

Comparative Highway Cost Allocations: Incremental and Other Methods

WILLIAM E. KOENKER, Professor of Economics, University of North Dakota

Three methods of allocating highway costs to different classes of users have achieved general recognition. These are the ton-mile, the cost-function, and the incremental methods. An allocation study recently made in North Dakota affords one of the better bases for comparing the relative tax assignments under each of the three methods.

The costs allocated under the North Dakota study were those of a future 15-year program of construction and maintenance. All costs on the state and one-half of the costs on the county system were assigned to users and included in the program. Assignments of cost responsibility were made to foreign as well as to domestic vehicles.

In the ton-mile method the annual program costs were divided by the total ton-miles of travel. The resulting rate was applied to the ton-miles of travel for which each vehicle classification was responsible in order to determine annual cost responsibility. In the cost-function approach the program costs were divided into three functional categories. The costs in each category were then allocated on a somewhat different basis. The following indicates the breakdown of costs and the method of assignment:

<u>Classification</u>	<u>Percentage</u>	<u>Allocated According to :</u>
Standby	4	Number of vehicles
Traffic volume	63	Axle-miles
Weight	33	Ton-miles

For the standby and the travel costs the allocation was made the same as under the cost function, except that vehicles were assigned costs for only those roads which they used. The weight costs, however, were assigned incrementally. All vehicles shared alike on an axle-mile basis in the cost assignable to the basic road. This was a hypothetical road designed to accommodate single-axle weights up to 6,000 lb or tandem-axle weights up to 9,000 lb. Single axles in the 6,000- to 12,000-lb category, or their tandem equivalent in the 9,000- to 18,000-lb class, were assigned, in addition to their basic road responsibility, an additional amount reflecting the higher cost necessary for roads designed for these heavier vehicles. Additional incremental assignments of cost were made for vehicles with still heavier axle weights.

In addition to making program cost allocations according to these three methods, an estimate was also made of how the program costs would be assigned to users under the existing two-structure tax.

On the basis of each of these methods it was possible to arrive at the annual per-vehicle cost responsibility of all vehicle type and weight classifications.

● **THREE GENERAL METHODS** have been developed, during the past several decades, for allocating highway costs among different classes of users. Each of these methods is designed to indicate the "equitable" share of highway costs which should be assigned to each vehicle type and weight group. These approaches are the ton-mile, the cost function, and the incremental method. The recent highway cost allocation made for North Dakota provides one of the better bases currently available for comparing the tax assignments which would result from each of the approaches. (1)

The purpose of the present article is to compare the allocations to various vehicle type and weight groups which would be made under the different methods. In addition,

these allocations will be compared with the allocation which would be effected by the present form of fuel and license tax. Before making these comparisons, however, it is necessary to outline briefly the procedure in each method and point out the several respects in which the North Dakota procedure deviated from what has come to be accepted as standard practice under each of the three methods.

In each of the various approaches the highway costs to be assigned were those of a 15-yr construction and maintenance program. These program costs included federal aid expenditures, some costs assigned to general property tax payers, and costs properly assignable to highway users. This last category included all the state's share of the cost of state highways and half of the cost of the country roads. The actual allocations were applied to only this user-share of the total program. For convenience the cost for the mid-year of the program (1964) was used. This amounted to 22.9 million dollars for the year which was about 40 percent in excess of current expenditures out of user-derived revenues.

Because of its simplicity and directness, the ton-mile method of allocation permits virtually no variation in the specific technique to be used. It requires that the mid-year program costs be divided by the product of miles of travel times vehicle weight. The resultant ton-mile rate may then be applied to the ton-miles of travel of each vehicle type and weight group to determine the group's share of the total cost. Travel by "foreign" vehicles on North Dakota roads and travel on county and local roads were included in the mileages used. This made it possible to assign a specific share of the user cost to foreign vehicles rather than to employ the usual assumption that out-of-state travel by domestic trucks matched the in-state travel by foreign trucks.

The cost-function method assumes that some highway costs are functions of factors other than miles times weight. Therefore, some of the program costs such as costs of vehicle registration are allocated on a per vehicle basis. Other costs such as traffic control, drainage, and part of clearing and grading have been charged on a travel volume basis. This leaves those costs primarily associated with thickness of pavement and base to be allocated on the basis of ton-miles. In the North Dakota study only 4 percent of the projected costs were allocated on the per vehicle basis, 63 percent were allocated on the basis of travel, and 33 percent on the basis of weight. In most of the cost-function studies made by the American Trucking Association higher percentages of costs were placed in the per vehicle and in the weight category.

The significant difference between the North Dakota cost-function analysis and the ATA studies was that travel costs in the North Dakota study were allocated on the basis of axle miles (2). Tandem axles, however, were considered as equivalent to single axles. In the ATA studies vehicle miles were used. This has the effect of assigning to a 5-axle combination the same portion of the travel costs as are assigned to a passenger car. The use of axle miles for travel cost assignment seems preferable in that it does provide a solution to the problem of whether to classify combinations as one or more vehicles. Use of axle miles also reflects axle repetitions; and, even though these are disassociated from weight in the travel costs, repetitions do have a wearing effect on bearing surfaces. Of greater significance is the fact that axle miles afford a better reflection of vehicle length and weight and, hence, of lane width, sight distance, and other elements that affect the geometrics of road design.

The incremental method is superior to both the ton-mile method and the cost-function in that it breaks away from any benefit basis of taxation and uses instead a cost responsibility basis. Each vehicle class and weight group is assigned only those highway costs which can properly be attributable to that class. Again in this method, as in the cost-function, certain costs such as registration are deemed to be a function only of numbers of vehicles. Hence these costs are properly assignable only on a per-vehicle basis. This included only 4 percent of all costs in the North Dakota incremental analysis. The remainder of the costs under the incremental approach are a function of traffic volume or of weight.

In the allocation of these traffic and weight costs the incremental method makes use of the basic road concept. This is a hypothetical road such as would be designed if only passenger cars and light weight trucks were expected to use it. In the North Dakota study this basic road was defined as one which would accommodate single-axle loads of

6,000 lb or tandem-axle loads up to 9,000 lb. All of the travel costs (61 percent of total costs) were assigned equally among all single and tandem axles, irrespective of weight carried. This equality was achieved through the assignment of all travel costs to the basic axle weight class (under 6,000 lb single or 8,000 lb tandem) since all heavier axle weights have this basic weight as their first component. Axles carrying more than the basic weights would bear their portion of the travel cost on an axle-mile basis and would then also be assigned a share of the weight related costs.

To assign the costs of building roads to standards adequate for vehicles weighing more than the basic vehicle, it was necessary to determine the design standards required for these heavier vehicles. These standards and the associated costs were determined for the following single-axle weights and tandem-axle equivalents. Data are in kips (thousands of pounds).

<u>Single Axle</u>	<u>Tandem Axle</u>
0 - 6	0 - 9
6 - 12	9 - 18
12 - 16	18 - 24
16 - 18	24 - 30

The tandem axle equivalencies were used in recognition of the WASHO test findings that the distress areas caused by single axles of a certain weight were about the same as those caused by tandem axles of $1\frac{1}{2}$ times that weight. (3)

In addition to developing the construction and maintenance costs assignable to different axle-weight groupings, these costs have to be broken down as to the various highway capacity systems. In the North Dakota study, five systems were distinguished ranging from the interstate, designed to carry 4,000 or more vehicles per day, down to the county roads carrying 200 or less vehicles per day. This classification is required because in the incremental analysis each vehicle type and weight class contributes only to the cost of the roads which it actually uses and in proportion to that use.

Because the travel costs were all assigned to the basic axle-weight class, the weight related costs had to all be assigned to the heavier axle-weight classes. In the incremental approach a cumulative procedure is used in allocating these costs.

In the case, for example, of the heaviest single-axle weight, 16 to 18 kips, those axles were to be assigned their share of the travel costs of the basic axle weight, also their share of the costs required to 6 to 12 and 12 to 16 kip loadings and the full cost made necessary by the last increment of design standard. This procedure follows from the theory that each axle-weight class should pay for the specific increase in costs which that class occasions, and also for its proportionate share of the subordinate or underlying design requirements.

The principal departure made in the North Dakota incremental analysis from previous incremental studies was the use of tandem axle equivalencies and the assignment of costs to foreign as well as domestic vehicles. Except for allocating travel costs on an axle-mile basis, the method follows basically that established by Pancoast. (4)

COMPARATIVE COST ALLOCATIONS

Because the costs assigned under each of the three equity approaches were user costs for the mid-year of the program, they are directly comparable, as is also the allocation of the program cost which would be effected under a two-structure (fuel and license) tax. In making these allocations, registrations were projected to 1964. The resulting tax assignments are referred to as "Adjusted 1964 Payments." Table 1 indicates the percentage of program costs assigned to each of the four vehicle types under the equity approaches and under the present type of two-structure tax.

Passenger cars bear a heavier cost under the existing type of gasoline and high license fee than is indicated under any of the equity approaches. For the domestic trucks, the incremental method assigns to them a substantially greater cost responsibility than is indicated under the adjusted 1964 payments or under the cost-function method. For foreign trucks the cost assignment under the incremental method is less than under either the cost-function or the ton-mile method. This is because costs of the various

classifications of highways are assigned only in proportion as particular classes of vehicles use those highways. Under the gasoline tax and license fee method foreign trucks would pay only 60 percent of the costs assigned to them under the incremental solution.

TABLE 1

	Adjusted 1964 Payments	Equity Approaches		
		Incremental	Cost-Function	Ton-Mile
Automobiles	56.3	42.7	54.9	33.8
Domestic trucks	40.0	51.5	38.6	54.6
Foreign trucks	3.3	5.5	6.1	10.8
Intercity buses	0.4	0.3	0.4	0.8
	100.0	100.0	100.0	100.0

In addition to comparing cost assignments for various vehicle types, it is important to make comparisons of the assignments to weight groups within a vehicle class. The annual per vehicle cost responsibility for domestic trucks is shown in Table 2. (5)

TABLE 2

Registered Weight Classification	Number of Vehicles	Adjusted 1964 Payments	Incremental Method	Cost-Function Method	Ton-Mile Method
4,000	89	10	3	3	-
6,000	2,853	27	32	36	24
8,000	39,949	41	35	41	31
10,000	14,455	44	30	34	31
12,000	7,768	36	21	24	23
14,000	6,483	49	22	21	23
16,000	9,943	58	24	21	25
18,000	11,193	67	43	33	43
20,000	8,096	88	93	63	89
22,000	3,669	114	238	140	210
24,000	5,690	226	328	208	320
26,000 - 30,000	349	421	526	364	640
32,000 - 36,000	834	620	802	605	1,087
38,000 - 44,000	347	940	1,778	1,050	1,878
46,000 - 54,000	276	1,725	3,642	2,259	4,456
57,000	77	1,915	3,858	2,388	4,817
60,000 and over	386	2,172	4,012	2,902	6,037
Average Total	112,457	81	95	74	105

In comparing the above cost assignments, the total cost responsibility assigned to the four vehicle types differed under the three methods. This difference affects the per vehicle cost assignments. It is significant that the present two-structure tax would exact substantially more from most of the trucks weighing under 20,000 lb than would be true under any of the equity approaches. This would occur because these vehicles are predominantly farm trucks and incur an annual average travel on public roads of only about 4,000 miles per year. For the heavier trucks the incremental method would assign costs substantially in excess of the two-structure tax but much less than the ton-mile approach.

Comparisons of the cost assignments for foreign trucks can only be made on a weight class basis rather than a per vehicle basis. The relative costs assigned to several important weight classes are shown in Table 3.

For the foreign trucks even the light-weight vehicles are assigned substantially more under any of the equity approaches than under the "Adjusted 1964 Payments." This occurs because under reciprocity and an administratively impractical prorationing system foreign trucks pay very little more than fuel taxes. This results in the 46,000- to 54,000-lb class paying under a two-structure tax only about half of its incremental cost responsibility.

TABLE 3

<u>Weight Group</u>	<u>Adjusted 1964 Payments (dollars)</u>	<u>Total Annual Cost Assignment (dollars)</u>		
		<u>Incremental</u>	<u>Cost-Function</u>	<u>Ton-Mile</u>
12,000	4,648	7,022	8,176	10,228
24,000	68,415	174,898	110,740	176,225
46,000 - 54,000	104,370	213,616	185,702	367,090

It is generally conceded that the incremental approach provides, despite its practical difficulties, the most reliable guide to proper user-cost assignment. If this is the case, the data in the North Dakota study certainly indicate the inadequate share of highway costs assigned to heavy trucks under a fuel tax and high license fee. (It was calculated that only 8 percent of a one cent increase in the gas tax would be paid by vehicles weighing over 24,000 pounds. Their cost responsibility under the incremental method, however, was 33 percent.) However, the data also confirm the motor carrier's contention that the ton-mile method would place an unreasonable burden on the very heavy trucks.

REFERENCES

1. Koenker, W.E. and Arlyn Larson, "Equitable Highway Cost Allocation in North Dakota," Bureau of Business and Economic Research, University of North Dakota, 1956.
2. Ross, W.D., "Financing Highway Improvement in Louisiana," Louisiana State University, 1955.
3. Highway Research Board, "The WASHO Road Test, Part II," 1955, p. 97.
4. Pancoast, D.F., "Allocation of Highway Costs in Ohio by the Incremental Method," Ohio Department of Highways, 1953.
5. "Equitable Highway Cost Allocation in North Dakota," Table XIV, p. 60.