues. A description of the standard-cost approach has been given by Simpson (2, pp. 81-87).

The earnings-credit study attempts to assign cost responsibility for each of the several highway and street systems by mediating or averaging such cost allocations between two somewhat inconsistent concepts: (a) each road and street system should receive an allocation of road-user tax revenues at a rate, per vehicle-mile of travel on it, adequate to support the primary or top rural and urban highway systems; and (b) each road and street system should receive an allocation of nonuser tax revenues at a rate, per mile of road or street on it, adequate to support the bottom or lowest-density road or street systems.

RELATIVE-USE STUDY

The principle of taxation according to benefit received underlies not only the practice of road-user taxation but also that of property taxation levied for the support of highways. Measurement of the cost responsibility of nonuser beneficiaries is complicated by the fact that benefits accruing to nonusers are now, in large part, transfers of benefits realized in the first instance by highway users; thus, charges paid by commercial users initially are transferred through the prices charged for their services.

St. Clair (3) postulates that cost responsibility for each road and street system may be allocated between users and nonusers by some measure of the relative amount of service each system renders to abutting property owners, to communities, and to motorists.

Before the 1950's, researchers and investigators were seriously handicapped in their efforts to make highway cost allocation analyses by the lack of usable data. This lack has been, to a substantial degree, reduced by the increasing amount of data made

available from the highway planning studies conducted by various State highway departments. As a result of the ever-growing reservoir of factual information, the researchers and investigators have been able to apply scientific study procedures to the cost allocation analyses instead of using the subjective approach.

Among the "scientific" approaches which have become applicable with the increasing availability of certain basic data, is the relative-use method, which St. Clair (3, pp. 3-4) describes as follows:

> A procedure which has been called the theory of relative use would allocate highway tax responsibility in accordance with the extent to which different classes of highways render different kinds of service. The service of direct access to land, although it is the predominant function of local roads and residential streets, is provided to some degree by all classes of highways except controlled-access facilities. Similarly, there is some through traffic even on unimportant roads and quiet streets. There is an intermediate service, that of providing access to neighborhoods, which is the primary function of roads and streets of intermediate traffic importance. This division of highway service into categories of land service, local or neighborhood service, and through-traffic service, immediately suggests the parallel allocation of tax responsibility to the land, the community or general tax base, and the motor-vehicle user.
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> Tax responsibility for the support of a given unit road section would, under the relative-use theory, be allocated as follows: to the land, the annual cost of a road facility adequate to support the existing volume of land-service traffic; to the community or general tax base, the annual cost of a facility adequate to support the existing volume of land-service plus community-service traffic, less the increment of cost assignable to the land; and to the motor-vehicle user, the annual cost of a facility adequate to support the total volume of traffic in the section, less the increments of cost assignable to the land and the community. Application of this procedure to a representative sample of all road and street sections in a given State would lead to an evaluation of the respective total highway tax responsibilities of the land, the community, and the highway user.

St. Clair also points out that this general approach to cost allocation was used by the Federal Coordinator of Transportation (4) as an alternate to the added-expenditure method; and subsequently by the Board of Investigation and Research (5), in its public aids study. Other students of the problem have accepted the relative-use thoory in principle, but have simplified its application by allocating tax support in accordance with the predominant type of use to which a given road is put.

In the years that have passed since St. Clair published his report, he and others have done a considerable amount of work toward providing more scientific tools and materials for the relative-use analysis. These efforts included pilot "road-service" studies conducted in Oregon and Washington, which were essentially roadside-interview origin-destination studies made to determine the character of service rendered by selected unit rural road sections. Attempts were also made to apply information obtained for statewide highway physical needs studies toward improving the relative-use analysis techniques.

Application of New Data

The motor-vehicle-use studies that have been conducted on a statewide basis by more than one-half of the State highway departments with Public Roads cooperation since 1951 appear to offer possibilities for the development of a more practical and yet scientific

method for making the relative-use analysis than any attempted or suggested previously. These studies provide data on number of trips, purpose of trip, trip length, highway systems used, place of origin, and place of destination. However, the tabulations customarily prepared from these studies are not in the detail necessary for the relative-use analysis. Therefore, recourse must be made to a special trip-by-trip analysis of the original interview forms to obtain the required information. Consequently, during the summer and fall of 1960 the Highway Economics Branch of the Bureau of Public Roads attempted to develop and apply procedures utilizing this data source.

Because in the relative-use analysis mileage of access, neighborhood, and through travel measures each type of service rendered by each road system it became necessary, first, to establish definitions of these terms to which the data available from the motor vehicle use studies could be adapted. It was also equally necessary to define what is meant by a neighborhood in terms of a plane of reference that is consistent with the findings of these studies.

For the study made by the Bureau of Public Roads, information about individual motor-vehicle trips was obtained from a sample of the questionnaires collected in studies conducted by four States: Colorado, Delaware, Kansas, and Tennessee. A comparison with some other data provides one indication that this very small, and perhaps not overly representative, sample provides an acceptable basis for a National relative-use study. Table 1 and Figure 1 show the trip-length distribution for passenger cars from three sets of sample estimates. The first set is that obtained from the four-State subsample. The second set is that obtained by combining the results of motor-vehicle studies conducted in 19 States. The third set is based on the preliminary results of a National automobile-use study conducted independently for the Bureau of Public Roads by the Bureau of the Census.

TABLE 1

PERCENTAGE DISTRIBUTION OF VEHICLE-MILES OF PASSENGER CARS BY TRIP-LENGTH GROUPINGS FOR THREE SETS OF SAMPLE ESTIMATES

One-Way Trip-Length (mi)	Passenger Car Vehicle-Mile Distribution (%)					
	Relative-Use Analysis[1]		Motor-Vehicle-Use Studies[2]		National Auto-Use Survey[3]	
	Actual	Cumulative	Actual	Cumulative	Actual	Cumulative
Under 5.0	12.2	12.2	13.2	13.2	12.3	12.3
5.0 - 9.9	12.2	24.4	15.4	28.6	16.8	29.1
10.0 - 14.9	10.4	34.8	11.2	39.8	14.1	43.2
15.0 - 19.9	9.1	43.9	8.2	48.0	8.4	51.6
20.0 - 29.9	12.3	56.2	10.4	58.4	13.2	64.8
30.0 - 39.9	10.5	66.7	6.5	64.9	7.3	72.1
40.0 - 49.9	8.8	75.5	4.3	69.2	4.1	76.2
50.0 - 99.9	16.4	91.9	10.8	80.0	10.5	86.7
100.0 and over	8.1	100.0	20.0	100.0	13.3	100.0
Total	100.0	-	100.0	-	100.0	-

[1] Based on motor-vehicle-use studies in Colorado, Delaware, Kansas, and Tennessee, excluding travel on toll roads.

[2] Based on motor-vehicle-use studies conducted in 19 States during 1951-56, including travel on toll roads.

[3] Preliminary tabulations from survey conducted for Bureau of Public Roads by the Bureau of the Census during fall of 1959; data obtained chiefly from travel logs kept by respondents, with travel on toll roads included.

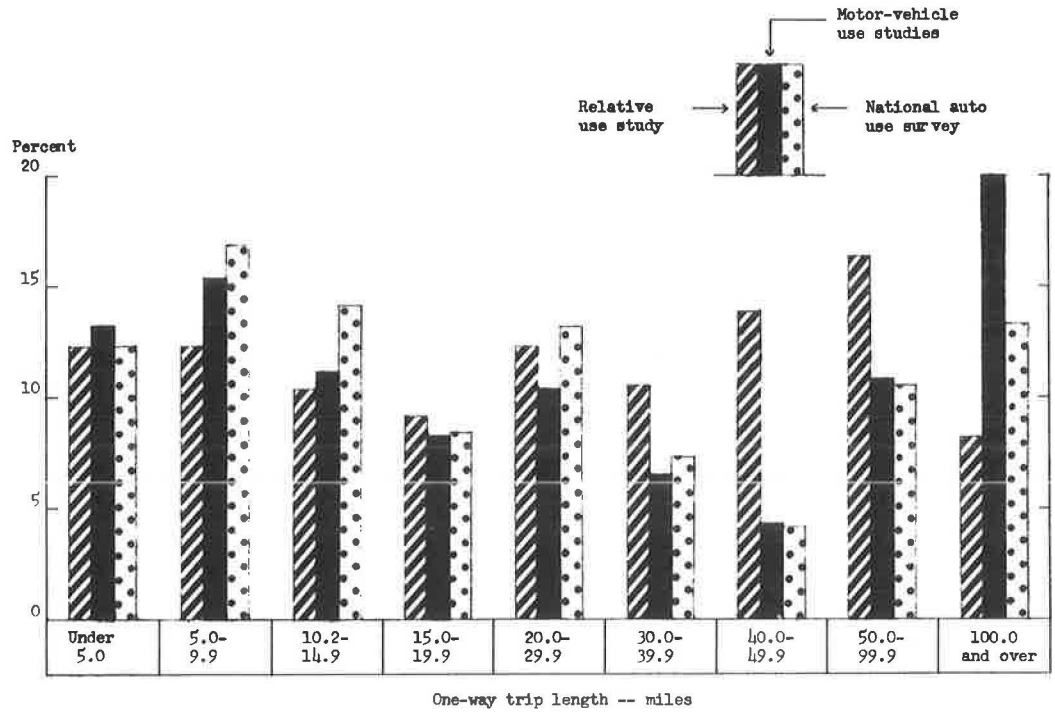

Figure 1. Percentage distribution of vehicle-miles of passenger cars by trip-length groupings for three sets of sample estimates.

The three distributions agree fairly well. At worst, the data for the relative-use analysis underestimate to a small extent the proportion of shorter trips. This possible bias would tend to cause an underestimate, on the National level, of the magnitude of nonuser cost responsibility because of the corresponding overrepresentation of the through-traffic component. On the other hand, it may result in a reasonably accurate forecast of the passenger car trip-length distribution at a time when better roads may be expected to encourage a greater proportion of longer trips.

Table 2 gives by States the total number of interview forms (cases) entering into the analysis for the relative-use study, the corresponding number of trips, and the total number of road system segments used on these trips.

TABLE 2

NUMBER OF CASES, TRIPS, AND ROAD SYSTEM SEGMENTS ANALYZED FOR RELATIVE-USE STUDY

State	Number of Cases	Number of Trips	Number of Road System Segments[1]
Colorado	121	1,044	2,084
Delaware	80	497	1,270
Kansas	177	1,457	2,825
Tennessee	189	2,006	4,242
Total	567	5,004	10,421

[1] Each highway system used on a trip was counted once only for that trip no matter how many times trip route included sections of system.

Access and Neighborhood Segments

Before analysis of any reported trip could be undertaken, it was necessary to define what constituted the "access" portion of a trip, and what constituted the "neighborhood" portion. Any remainder of a trip then constituted the "through travel" portion.

Access Segments. — In the paper previously cited (3), the access portion of a trip was defined as the sum of the distance in the direction of travel along the road or street serving the point of origin of the

TABLE 3

NUMBER OF SAMPLE LENGTHS AND AVERAGE BLOCK LENGTH

1950 Population	City	Uptown		CBD	
		No. of Sample Lengths	Avg. Block Length (mi)	No. of Sample Lengths	Avg. Block Length (mi)
100,000 or more	Wichita, Kans.	157	0.08	59	0.08
	Kansas City, Mo. - Kans.	230	0.08	104	0.07
	Wilmington, Del.	88	0.06	47	0.06
	Dallas, Texas	97	0.08	56	0.06
	San Diego, Calif.	91	0.07	65	0.06
25,000 to 100,000	Muncie, Ind.	54	0.06	26	0.06
	Fayetteville, N. C.	21	0.08	25	0.09
	Lancaster, Pa.	32	0.06	34	0.06
	Boulder, Colo.	38	0.08	32	0.08
5,000 to 25,000	Americus, Ga.	19	0.09	5	0.07
	Aberdeen, S. Dak.	44	0.07	20	0.07
	Gardner, Mass.	24	0.09	- [1]	- [1]

[1] Not determinable; measurements taken in every area.

trip to the first intersection, and the distance from the last intersection to the destination. This definition was applied without modification to reported trips beginning or ending in unincorporated areas, inasmuch as trip beginnings and trip ends could be accurately located on county culture maps prepared by the State highway departments.

Available information was not sufficient to pinpoint an origin or destination on a map of urban streets. A standardized access distance, therefore, had to be adopted to make analysis possible. Samples of the block lengths of a few cities of various sizes — size being equated to 1950 population — were map-measured to yield estimates of the average block length in each city-size group. In all except one case, a separate average was calculated for block lengths in the central business district (CBD) and in the remainder of the city. Each measurement was of several blocks in a straight line to reduce the relative error for a single block. Table 3 gives the results.

No well-defined trends could be discerned among the sample cities. Therefore, a uniform standard length of 0.08 mi was adopted; this block length lay between the two extremes of 0.06 and 0.09 mi.

The access segment within cities was always taken as one-half the standard block length, or 0.04 mi.

Neighborhood Components. —Two basic approaches were considered in defining a neighborhood. St. Clair (3) defines a neighborhood as an area of such size as to generate a prescribed number of trip ends (origins and destinations) per day. Available data were not sufficiently detailed to permit the ready establishment according to this approach of standardized neighborhoods for areas of varying population density and land use. A sociologically-oriented definition of neighborhood was, therefore, considered and adopted. Under this approach, neighborhoods are recognized, among other criteria, by the presence of certain facilities and services, such as elementary schools, churches, and local businesses; by a general homogeneity of development; and by the absence of physical barriers that would impede or prevent the normal flow of neighborhood traffic.

The approach adopted also avoids one area of criticism of the St. Clair hypothesis — the determination of neighborhood size strictly on the basis of the number of trip ends generated. It has been contended with merit that to delimit neighborhoods on this basis is neither practical nor correct in theory, although it is granted that for purposes of allocation by the relative-use method the "neighborhood" definition adopted does not need to be in agreement with generally-recognized "community" concepts. It is pointed out, however, that a single block in a downtown business zone, an industrial area, or a

TABLE 4

DISTRIBUTION OF TRIPS MADE FOR FAMILY-NECESSITOUS PURPOSES CLASSIFIED BY STATE, POPULATION GROUP OF RESIDENCE, AND BY TRIP LENGTH

State	Population Group	Trip Distribution for Trip Length of													Total No. of Trips
		0.1 - 0.9 mi	1.0 - 1.9 mi	2.0 - 2.9 mi	3.0 - 3.9 mi	4.0 - 4.9 mi	5.0 - 5.9 mi	6.0 - 6.9 mi	7.0 - 7.9 mi	8.0 - 8.9 mi	9.0 - 9.9 mi	10.0 - 14.9 mi	15.0 - 19.9 mi	20.0 mi and over	
Kansas	Incorporated places of:														
	100,000 and over	74	58	48	27	9	7	6	1	2	1	2	-	1	236
	25,000 - 99,999	67	38	32	16	13	3	2	1	1	2	2	2	-	179
	5,000 - 24,999	78	77	19	7	7	2	3	-	2	-	6	-	6	213
	1 - 4,999	97	19	13	4	4	6	2	-	2	1	11	-	13	171
	Unincorporated areas	44	24	38	21	21	18	15	11	4	2	18	33	15	263
Delaware	Incorporated places of:														
	100,000 and over	26	50	20	22	6	1	-	-	-	4[a]	-	-	-	129
	25,000 - 99,999[b]	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	5,000 - 24,999	110	62	4	4	2	4		10	2	10[a]	-	-	-	208
	1 - 4,999	168	8	2	4	16	4	12	-	-	56[a]	-	-	-	270
	Unincorporated suburban areas	10	16	22	6	28	6	14	-	-	4[a]	-	-	-	107
	Unincorporated nonsuburban areas	24	56	60	78	72	73	50	26	28	170[a]	-	-	-	637

[a]9.0 mi or greater.
[b]No place of this size in State.

dense apartment area might easily generate more trip ends per day than would a thousand square miles in a sparsely settled rural area, which is typical of at least 17 States west of the Mississippi River.

The motor-vehicle-use studies offered a means of at least partially employing the sociological concept of a neighborhood. It is a matter of general knowledge that trips to transact family business (such as medical, dental, or shopping trips) as well as trips to school and church are very frequently made to neighborhood destinations, although the present counter tendency for the cruising radius of the family car to increase is recognized. Any samples of trips made for such purposes, such as described in motor-vehicle-use study questionnaires, would be expected to show a pronounced clustering about a value that could be taken as the neighborhood radius, especially if the analyses were made separately for each population group.

The trip lengths for a sample of the interview forms from the Kansas and Delaware studies were analyzed to discover any clustering tendency. The results are given in Table 4.

For incorporated places, by far the most frequent family business trips were those of less than 2.0 mi. Within this group, when trips were arrayed in increments of 0.1 mi each, trips tended to cluster around 1.0 mi. No pronounced variation in the modal trip length with size of incorporated place could be established.

No consistent tendency to cluster could be discerned for trips made by residents of unincorporated areas on family business. Because no positive basis could be found for a unique definition of a standard neighborhood in unincorporated areas, a uniform definition of 1.0 mi was adopted for the original analysis for the standard neighborhood around all points of origin and destination, with one exception. That exception is for points within the CBD of a place of 5,000 or more people. Because of the narrow and congested character of CBD's, a distance of 0.5 mi was used to define the neighborhood area around points of origin and destination within them.

"Through-Travel" Components.—The "through" portion of a trip is the mileage remaining after the access and neighborhood components have been subtracted. For purposes of the original analysis, through travel was divided into two types, A and B.

Inasmuch as the data available did not permit an exact classification, the classification was made arbitrarily on a graduated trip-radius basis, depending on the type of area in which the trip occurred. Thus, those portions of through travel occurring within 3 mi of the point of origin or destination in unincorporated areas were classified as "through travel, type A," and those portions beyond that point were classified as "through travel, type B." Similarly, a radius of 5 mi was used for medium-sized urban places, and one of 7 mi for the larger metropolitan areas. Although this breakdown was carried throughout the analysis, it was dropped in the final stage when the travel percentages were applied against the dollar program requirements; here the two subtypes of through travel were combined.

Assignment of Trip Mileages

With the adoption of these definitions, it was possible to assign trip mileages to appropriate highway systems and to proper service components. Trip routes that were reported on the motor-vehicle-use study interview schedules for the four States noted earlier were traced on highway maps. Construction of the Interstate System was not far advanced when data for the latest of the motor-vehicle-use studies were collected in 1958. Therefore, the highways that most closely paralleled the routes of the projected Interstate System were designated as comprising that system for the purpose of the relative-use analysis.

The procedure outlined next was adopted for assigning the travel to the correct system and to the proper components of access, neighborhood, and through traffic. The information was entered on coding forms, a sample of which is appended to this paper. To simplify the coding procedures, a separate line was used to record each system-segment of a trip as it was encountered. Thus, if county highways were used on two different portions of a given trip, a separate entry was made for each portion.

"Through travel, type B" is not recorded on the form. It was calculated by subtracting the sum of the mileages shown under "access" (cols. 30-32), "neighborhood (cols. 33-36), and "through travel, type A" (cols. 37-41) from the system-segment total (cols. 25-29). All travel was recorded on one-hundredths of a mile to provide for exact recording of the "access" portions of the trips.

The detail of this procedure was as follows:

1. For a given trip, the highway systems and the mileage traveled on each system were listed in the sequence they were encountered on the trip. Any system might be listed more than once if the trip entered and left that system more than once.
2. The appropriate length of access mileage was credited to the proper system at both origin and destination ends of the trip. This was determined by map measurement for any origin or destination located in an unincorporated, nonsuburban area. Elsewhere, the standardized distance of 0.04 mi was assigned.
3. If any of the listed mileage then remained unassigned, net neighborhood mileage was assigned to the system or systems with the mileages listed immediately following the access mileage, both at the origin and destination end of the trip. Net neighborhood mileage equaled the standard neighborhood radius of 1.0 mi (except for 0.5 mi in CBD's) minus the assigned access mileage. In some cases the trip was so short as to require assignment of all the mileage to the access components.
4. After deduction of the access and neighborhood components, any remaining trip mileage was assigned to the through-traffic component (subdivided between types A and B in the original analysis) and credited to the proper system or systems.

Results

This analysis technique for the trip data in the motor-vehicle-use study sample was applied separately to two vehicle groupings: (a) passenger cars, and (b) trucks and combinations. The distributions of sample mileages by systems were converted to percentage distributions and weighted by the total vehicle-miles of traffic on the system. Two sets of weight bases were used, the nationwide travel estimates for 1957 and the nationwide travel forecasts for 1975. However, Tables 5 and 6 present the unweighted sample distributions as more amenable to weighting with different system and total

TABLE 5

ESTIMATED PERCENTAGE DISTRIBUTION OF TRAVEL BY PASSENGER CARS AND TRUCKS AND COMBINATIONS BY HIGHWAY SYSTEM AND BY RELATIVE-USE CLASSIFICATION COMPONENTS, SOCIOLOGICAL CRITERIA: 1957

Highway System	Area	Distribution of Travel (%)				
		Access	Neighborhood	Access + Neighborhood	Through	Total
(a) Passenger Cars						
Interstate	Rural	1.38	3.05	4.43	95.57	100.00
	Urban	0.52	14.96	15.48	84.52	100.00
Other Federal-aid primary	Rural	0.75	3.40	4.15	95.85	100.00
	Urban	0.69	23.89	24.58	75.42	100.00
Federal-aid secondary	Rural	1.98	8.49	10.47	89.53	100.00
	Urban	0.67	32.17	32.84	67.16	100.00
Non-Federal-aid	Rural	16.62	20.32	36.94	63.06	100.00
	Urban	5.06	63.46	68.52	31.48	100.00
(b) Trucks and Combinations						
Interstate	Rural	0.60	1.11	1.71	98.29	100.00
	Urban	0.24	5.49	5.73	94.27	100.00
Other Federal-aid primary	Rural	0.82	2.20	3.02	96.98	100.00
	Urban	0.40	13.66	14.06	85.94	100.00
Federal-aid secondary	Rural	2.46	8.50	10.96	89.04	100.00
	Urban	0.78	23.86	24.64	75.36	100.00
Non-Federal-aid	Rural	14.97	20.02	34.99	65.01	100.00
	Urban	3.79	53.88	57.67	42.33	100.00

TABLE 6

FORECAST PERCENTAGE DISTRIBUTION OF TRAVEL BY PASSENGER CARS AND TRUCKS AND COMBINATIONS BY HIGHWAY SYSTEM AND BY RELATIVE-USE CLASSIFICATION COMPONENTS, SOCIOLOGICAL CRITERIA: 1975

Highway System	Area	Distribution of Travel (%)				
		Access	Neighborhood	Access + Neighborhood	Through	Total
(a) Passenger Cars						
Interstate	Rural	0.40	2.38	2.78	97.22	100.00
	Urban	0.33	12.48	12.81	87.19	100.00
Other Federal-aid primary	Rural	0.75	3.40	4.15	95.85	100.00
	Urban	0.69	23.89	24.58	75.42	100.00
Federal-aid Secondary	Rural	1.98	8.49	10.47	89.53	100.00
	Urban	0.67	32.17	32.84	67.16	100.00
Non-Federal-aid	Rural	16.62	20.32	36.94	63.06	100.00
	Urban	5.06	63.46	68.52	31.48	100.00
(b) Trucks and Combinations						
Interstate	Rural	0.17	0.97	1.14	98.86	100.00
	Urban	0.21	5.04	5.25	94.75	100.00
Other Federal-aid primary	Rural	0.82	2.20	3.02	96.98	100.00
	Urban	0.40	13.66	14.06	85.94	100.00
Federal-aid secondary	Rural	2.46	8.50	10.96	89.04	100.00
	Urban	0.78	23.86	24.64	75.36	100.00
Non-Federal-aid	Rural	14.97	20.02	34.99	65.01	100.00
	Urban	3.79	53.88	57.67	42.33	100.00

travel estimates, such as would be found in different States. This will result in more reasonable composite estimates by other users of these data.

Effects of Future System Changes

The expenditure of Federal funds for the improvement of the Interstate System is directed toward the achievement of a condition where nearly the entire system is improved to a controlled-access status. It is, therefore, reasonable to take the attitude that the allocation of cost responsibility should be based on the end-of-program status for which the funds are to be spent, rather than on the status at an intermediate year. The estimated access, neighborhood, and through-traffic components of travel on the several systems in 1975 are given in Table 6.

The access changes on systems below the Interstate are assumed to be negligible, as these lower systems are expected to render much the same kinds of service in the future as they do now. The estimated changes in the service characteristics of the Interstate System were based on certain known or highly predictable changes that will occur, among which the following are the most prominent:

1. Access service on the Interstate System will be rendered only by frontage roads. The volume of access service will, therefore, be contingent on the expected mileage of frontage roads.
2. Neighborhood service on the Interstate System will be rendered by both frontage roads and interchanges.
3. An expected reduction of neighborhood service on the Interstate System will be chiefly accomplished by the elimination of short trips. All those that are shorter than the spacing between interchanges may be presumed to be eliminated; and a part of those that are longer will be discouraged by the effort of getting on and off the controlled-access highway, although it is impossible to estimate the latter with any degree of accuracy. The amount of reduction in neighborhood travel will, therefore, be contingent on the average spacing of interchanges, which will probably average between 4 and 5 mi in rural areas and slightly over 1 mi in urban areas. Consequently, for the end-of-program analysis all rural trips under 5 mi and all urban trips under 2 mi were eliminated from the Interstate System.

Modification Based on Recalculation of Travel Radii

The draft of the final report on the Highway Cost Allocation Study underwent extensive and critical scrutiny before the report was submitted to the Congress. Some of the reviewers of the draft expressed dissatisfaction with the values used for the neighborhood distances or radii (0.5 mi in CBD and 1 mi elsewhere) used in the single relative-use analysis included in the draft report, the procedure already described in this paper. The reviewers inquired what the effect on the percentage findings of the relative-use analysis would be if reasonable but significant changes were made in the specifications for the size of neighborhood area.

When the original analysis was made, it had been considered that lack of necessary data would bar the use of a neighborhood concept based on the number of trips terminating within specified areas, the procedure advocated by St. Clair (3). To answer the questions raised by the reviewers it was decided to attempt an alternative analysis conforming generally to St. Clair's procedure in spite of the lack of important segments in the basic data required for such an analysis.

The St. Clair thesis was that the size of the neighborhood area should be made to vary inversely with the density of population and business aggregation — from very small in the CBD's of large cities to very large in areas of low density of dwellings or other traffic-generating establishments. He suggested that to tie the neighborhood definition in with the generation of motor vehicle traffic, a neighborhood area might be defined as an area generating a fixed number; say, 5,000 or 10,000 trip origins or destinations per day.

To test his hypothesis, St. Clair made extensive analyses of origin-destination data obtained some years ago for the Baltimore Transportation Study. The results of his

analysis of various zones in downtown Baltimore and its suburbs indicated that if a neighborhood were to be defined in terms of 10,000 trip ends per day the radius of a circular area would vary from approximately 0.12 mi in the center of the city to 1.8 mi or more in the outlying suburbs. Expressed in terms of "square" areas the variation would be from about 0.2 to 3.2 mi or more on a side of such an area, or, expressed in terms of average-sized city blocks, from 2 to 30 blocks or more on a side.

The data applied in the first analysis made for the Highway Cost Allocation Study were reexamined under this concept, and "neighborhood" and "through travel" (types A and B combined) components were reallocated on this general basis. Access travel was not affected. The result was a range in neighborhood-area radii considerably more modest for urban areas than would have been indicated by the Baltimore data analyzed by St. Clair, but which was still generally in line with the traffic-generation concept. The redefined radii for the various classes of incorporated and unincorporated areas adopted for the analysis are given in Table 7.

The changes in definition of the neighborhood radius were such as to reduce the size of the neighborhood component of a trip in urban areas and to enlarge it in rural areas. The resulting changes in allocation of highway costs between motor-vehicle-user taxes and other revenue sources were substantial but were not of such magnitude as to indicate fundamental disagreement with the previous analysis. The unweighted sample percentages from this analysis are given in Tables 8 and 9 for 1957 and 1975. These may be compared with those resulting from the previous analysis (Tables 5 and 6).

Suggestions on Application of Relative-Use Procedures

In applying these percentages in a relative-use analysis for a given State where a motor-vehicle-use study had not been made or where the individual interview forms were not available, the proper procedure would be to determine the vehicle-type composition of present and projected travel for the rural and urban portion of each highway system separately, then multiply each travel figure by the appropriate percentage in Tables 5 and 6 or Tables 8 and 9, depending on the neighborhood definition adopted. The resulting values should be summed to make a composite travel table, and a new composite percentage distribution should then be calculated. These latter percentages can be applied against the appropriate program dollars to obtain the individual assignments of dollar responsibility.

Certain shortcomings which must be made up for by some means are reflected in Tables 5 and 6. Unfortunately, the motor-vehicle-use study samples were too small to provide stable samples for the various classes of trucks and combinations separately. Furthermore, motorcycle and bus operations were not included in these studies nor in Tables 5 and 6. The adjustment to separate light trucks from heavy trucks and combinations should not be unduly difficult to make if separate travel figures are available for such vehicle types, and if it can be assumed that the travel patterns of passenger cars and light trucks are essentially similar.

Estimating the characteristics of bus travel is a different matter. Bus operations are usually divided into three broad groupings: (a) intercity; (b) transit, including sightseeing and certain miscellaneous operations; and (c) school and nonrevenue. Estimates by rural and urban system segments of travel by these groupings of vehicles during one year were made by the individual States for the Public Roads

TABLE 7

REDEFINITION OF NEIGHBORHOOD RADII FOR RELATIVE-USE ANALYSIS

Location of Trip Origin or Destination	Neighborhood Radius (mi)
Unincorporated, nonurbanized areas:	
Sparse rural[1]	3.00
Medium rural[2]	2.00
Dense rural[3]	1.00
Urbanized areas:	
Central city, downtown[4]	0.25
Central city, remainder	0.50
Outside central city	0.50
Incorporated places with population of 5,000 and over, not in urbanized area:	
Downtown	0.50
Remainder	0.50
Incorporated places with population of 4,999 or less, not in urbanized area	1.00

[1] Less than 2 dwelling units per square mile.
[2] From 2 to 40 dwelling units per square mile.
[3] More than 40 dwelling units per square mile.
[4] Including CBD, industrial, waterfront, and financial areas.

TABLE 8

ESTIMATED PERCENTAGE DISTRIBUTION OF TRAVEL BY PASSENGER CARS AND TRUCKS AND COMBINATIONS BY HIGHWAY SYSTEM AND BY RELATIVE-USE CLASSIFICATION COMPONENTS, TRIP TERMINI CRITERIA: 1957

Highway System	Area	Distribution of Travel (%)				
		Access	Neighborhood	Access + Neighborhood	Through	Total
(a) Passenger Cars						
Interstate	Rural	1.38	4.33	5.71	94.29	100.00
	Urban	0.52	8.79	9.31	90.69	100.00
Other Federal-aid primary	Rural	0.75	4.72	5.47	94.53	100.00
	Urban	0.69	11.67	12.36	87.64	100.00
Federal-aid secondary	Rural	1.98	13.79	15.77	84.23	100.00
	Urban	0.67	13.11	13.78	86.22	100.00
Non-Federal-aid	Rural	16.62	34.58	51.20	48.80	100.00
	Urban	5.06	50.21	55.27	44.73	100.00
(b) Trucks and Combinations						
Interstate	Rural	0.60	1.85	2.45	97.55	100.00
	Urban	0.24	3.57	3.81	96.19	100.00
Other Federal-aid primary	Rural	0.82	3.03	3.85	96.15	100.00
	Urban	0.40	5.90	6.30	93.70	100.00
Federal-aid secondary	Rural	2.46	13.37	15.83	84.17	100.00
	Urban	0.78	13.96	14.74	85.26	100.00
Non-Federal-aid	Rural	14.97	35.69	50.66	49.34	100.00
	Urban	3.79	39.54	43.33	56.67	100.00

TABLE 9

FORECAST PERCENTAGE DISTRIBUTION OF TRAVEL BY PASSENGER CARS AND TRUCKS AND COMBINATIONS BY HIGHWAY SYSTEM AND BY RELATIVE-USE CLASSIFICATION COMPONENTS, TRIP TERMINI CRITERIA: 1975

Highway System	Area	Distribution of Travel (%)				
		Access	Neighborhood	Access + Neighborhood	Through	Total
(a) Passenger Cars						
Interstate	Rural	0.40	3.19	3.59	96.41	100.00
	Urban	0.33	5.04	5.37	94.63	100.00
Other Federal-aid primary	Rural	0.75	4.72	5.47	94.53	100.00
	Urban	0.69	11.67	12.36	87.64	100.00
Federal-aid secondary	Rural	1.98	13.79	15.77	84.23	100.00
	Urban	0.67	13.11	13.78	86.22	100.00
Non-Federal-aid	Rural	16.62	34.58	51.20	48.80	100.00
	Urban	5.06	50.21	55.27	44.73	100.00
(b) Trucks and Combinations						
Interstate	Rural	0.17	1.85	2.02	97.98	100.00
	Urban	0.21	2.94	3.15	96.85	100.00
Other Federal-aid primary	Rural	0.82	3.03	3.85	96.15	100.00
	Urban	0.40	5.90	6.30	93.70	100.00
Federal-aid secondary	Rural	2.46	13.37	15.83	84.17	100.00
	Urban	0.78	13.96	14.74	85.26	100.00
Non-Federal-aid	Rural	14.97	35.69	50.66	49.34	100.00
	Urban	3.79	39.54	43.33	56.67	100.00

Highway Cost Allocation Study, and should be available as a guide to further estimating. Accurate determination of the access, neighborhood, and through components of bus travel is probably out of the question because buses render all types of travel at the same time depending on the origin and destination of their passengers. Consequently, it might, perhaps, be assumed with impunity that for want of a better base all travel of intercity buses can be assigned to the "through" category, and that of transit, school, and nonrevenue buses to the "neighborhood" category.

Motorcycle operations were estimated to account for less than 0.2 percent of travel on all systems in 1957, according to Table 7 (6). Considering this fact and the extreme lightness of these vehicles, even when loaded, it may be entirely reasonable to omit them from the cost-allocation calculation. If it is desired to include them, it might be safe to assume that their travel characteristics are essentially the same as those of passenger cars.

EARNINGS-CREDIT ANALYSIS

In 1951, Simpson (2, p. 78) stated that all the three classical theories of public finance have been drawn on for the financial support of the highway function: benefit, ability to pay, and cost. He cited the use of special assessments in the financing of city streets as an example of direct "benefit" taxation; the support of highways by general taxation as an example of taxation on the basis of some assumed measure of ability to pay; and the financing of main highways through taxes on motor vehicle users graduated somehow in relation to costs incurred as an example of taxation on the basis of cost. Except for residual allocations, Simpson rejected all but the cost principle in his analyses.

In his discussion of highway tax theory, Simpson (2, p. 76) described the then new proposal by St. Clair for an "earnings-credit" analysis as an application of "predominant use at both ends [i.e., primary highways and land-services roads] so to speak," with an averaging of the results. He summarily dismisses this method, along with others, as a "benefit" approach, and applies in its place the "standard-cost" approach, which he describes as an attempt to allocate "the cost of providing highway facilities for motor traffic" according to a measure of "a 'reasonable cost' that is properly chargeable to motor traffic." He justifies his approach (2, pp. 81-82) as being in line with the application of the reasonable cost concept as applied by the Interstate Commerce Commission, other regulatory bodies, and the courts to railroads and public utilities for nearly a century.

To many, the differentiation noted by Simpson between the earnings-credit "top-drawer" calculation, which he designated a benefit approach, and his own standard-cost method, which he described as a cost approach, seems rather illusory because of the great similarity between the calculations involved in both instances, even though Simpson made his cost allocation on the basis of ton-mile units, whereas vehicle-mile units are customarily, but not necessarily, used in the earnings-credit analysis. A brief description of the standard-cost approach will clarify the situation.

Standard-Cost Approach

Drawing on the utility analogy, Simpson attempted to begin the distribution of joint highway costs by determining the costs chargeable to highway users and treating the remainder as "residual costs" assignable to other groups. He contended that the costs assignable to general property, governmental functions, and "neighborhood and community services" were "practically unascertainable." But, he also contended, the cost of providing services to motor vehicle traffic can be ascertained with a reasonable degree of accuracy, providing certain assumptions are made.

The "standard-cost" approach consists of assigning "reasonable costs" of providing "highway facilities for motor traffic." The development of the so-called "reasonable-cost" concept was, then, the key item in the Ohio Study. The "reasonable cost" assignment used was the cost per ton-mile of the rural portions of the State A and B systems. This cost per ton-mile was applied to the ton-miles of travel for all roads and streets as the highway-user share of total costs. The difference between this share and the

total cost was considered as the nonusers' contribution. In discussing the assignment of costs, Simpson (2, p. 81) says:

> But when we undertake to ascertain the cost of providing "highway facilities for motor traffic," we are immediately confronted by the fact that there are highway facilities which are not provided primarily for motor traffic, which have little relation to the volume of motor traffic on them, and which would, in fact, be there if there were no motor traffic. These are the local rural roads and residential access streets in the cities, upon which the costs, if assigned entirely to motor transportation, would be excessive and unreasonable. Any assignment of costs, whether per vehicle-mile, per ton-mile, or other measure, on a Statewide mileage basis must necessarily include these lightly traveled roads and streets.

Simpson used his standard-cost technique to accomplish three ends: (a) to determine the costs to be assigned to motor vehicle users, (b) to determine a residual cost to be assigned to others, and (c) to allocate the users' share among the various types and classes of vehicles.

Earnings-Credit Approach

It has already been mentioned that the earnings-credit method of cost allocation is based on a pragmatic rather than a theoretical approach to the problem. Simpson (2, p. 76) describes it as a method of overcoming some of the obvious shortcomings of the "predominant-use" modification of the "relative-use" analysis, in which predominant-use concepts are applied to both the primary and local highway systems, and the results averaged. This is an oversimplification, but it dramatically and succinctly describes what actually takes place in the usual earnings-credit analysis without giving the fundamental reasons.

The earnings-credit method may properly be considered as a variant of the "standard-cost" and "relative-use" approaches in which certain somewhat inconsistent concepts of the two methods are applied to combine some of the best features of both. It is based on a merger of or compromise between two concepts:

1. That the user component of tax support on all highway systems should be based on the average cost per vehicle-mile of primary highways, or better. This is the so-called "top-drawer" solution.
2. That there should be a nonuser component of highway tax support on all systems based on the average cost, per mile, of tertiary or access roads and streets. This is known as the "bottom-drawer" solution.

The first concept recognizes that the user has tax responsibilities chiefly for the support of the primary highways and also to a lesser, yet substantial degree, for all other roads and streets. In an orderly array of highway program costs, the costs per vehicle-mile of travel will increase substantially as the traffic importance of the highway system decreases. The costs per mile, however, act in reverse order, with the unit costs decreasing as the traffic importance of the system decreases. Therefore, a cost-per-vehicle-mile rate which will pay for the primary system can be considered as a reasonable contribution toward the support of all other highway and street systems. This, of course, results in a very substantial allocation of costs for all roads and streets to the user.

The second concept recognizes the fact that the tertiary or access road and street costs constitute a tax responsibility of the abutting property and the community which are the chief beneficiaries of such improvements. It also recognizes another principle — communities derive benefits, possibly intangible but nonetheless substantial, from the primary and secondary systems. Cognizance of this principle is expressed by assigning the cost per mile of the lowest system to all systems as a nonuser contribution.

This concept called the "bottom-drawer" solution results in a distribution of costs which materially lessens the user-cost responsibility.

To smooth out the rather variable assignments of costs arrived at by the application of the two concepts, a compromise of the cost assignments is arrived at by averaging the costs per vehicle-mile obtained from the two solutions. This modifies the user share obtained from the "top-drawer" solution to some extent and ordinarily raises it above that obtained from the "bottom-drawer" solution.

In the original work on the "earnings-credit" approach, a modification was introduced which took account of the lower level of costs per vehicle-mile on urban systems. In commenting on this modification, St. Clair (3, pp. 12-13) states:

> Certain of these principles and provisos need to be amplified by further discussion. The indicated modification providing that motor-vehicle tax earnings shall be credited at a lower rate to urban streets than to rural roads appears to be inconsistent with the earnings-credit principle, if the latter is to be taken as the guiding concept of the solution. This modification obviously works to the disadvantage of the cities and to the advantage of the rural roads, and particularly of the local rural units. It may be remarked at this point that the proposed method of analysis does not attempt to set up a completely logical theory, but rather to bring about a compromise among several concepts, none of which appears able to stand alone.
>
> With respect to the rural-urban modification, it may be remarked that the cities are a more productive source of taxable wealth than the rural areas, and that this wealth is in large part derived from industrial and commercial relations with the surrounding countryside. Furthermore, as a practical matter, the cities in most States will fare much better under the proposed solution, even with the rural-urban modification, than they do at the present time.
>
> A study. . . will reveal the fact that costs per vehicle-mile on city streets are likely to be remarkably low; and this is particularly true of those arterial streets which form the connecting links of the State primary system. If the earnings-credit solution were applied, so to speak, across the board, the rate of motor-vehicle taxation per vehicle-mile would have to be set at a point below the cost per vehicle-mile of the primary urban system, and this would result in a ratio of motor-vehicle to non-motor-vehicle tax responsibility so low as to prove unacceptable to most students of the subject, as well as to the general public.

Availability of Data

To perform an earnings-credit analysis, it is necessary to have available detailed needs, costs, and travel data for all road and street systems. The highway needs, costs, and travel data for all systems were prepared and submitted by the several State highway departments in connection with the Section 210 Study. Such data contemplated a 15-year improvement program (1956-71), and the needs were based on design criteria that were assumed adequate to accommodate types and volumes of traffic anticipated for the year 1975. There was, therefore, an array of needs, costs, and travel data much more complete and detailed than had hitherto been available for any earnings-credit study concerned with all roads and streets.

Conduct of Study

In making previous earnings-credit analyses for individual States, certain standard procedures were followed which had been more or less predetermined. It was observed

rather early in the Highway Cost Allocation Study that some of those procedures would have to be modified in order to be applicable to an analysis involving all roads and streets of the Nation. These procedures and reasons for the modification are given next.

The highway systems, their needs, estimated travel and mileage usually included in a typical analysis at the State level are approximately as follows:

System	Rural	Urban
State primary	x	x
State secondary	x	x
County and other local rural roads	x	-
City streets:		
Arterials	-	x
Local	-	x

The rural and urban portions of the State primary systems constituted the road systems used for the top-drawer solution; and county roads and local city streets constituted the respective rural and urban road systems for the bottom-drawer solution. It has always been recognized that the arbitrary grouping of needs under the legally constituted road systems, although implementing the presentation of the assembled data, and very satisfactory for administrative purposes, did not represent as refined a presentation of the data as would be desirable. There is usually a considerable mileage of the county road system in an average State which will be expected to carry a substantially greater volume of traffic than many portions of the rural State secondary system and, possibly, a few sections of the State primary system. The same is generally true with regard to arterial and local streets in comparison with the urban portions of the State systems. Therefore, the grouping of all county and local rural road costs under the county system, and assigning to that system the key index of the bottom-drawer solution, results in some sections of road with a high-type design criterion being assigned to a system supposedly concerned only with a land-access function. Similar situations also exist among other systems.

This situation became very apparent in the data assembled in connection with the Highway Cost Allocation Section 210 Study. Projections of travel by road systems and surface types to 1975 showed that about 496, 000 miles of county and local rural roads, and 333, 000 miles of city streets were designed with intermediate- or high-surface types. The anticipated average daily traffic (ADT) on these roads and streets ranged from 161 to 981 on the rural portion and from 191 to 3, 221 on urban. Obviously, the function of such roads and streets is expected to be above that which could be considered access.

The detail of data available as already noted made it possible to array the mileage of various surface types of a road system into what appeared to be the most logical order for the earnings-credit analysis. The original data submitted by the States showed the needs, by surface types (unsurfaced, low, intermediate, and high) for 12 separate systems. These were as follows:

System	System Number	
	Rural	Urban
Interstate	1	2
Other Federal-aid primary	3	4
Federal-aid secondary:		
State	5	6
Local	7	8
Other State highways	9	10
Local roads	11	--
Local streets	--	12

TABLE 10

DISTRIBUTION OF ROAD SEGMENTS, MILEAGE, AND TRAVEL TO TOP, SECONDARY, AND BOTTOM GROUPS OF EARNINGS-CREDIT ANALYSIS

Group	Highway System	Surface Type	Miles on System[1]	Percent	Cost[2] per Mile ($)	1975 Travel on System			
						Vehicle-Miles (millions)	Percent	Cost per Vehicle-Mile ($)	ADT
Top	Interstate	High	36,427	1.17	25,470	232,605	20.39	0.00399	17,495
	Other FA primary	High	196,265	6.33	12,020	367,797	32.23	0.00641	5,134
		Intermediate	23,189	0.75	6,840	4,199	0.37	0.03775	496
	Subtotal		255,881	8.25	13,460	604,601	52.99	0.00570	6,473
Secondary	FAS	High	203,725	6.57	6,540	153,861	13.48	0.00866	2,069
		Intermediate	297,420	9.59	2,290	27,277	2.39	0.02493	251
	Other State highways	High	36,495	1.18	10,750	36,292	3.18	0.01081	2,724
		Intermediate	39,411	1.27	2,650	3,972	0.35	0.02633	276
	Other local roads and streets	High	322,581	10.40	6,720	257,519	22.57	0.00842	2,187
	Subtotal		899,632	29.01	5,200	478,921	41.97	0.00977	1,458
Bottom	FAS	Low	128,904	4.16	1,770	2,732	0.24	0.08338	58
	Other State highways	Low	4,978	0.16	2,430	180	0.01	0.06722	99
	Other local roads and streets	Intermediate	506,922	16.35	2,470	31,591	2.77	0.03963	171
		Low	1,304,603	42.07	0,930	23,012	2.02	0.05269	48
	Subtotal		1,945,407	62.74	1,390	57,515	5.04	0.04702	81
Total			3,100,920	100.00	3,490	1,141,037	100.00	0.00949	1,008

[1]Estimated in service at completion of program, excluding toll-facility mileage or the 2,102-mi expansion of Interstate System.
[2]Estimated annual cost of investment in right-of-way and construction and estimated maintenance and administration costs, all at last half of 1956 price level and at 0 percent interest rate.

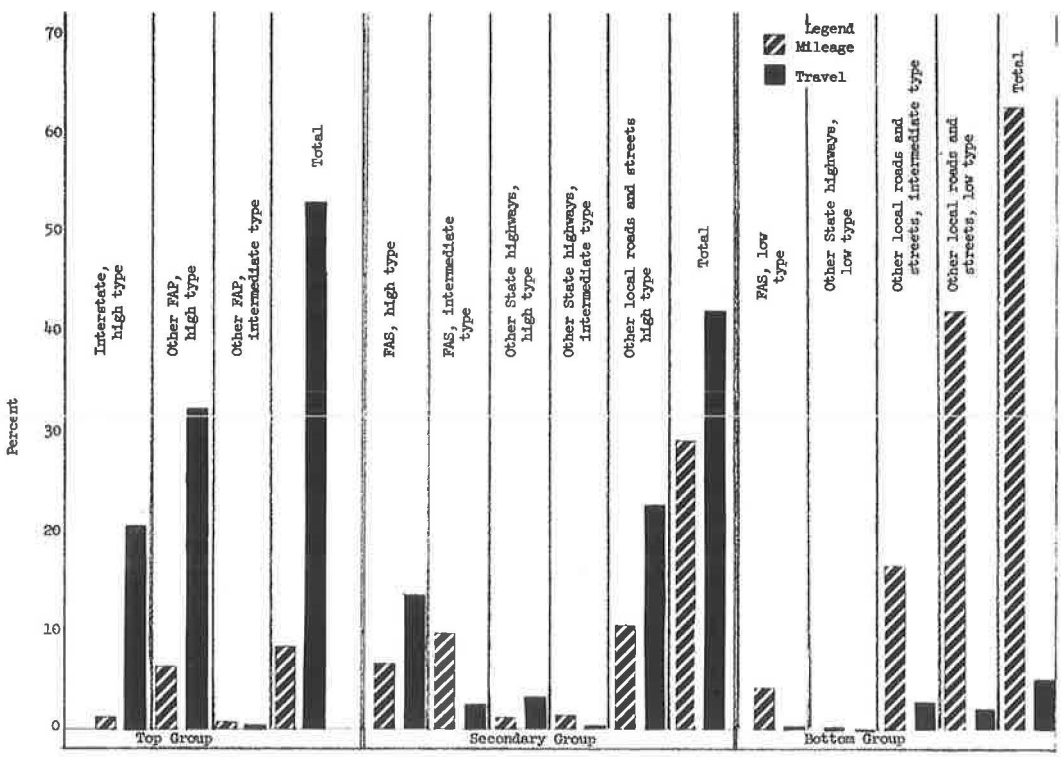

Figure 2. Percent distribution of mileage and travel for all roads and streets by earnings-credit study distribution, 1975.

In the usual conduct of an earnings-credit analysis the Interstate and other Federal-aid primary systems would be combined to form the top-drawer systems, with the local roads and urban streets forming the bottom-drawer systems. However, the available data made it possible to segment the systems in a more realistic pattern. The resulting array for each road system segment is included in Table 10 and Figure 2.

The road systems in the top grouping comprise only 8.3 percent of the total mileage but are expected to accommodate 53.0 percent of the estimated total travel in 1975. These systems are expected to have an ADT of about 6,500 at that time; this system is composed of all Federal-aid primary (FA) highways, including the Interstate routes.

The segments of road systems in the secondary groups contain 29.0 percent of the total mileage and are expected to carry 42.0 percent of the total travel in 1975 and to have an ADT of 1,458. About 80 percent of the Federal-aid secondary (FAS) mileage is on this system.

The bottom groups, consisting of 62.7 percent of the total mileages, are expected to carry only 5.0 percent of the total traffic and have an ADT of 81 by 1975. About 20 percent of the FAS mileage is on this system.

Table 10 and Figure 2 show that a rather orderly array of road types by traffic volume groups was obtained, and that the three groups appear to line up fairly well with the three travel components of the traffic stream; namely, through, neighborhood, and access.

Figure 3 shows costs per mile and costs per vehicle-mile for the three highway

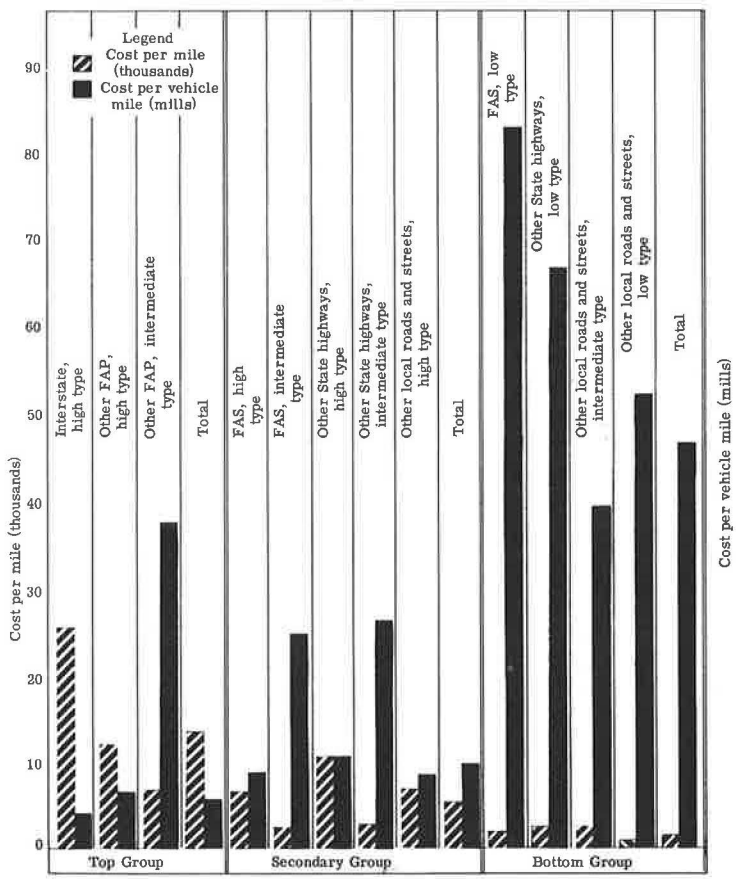

Figure 3. Cost per mile and costs per vehicle-mile for all roads and streets by earnings-credit study distribution.

groups. The top group, although having the highest average annual cost per mile ($13,460) has the lowest cost per vehicle-mile ($0.00570).

As the earnings-credit analysis for the Highway Cost Allocation Study was concerned only with equity of taxes imposed at the Federal level and earmarked for the highway trust fund, program costs in which there was no Federal participation could not be considered. Therefore, the costs of maintenance, operation, administration, and highway police incurred by the States for Federal-aid highways were not included. Also, because the study was concerned with only capital costs, a large mileage of road which would be unsurfaced at the end of the program period (1971) was eliminated from the analysis as, obviously, no capital costs would be incurred. The roads thus eliminated totaled about 633,000 miles, having an anticipated 1975 ADT of 25.

"Average annual program costs" is the term applied to the annual expenditures of a given year of a scheduled program. These costs are ordinarily used by a State in making an earnings-credit solution. Such costs include captial outlay, maintenance, operation, administration, policing, and interest on debt. As noted previously, only capital costs were considered in this analysis. The use of average annual capital program costs has one very serious deficiency in that such costs overstate the actual cost requirements of the high-type improvements while understating the costs of the low-type improvements. This results from the high initial costs of major improvements and the low initial costs of the minor improvements. Such methodology does not take into account the longer average lives of the high-type improvements. Use of the annual-cost method appeared to be dictated by this problem. Annual costs can be described as the amortization of the capital expenditures over the given life of the investment at a given rate of interest. This, of course, equalized to a certain degree the program cost differences in the high-type and lower-type improvements.

The last major modification adopted for the analysis was the use of predicted travel for the year 1975. Ordinarily, the estimated travel at the midyear of the program is employed, along with a fixed average annual program cost. Thus, the costs per vehicle-mile remain constant. In using annual costs, however, the computed vehicle-mile costs vary from year to year due to the changes in the volume of travel. It was necessary, then, to decide which year should be taken to provide traffic volumes that would be suitable for the solution. The decision to use 1975 travel was based on the thinking that if annual costs are used, the travel should reflect the cost per vehicle-mile of a completed program, rather than one partially completed.

The computations involved in establishing the annual capital costs consist of multiplying the given investment item by the recovery factor that will provide for its replacement, at a given rate of interest, at the end of its investment life. The given rate of interest runs the gamut from 0 to 7 percent, depending on the individual researcher, with the majority using a 6 percent interest rate. Such calculations are employed in determining economic costs in engineering economy studies of alternate highway investments. This study was concerned only with the financing of the Federal-aid systems which for all practical purposes are being financed on a current-revenue basis. It seemed that the inclusion of an interest charge was not relevant to the work at hand and yet such charges are an integral part of the computations of annual costs. A decision to compute annual costs at three different interest rates (0.0, 2.5, and 5.0%) was made. The computation at 0.0 percent tends to favor the high-type systems in terms of cost per vehicle-mile, and because of the high recovery factor of investments in such facilities, the 5.0 percent rate tends to disfavor them. A rate of 2.5 percent probably comes nearest to representing a normal credit-financing situation.

When highway expenditures and estimated costs per vehicle-mile are plotted against average daily traffic, there is usually a tendency for the values for the urban systems to be at a lower level than the values for the rural systems. Although such values, when plotted, appear to mingle randomly, the values of functionally comparable rural and urban systems definitely show this tendency. Such data were available from earnings-credit studies recently completed in Missouri and Iowa (7, p. 189; 8, p. C-3). The values are shown in Table 11 and Figure 4.

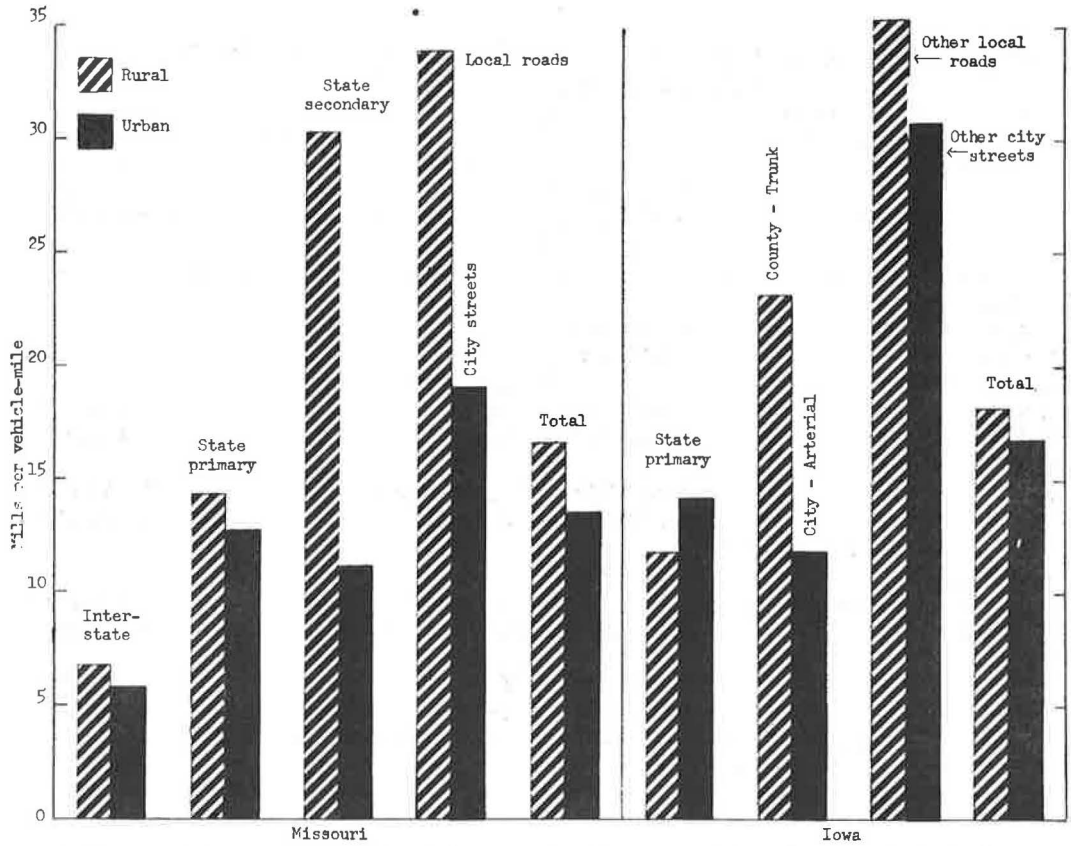

Figure 4. Cost per vehicle-mile of various road systems in Missouri and Iowa.

Critique of Earnings-Credit Analysis

In spite of its somewhat tenuous theoretical basis, the earnings-credit analysis has proven to be a most acceptable and useful tool for those who must attempt to allocate highway costs between users and others. Consequently, it has been utilized by other Federal investigators besides the staff of the Highway Cost Allocation Study, and in numerous State studies. Unfortunately, the findings of some of the State studies exhibited certain rather serious aberrations, probably traceable largely to shortcomings of the basic data available and the highway classification scheme used. There is reason to believe, however, that if adequate data are available, if a realistic classification of highways is adopted, and if certain other pitfalls can be avoided the earnings-credit analysis will produce consistent and useful results. In the paragraphs that follow, some of the major problem areas are considered for the benefit of those who may undertake earnings-credit analyses in the future.

Findings Affected by Program Costs.—The findings of the relative-use analysis are not affected by program costs because the determinations of cost responsibility are based entirely on the magnitude and characteristics of motor-vehicle travel. On the other hand, program-cost data are a part of the foundation on which the entire structure of the earnings-credit analysis rests. Consequently, errors or inconsistencies in the program-cost information utilized in the earnings-credit analysis can have a greatly adverse effect on the reasonableness of the results. Even the application of a different

TABLE 11

AVERAGE ANNUAL PROGRAM COST PER VEHICLE-MILE FOR SELECTED SYSTEMS IN MISSOURI AND IOWA

Missouri[1]		Iowa[2]	
System	Cost per Vehicle-Mile ($)	System	Cost per Vehicle-Mile ($)
Interstate:			
Rural	0.0066284		
Urban	0.0058016		
State primary:		State primary:	
Rural	0.0144739	Rural	0.0118406
Urban	0.0126879	Urban	0.0142687
State secondary:			
Rural	0.0302915	County-trunk	0.0230602
Urban	0.0112034	City-arterial	0.0119393
County, township and special road district	0.0339879		
Arterials, collectors, and local streets	0.0190042	County-Federal and local	0.0353528
		City-Access	0.0307590
Total:		Total:	
Rural	0.0165105	Rural	0.0180721
Urban	0.0135251	Urban	0.0166816

[1] Source: Table XIII-3, p. 189 (7).
[2] Source: Table C-1, p. C-3, (8).

interest-rate or rate-of-return factor can have a pronounced effect, as was amply demonstrated in the analysis made for the Highway Cost Allocation Study; for example, the discussion and accompanying tables, pp. 141-145 (1).

It is essential, then, that due consideration be given to the quality and reasonableness of the program-cost or annual-expenditure data available before an earnings-credit calculation is attempted. The desirability of including interest or rate-of-return factors in the analysis should also be given careful attention. The inclusion of such factors is proper and sometimes necessary, but their possible effects on the findings should be thoroughly understood.

Effects of Highway Classification.—The findings of the earnings-credit analysis are especially susceptible to aberrations in the highway classification scheme used. Thus, inclusion of extensive mileages of low traffic importance in the primary system will tend to increase the proportional responsibility of motor-vehicle users, whereas the inclusion of high-density roads and streets in the tertiary system will tend to increase the per-mile costs of access roads and streets developed in the bottom-drawer analysis. A less drastic but nonetheless apparent effect will result from the inclusion in the intermediate grouping of roads or streets that belong either in the primary category or in the land-access category.

In several States that have undertaken earnings-credit analyses such classification problems arose and, where it was not possible to rectify the situation, the findings of the analysis were considerably affected, even to rendering them questionable in some aspects. The modification in the highway classification adopted for the Highway Cost Allocation Study analysis was an ingenious approach to this problem, and is one that should be available in most States (1, pp. 135-136). It is worthy of adoption wherever possible.

Modified Compromise Solution.—Some objection has been raised to the usual type of compromise solution developed for the earnings-credit analyses. Another that has been proposed would attempt to overcome most of these criticisms by retaining the user

TABLE 12

HIGHWAY COST ALLOCATION STUDY: EARNINGS-CREDIT ANALYSIS – CAPITAL COSTS, ALL SYSTEMS, RURAL AND URBAN
(Modified Compromise Solution)

Highway System	Surface Type	User Share, Top-Drawer Solution[a]		Nonuser Share, Bottom-Drawer[b]	Total Allocations (million $)	Avg. Annual Capital Costs (million $)	Allocations/Costs (million $)		Adjustments (million $)	Net from Other Sources (million $)
		Dollars/Mile	Total Dollars (million $)	Total Dollars (million $)			Excesses	Deficits		
Interstate	All			22.7						
Other FAP	All			137.0						
	Subtotal	15,533	3,979.7	159.7	4,139.4	3,979.7	159.7	-	-159.7	-
FA secondary	High	4,971	1,012.7	126.9						
	Intermediate	603	179.5	185.4						
	Low	139	18.2	81.3						
	Subtotal	1,916	1,210.4	393.6	1,604.0	1,991.1	-	387.1	+285.6	101.5
All FA		5,846	5,190.1	553.3	5,743.4	5,970.8	-	227.4	+125.9	101.5
Other State highways	High									
	Intermediate									
	Low									
	Subtotal	3,234	266.2	51.3	317.5	547.4	-	229.9	+229.9	-
Local roads and streets	High									
	Intermediate									
	Low									
	Subtotal	783	2,086.7	1,660.1	3,746.8	3,391.0	355.8	-	-355.8	-
All non-FA		857	2,352.9	1,711.4	4,064.3	3,938.4	125.9	-	-125.9	-
All roads and streets		2,076	7,543.0	2,264.7	9,807.7	9,909.2	-	101.5	-	101.5

[a] $0.006582118 for all surface types.
[b] $623.181 for all surface types

share at the top-drawer solution level and the nonuser share at the bottom-drawer solution level, and would undertake to make all of the necessary adjustments in the allocation for secondary roads and streets. This is shown in Table 12 in which this type of analysis has been applied to the capital costs of all systems, both rural and urban, determined for the Highway Cost Allocation Study. The total program costs and the costs by systems are those shown in Table III-g-3, p. 137 (1). The modified compromise is worked out in the last four columns at the right-hand side of the table.

The nature of the information available in Table III-G-3 imposed certain limitations on this analysis. Thus, it had to be assumed that the so-called "primary" system — to be supported entirely from user earnings — would be composed of the Interstate and other Federal-aid primary highways as given in the table. The user cost of fully supporting the capital outlay program for this system was determined to be $0.00658+ per vehicle-mile. This earnings rate was applied to all systems as set up in the table and produced the "dollars per mile" and the "total dollars" of earnings shown.

The amount per route-mile necessary to support the local roads and streets was calculated by dividing the total capital costs for the intermediate-type and low-type segments of "other local roads and streets," and was found to be $623.18. The "total dollars" column indicates, by systems, the gross expected from this source.

The amounts shown in the "total allocations" column are, for each system, the sum of the calculated motor-vehicle earnings at the $0.00658 rate and the nonuser share calculated by multiplying the route miles on the system by the $623.18 rate per mile. When these figures are compared with those shown in the "average annual capital costs" column it can be observed that total allocations exceed the annual capital costs for two of the system groups for which subtotals are shown, and annual capital requirements exceed total allocations for the other two. Also, total annual requirements exceed total allocations by $101.5 million.

In making the "adjustments" shown in the next-to-last column of Table 12, the following assumptions were made:

1. All primary systems would be under direct supervision and control of the State highway department.
2. Part of the roads on the Federal-aid secondary system would be under State control, and others would be under the control of counties or local units.
3. "Other State highways" would be under direct control of the State highway department.
4. All so-called local roads and streets would be under the control of counties or local governments.
5. The user share, to be collected through imposts on motor vehicle users, would be collected by the Federal and State governments.
6. The nonuser's share, to be collected at the rate of $623.18 per route-mile of all roads and streets, would be collected entirely by counties and/or local jurisdictions.

These assumptions are reflected in the adjustments made. It was assumed that the State highway departments would spend the State motor-vehicle-user revenues and Federal aids received to defray the total annual costs of the primary system, and to the extent justified by "earnings" (including Federal aid), on the other State highways and Federal-aid secondary highways under State jurisdiction. On the other hand the counties and local units would be expected to apply the funds collected from their own revenue sources to meet the non-motor-vehicle-user share of the requirements of local roads and streets (the entire cost), and would also spend these revenues at the predetermined mileage rate on secondary roads and streets under their jurisdiction.

This would mean, in effect, that the State highway departments would forego all nonuser "earnings" on the primary system and on other State highways, allowing the counties and local units who collect them to apply these funds where deficits would be found to exist on roads and streets under their control. It would also be assumed that the States would retain and apply to "other State highways" and secondary roads under their jurisdiction incomes from motor-vehicle-user taxes sufficient to overcome the deficits between motor-vehicle-user taxes earned on those highways and the amounts required for annual capital costs.

At the levels of earnings and capital requirements given in Table 12, the result would be complete financing of all systems (as there classified) except for the Federal-aid secondary. For these roads and streets, it was found that even after allocating all excesses of both user-tax earnings and nonuser collections, a net annual deficiency of $101.5 million would still remain. Funds to meet these deficiencies would need to be drawn from sources not included in this table, such as the general revenue funds of the governmental agencies responsible for the roads and streets in question. Just what agencies these would be cannot be determined precisely from the data available for this analysis because no separation was made between Federal-aid secondary highways administered by the State highway departments and those administered by other jurisdictions.

It is obvious that this particular analysis will work satisfactorily only when the allocations produced by the top- and bottom-drawer calculations do not produce quite enough revenue to finance the entire program.

When it is calculated that the totals of responsibility, as determined in the top-drawer solution, and of access responsibility, as determined in the bottom-drawer solution, exceed the total amount needed, the compromise can, probably, be made best as was done for the Highway Cost Allocation Study.

Treatment of Federal Aid in State Studies. — The proper treatment of Federal highway aid has always presented a major problem in State studies of highway cost allocation. Before passage of the 1956 Federal highway legislation, when aid for highways was paid from the general revenues of the Federal Government, and when the levels of aid payments were much lower than they now are, it was customary (but not universal practice) to deduct an amount equal to expected Federal aid from the program costs of the road systems affected before undertaking any allocation of costs between users and others. Since enactment of the 1956 legislation, however, the proper treatment of Federal aid in State analyses has become a very controversial matter, with eminent authorities lined up on either side of the issue.

The principal arguments for inclusion of Federal aid in the State analysis appear to be that (a) inasmuch as such aid is now paid from the proceeds of motor-vehicle-user taxation, account should be taken of this contribution in calculating the allocation to highway users at the State level; and (b) the level of Federal aid received on a very small portion of the primary system (the Interstate highways) is so high that to omit this segment in the earnings-credit analysis will result in understating the level of user contributions required. On the other hand, the staff of the Highway Cost Allocation Study (1, p. 18) took the following position:

> In the conduct of an earnings-credit study (or, indeed, any study of the highway cost allocation problem) in an individual State the customary practice is to deduct anticipated Federal-aid funds from the data on program costs, so that only the net costs to the State and its civil subdivisions will be involved in the solution. Only in the conduct of an earnings-credit study on a nationwide basis is it feasible to take account of the entire package of highway costs.

During the six years that have elapsed since passage of the 1956 Act, the authors of this paper have rendered technical assistance on highway cost allocation studies made in several States. It has been their observation that to omit Federal aid from the initial determination of vehicle-user responsibility results in levels of such responsibility that are entirely unrealistic (too low) in most instances. Therefore, they have recommended that Federal aid be left in for the calculation of the burdens to be allocated between users and others. The allocation of costs among various classes of vehicles also includes Federal aid but the vehicles are given credit for the Federal taxes paid by each type, which, in effect, offsets the Federal aid involved.

CONCLUSION

Highway economists, especially those concerned with taxation and finance, are

sometimes inclined to be pessimistic about the outlook for developing theoretically sound and foolproof methods for the allocation of highway costs between users and others, not to mention the allocation of such costs among the various groups of users. They are even inclined to feel, sometimes, that no significant progress in either theory or methodology has been made in recent years, and that further penetrating studies of the questions involved would be of little avail. Even such a competent and well-regarded authority as Zettel took this position in the panel discussion, previously referred to, before the Committee on Highway Finance held during the October 1961 meeting of the American Association of State Highway Officials, when he said:

> It seems to me that there is not much point in making anymore studies of the kind that have been made in the States, or in the Section 210 Study, until we can find some way of getting authoritative agreement on what . . . we are trying to do in the area of highway financing and taxation. I have hopes that the National Tax Association's Subcommittee on Federal Excise Taxation may develop something along these lines, dealing with both excises and highway-user taxes.
>
> At the present time, it is almost ridiculous to carry allocation of costs of highways between users and nonusers to a second decimal point when we can't even agree whether $20 billion worth of automotive excises are general taxes or highway-user taxes. If we don't agree on this, our attempts to get arithmetical accuracy in cost allocations are pretty much nonsense.

The authors of this paper are not as pessimistic as Zettel seems to be. Although they agree that there seems at present to be no single correct or even best answer to some of the fundamental questions of highway cost allocation, and recognize that there is room for argument about the treatment of certain excise taxes, they are convinced that satisfactory empirical approaches to solution of the problem can be made as has been done at both Federal and State levels in recent years. After all, the problems of fund-raising for highways that face legislative bodies and executives at Federal and State levels cannot be deferred until the public finance theorists can agree on some of the more esoteric points involved in such analyses. The authors of this paper believe that the additional data now available in all the States, and accordingly to the Federal Government, make it possible to do a much more theoretically sound and practically satisfying job of allocating highway costs than has been possible at any time in the past.

Also, the relative-use and earnings-credit analyses offer two of the best available means of allocating highway costs between users and others. Until better and more practical methods are available, the authors will continue to recommend that those who have the responsibility of undertaking cost allocation studies at the State level utilize at least two methods of cost allocation between users and others, and that careful consideration be given to using these two methods. Additional methods could also be used if the local circumstances appear to warrant it.

It has been observed that past studies have sometimes failed to be most effective because they have presented several allocation bases without recommending any particular one or a means of combining their results. It is recognized that when the investigators find no special virtue in any one method of allocation they would hesitate to recommend it over others. Consequently, the mediation approach adopted by the staff of the Highway Cost Allocation Study has much to recommend it under such circumstances. A procedure adopted for mediation between the relative-use and the earnings-credit findings is described elsewhere (1, pp. 146-147).

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Appendix