Comments on Tax-Allocation by Incremental Method Based on Application of the Method in Minnesota, 1953-54

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● THIS paper is based on two applications of the incremental method conducted by Public Administration Service as part of a highway finance study in Minnesota in 1953-54. Those applications were in turn based upon publications about other applications of the incremental method, and related subjects. This paper will attempt to establish the philosophical framework within which the incremental method has been developed, to outline the Minnesota study procedure and indicate how certain classes of vehicles were treated as the result of the use of that procedure, and to suggest ways of performing future incremental method solutions of the problem of allocating highway user taxes.

SOME PHILOSOPHICAL CONSIDERATIONS

Government activities may be characterized as proprietary activities or general activities according to the way they are financed. For the purposes of this discussion, proprietary governmental activities are defined as those services for which users pay on the basis of the cost of providing the service, such as the supply of water or the delivery of mail. General government activities are defined as those which provide a service that is paid for out of government revenue raised without regard for the use to which it will be put, and include such activities as police protection or the coinage of money.

The line between the two is not hard and fast, and occasionally an activity will be shifted, in whole or in part, from one basis to another. Apparently general activities are changed to a proprietary classification when a segment of the people or the legislative body becomes dissatisfied with the share of general revenue that has been expended for an activity and convinces the majority that a special group of beneficiaries can be isolated and taxed to obtain the desired revenue to carry on the activity at higher level of expenditure. Contrariwise, a proprietary activity reverts to a general basis when the majority wishes to regain flexibility in the use of all revenue available.

The activity of providing highways and byways to move people and products and to provide access to and egress from property has been supported through both approaches at various times. On the one hand, the completely proprietary toll highways have kept reappearing in the tapestry of history. On the other hand, the free use of paths turned into traces and tracks by the road building action of the users who cleared away this obstacle or filled in that hole has been the pioneering phase of public highway activity since man began walking. In Minnesota, the state government started with a completely general approach that ignored the question of who used the roads or how much anyone used them. Road work in the young state was paid for by a tax on all property supplemented by a tax of two days time to be put in on the roads by each able man. The coming of self propelled vehicles introduced a new type of thinking into Minnesota and culminated in a constitutional amendment in the early 1920's. As a part of this amendment, the people of Minnesota approved a change in highway finance philosophy. The meeting of this panel on the incremental method is one of the by products of this change in philosophy in Minnesota and other states.

Minnesota was in the van of a movement to dedicate certain revenue for exclusive use on highways. Since the action of dedicating highway revenue implies that portions of the revenue had been "diverted" to other activities, the logical conclusion of dedication is for all highways to be supported by the dedicated revenue alone. However, the conclusion actually reached through practical politics, as exemplified in Minnesota, is that the dedicated revenue should pay for only a certain part of the highway program; other parts of the program, largely those parts carried on by the local governments, should be supported by general revenue.

Thus, Minnesota highways can not be considered as a completely proprietary activity, nor are they an activity readily synchronized with general government activities. Each other lines which represented the relative maintenance costs on two highway sections which were alike in geographical location, width, materials, and construction standards, that is, everything but traffic volume. For instance, if costs on one section carrying 900 vehicles per day were 120 percent of the costs on its companion section which carried 500 vehicles per day, then a line was drawn between the point where the trial line crossed the 500 vehicle per day ordinate to a point on the 900 vehicle per day ordinate which was 120 percent of the first point. The slope of these test lines indicated whether the slope of the trial line should be changed. The lines finally determined gave a higher responsibility for maintenance costs to the forces of nature than did the Ohio study, a difference possibly due to the more severe Minnesota climate, or perhaps to the use in Ohio of a multiple correlation process to develop the curve, the controlled variables being total traffic and a general class of "heavy vehicles."

The increments finally used are presented in Appendix A.

Item 4. Tabulating the number of vehicles in each class according to registered weight is largely a mechanical task. The only problem facing the Minnesota study was to isolate tandem axle equipment from single axle. This was done by checking model numbers and by a survey of automotive chassis shops to determine the number of single axle vehicles converted to tandem axles. Tabulating vehicles by axle arrangement deviated from the Ohio study procedure, but in Minnesota tandem-axle equipment has different highway use characteristics than single axle equipment of similar capacity. The tabulations were for the first six months of 1953, rather than estimates for mid year of the program as in Ohio. (Registration fees in Minnesota go down one-twelfth each month after the first of the year, thus six months of vehicle registrations were used to get a normal registration fee.) The registration tabulation, as finally used, limited the number of weight brackets in each vehicle class according to the pattern of registrations and the load distribution characteristics of the vehicle type. The use of brackets larger than those used in the Ohio study reduces the computation work involved, but left enough points to plot a curve to obtain the graduated tax schedule.

Item 5. The tabulation of vehicle miles according to vehicle class and axle loading was made by the Traffic Section of the Highway Planning Survey. The accumulation of data from studies at loadometer stations, origin and destination surveys, traffic volume and classification counts, speedometer checks and reports of regulatory bodies provided the background of information necessary. These tabulations were on a current basis rather than estimates for midyear of the program as in Ohio.

Item 6. The arithmetical procedure used to distribute the appropriate share of the highway program in accordance with the above factors is expressed in the formula in Appendix B. This formula does not significantly deviate from the Ohio procedure, although one difference in computation that was introduced involved the smoothing of the license fee allocation left after the gas tax credit is applied to the vehicle tax allocations. The Ohio study developed a least squares curve to establish the license fees for each vehicle class. Feeling that distortion in the tax allocation to the class of vehicles might result from a least squares curve, the Minnesota study adjusted the rates visually to make a neat curve while keeping potential tax income at the proper level. Thus if a rate were raised $5 and it affected 500 vehicles, some other rate or rates would have to be reduced for enough other vehicles to eliminate the added $2,500.

ASSUMPTIONS THAT MAY HAVE AFFECTED ALLOCATIONS TO CERTAIN VEHICLE CLASSES

If action waited upon complete knowledge of all the pertinent factors, there would be no action. Knowing this to be true, the Minnesota study consciously included certain assumptions, with at least partial knowledge as to their effect. For example:

1. It was assumed that each vehicle affected lane capacity equally, hence, no responsibility was assigned to any class of vehicles for disproportionately reducing lane capacity. However, certain studies have shown one commercial vehicle to be equivalent to four passenger vehicles in reducing lane capacity on normal rolling terrain. Undoubtedly, this is responsible for adding additional lanes to various highways with attendant higher costs of right of way, construction, and maintenance.

Recognition of this greater reduction in capacity would have been reasonable.

2. It was assumed that loads over the legal limit have no extra effect upon highway costs, hence, no attempt was made to penalize the classes of vehicles that have frequent axle loads over the legal limit. Naturally, these loads beyond the designed capacity of the roadway hasten the day of replacement and add to the costs of maintenance up to the day of replacement.

3. Average annual mileages as used in the report for certain commercial vehicles may be both high and low in some instances, as judged from early returns of a speedometer check being made too late for inclusion in the study. While this is true, no serious inequities would result in the taxes paid since a pay as you go tax structure was recommended for the classes of vehicles with the higher mileages.

4. Lane widths for the design sections in the two highest capacity systems were the same for all axle loads. The Ohio study, backed up by research, did have a narrower lane width for the lightest class of vehicles. The Minnesota procedure gave an advantage to heavy vehicles.

5. Whereas the incremental method formally ends with an allocation of total tax responsibility against the several types of vehicles analyzed, practically, the gas tax paid by each vehicle is subtracted from the total tax allocation for that vehicle in order to determine the amount of license fee and weight tax to be paid. The rate of topographical rise and fall of Minnesota highways is less than that established in gas consumption curves in Research Report 9-A of the Highway Research Board. This means that actual rate of gas consumption in Minnesota is less than that plotted in the lowest gas consumption curve. However, the lowest gas consumption curve was assumed, providing a differential of allocated but unchanged tax that becomes significant for heavier vehicles.

In spite of giving the heavier vehicles the benefit of every doubt, the tax allocation developed for them was much higher than their present tax payments.

FUTURE USE OF INCREMENTAL METHOD

Some objective means of allocating a share of highway program costs to each highway user must be used as long as there is pressure to treat highways as a proprietary rather than a general function of government. The general procedure of the incremental method is the only one upon which interested parties have reached substantial agreement, indicating that this method probably will continue to be used in the future.

Suggested Changes in Technique

It would be folly to think the zenith will be reached tomorrow in this type of engineering-economic analytical problem. Research keeps pressing forward into the vague areas of the unknown and no one can say where the boundaries of ascertainable knowledge about this field are. But based on two applications of this procedure and having available the excellent exposition of the Ohio study, it would seem that techniques can be improved in at least five ways.

First, the costs of the highway program in all its aspects should be allocated with sureness to the proper incremental study systems. Present needs study techniques develop and present certain portions of highway cost information quite capably. But to conduct the incremental method, program costs must be by the traffic characteristic systems selected for study. Further costs should include all costs occasioned by modern vehicles, that is, enforcement of vehicle registration, load limit regulation, traffic police, street lighting, traffic control devices, and a proportionate share of street cleaning and storm drainage; these are all a part of highway costs and should not be avoided simply because they are controversial. Naturally some of this will require a special investigation not being done in current needs studies.

Second, the costs must be broken between the share to be treated as a proprietary responsibility and the share to be treated as a general government responsibility. This split between cost to the highway user and cost to the general public requires some additional work, since available solutions to the problem have proceeded from shaky philosophical bases.

Third, it may well be that in future solutions, costs should be distributed upon wheel load rather than axle load. This suggestion leads directly into another question as to whether load per square inch of tire-pavement contact area is not the proper way of grouping vehicles, at least for obtaining construction cost increments. Tied into this general question is the problem of whether tandem wheels should be considered as a single unit acting upon the highway, or as two individual loads, or as partly one and partly the other. At any rate, just as axle load is a better measure for distributing highway costs than total load, so may wheel load or load per unit of contact area be a better measure than axle load.

Fourth, there should be separate solutions for rural and urban highways. The characteristics of vehicle travel, the increments of cost and the emphasis of program is quite liable to be different in each case. The lumping of urban and rural highways into one solution probably distorts the answers obtained through the incremental or any other method of vehicle tax allocation.

Fifth, there should be a way developed to penalize each class of vehicles according to the regularity of axle loads over the legal limit. If our highway designs are correct, overloads are probably a heavier contribution to highway costs than any other one thing, and as such, it would seem desirable to realize additional revenue from the classes of vehicles that carry overloads regularly. Unless enforcement procedures are intensified, this may be the only (though undesirable) way of penalizing weight violations.

Availability of Data

The Minnesota Highway Department was in a position to provide much of the basic data needed for the incremental method, although it must be recognized that not every state is in that position. However, even in a state like Minnesota some data must be estimated on the basis of circumstantial evidence, and, unfortunately, the need for other data must be ignored or treated expediently.

Travel Data. In particular, better data are needed on urban travel. The nature of most state highway planning surveys has restricted the scope of survey operations within cities and this has left a void in knowing what vehicles are in the urban traffic stream, where they travel, how often, and with what loads. Generally speaking, more accurate data is needed on the annual average mileage of the various vehicle weight groups within each class of vehicle.

Maintenance Cost Data. Better data are needed on the relative effect of each type of vehicle upon costs of maintenance of condition. For instance, do multiple axle vehicles cause a disproportionate part of the maintenance, either more or less? Is the share attributable to vehicles of each weight and type constant from rural highways to urban streets, or high structural strength roads to low strength roads?

Data on Cost of Auxiliary Facilities Caused by Highways. A more accurate accounting is needed of the expenditures, particularly by local governments, which are auxiliary to highways; such things as traffic police and traffic technicians, traffic control devices, bigger drainage facilities occasioned by rapid runoff from increasing areas of impervious pavement, and the costs of storing vehicles are all things which should be considered in a proprietary treatment of highway use.

ESSENCE

This paper has reviewed the philosophical base which creates a need for some such device as the incremental method. If the pressure for dedicating highway user tax revenue were removed, the need for this type of approach would be lessened. It appears, however, that the necessity of developing a tax structure based on a buyer-seller relationship must be faced; the incremental method presents a rational approach. The basic information is generally available and the gaps represent data which can and should be developed for better highway construction and operation and for purposes of tax analysis. The extent of agreement as to the suitability of the incremental method indicates that the results should provide a reliable base for legislative action in states requiring the dedication of highway user revenue.

Appendix A

INCREMENTS OF COST DETERMINED IN THE MINNESOTA STUDY

Axle Load in Kips	System A	System B	System C	System D
		Roadway Costs		
0- 4	52	64	75	100
4-10	13	18	25	
10-14	13	18		
Over 14	22			
		Structure Costs		
0- 4	73	76	88	100
4-10	11	12	12	
10-14	11	12		
Over 14	5			
		Maintenance of Condition Costs		
0- 4	64	84	87	100
4-10	2	5	13	
10-14	6	11		
Over 14	28			

Appendix B

INCREMENTAL METHOD OF ALLOCATING VEHICLE TAXES EXPRESSED ALGEBRAICALLY

Primary Equation

Tax Allocation to One Vehicle of a Certain Type=

$$AMA_{0\text{-}4} \times WCA_{0\text{-}4} + AMB_{0\text{-}4} \times WCB_{0\text{-}4} + AMC_{0\text{-}4} \times WCC_{0\text{-}4} +$$

$$AMD \times WCD + AMA_{4\text{-}10} \times WCA_{4\text{-}10} + AMB_{4\text{-}10} \times WCB_{4\text{-}10} +$$

$$AMC_{\text{over } 4} \times WCC_{\text{over } 4} + AMA_{10\text{-}14} \times WCA_{10\text{-}14} + AMB_{\text{over } 10} \times WCB_{\text{over } 10} +$$

$$AMA_{\text{over } 14} \times WCA_{\text{over } 14} + VMA \times TCA + VMB \times TCB + VMC \times TCC +$$

$$VMD \times TCD + FC$$

Secondary Equations

Elements of Weight Costs

$$WCA_{0\text{-}4} = \frac{RIA_{0\text{-}4} \times RPA + SIA_{0\text{-}4} \times SPA + MIA_{0\text{-}4} \times MCPA}{CAMA_{\text{over } 0}}$$

$$WCA_{4\text{-}10} = \frac{RIA_{4\text{-}10} \times RPA + SIA_{4\text{-}10} \times SPA + MIA_{4\text{-}10} \times MCPA + WCA_{0\text{-}4}}{CAMA_{\text{over } 4}}$$

$$WCA_{10\text{-}14} = \frac{RIA_{10\text{-}14} \times RPA + SIA_{10\text{-}14} \times SPA + MIA_{10\text{-}14} \times MCPA + WCA_{4\text{-}10}}{CAMA_{\text{over } 10}}$$

$$WCA_{\text{over } 14} = \frac{RIA_{\text{over } 14} \times RPA + SIA_{\text{over } 14} \times SPA + MIA_{\text{over } 14} \times MCPA + WCA_{10\text{-}14}}{CAMA_{\text{over } 14}}$$

$$WCB_{0\text{-}4} = \frac{RIB_{0\text{-}4} \times RPB + SIB_{0\text{-}4} \times SPB + MIB_{0\text{-}4} \times MCPB}{CAMB_{\text{over } 0}}$$

$$WCB_{4-10} = \frac{RIB_{4-10} \times RPB + SIB_{4-10} \times SPB + MIB_{4-10} \times MCPB + WCB_{0-4}}{CAMB_{over\ 4}}$$

$$WCB_{over\ 10} = \frac{RIB_{over\ 10} \times RPB + SIB_{over\ 10} \times SPB + MIB_{over\ 10} \times MCPB + WCB_{4-1}}{CAMB_{over\ 10}}$$

$$WCC_{0-4} = \frac{RIC_{0-4} \times RPC + SIC_{0-4} \times SPC + MIC_{0-4} \times MCPC}{CAMC_{over\ 0}}$$

$$WCC_{over\ 4} = \frac{RIC_{over\ 4} \times RPC + SIC_{over\ 4} \times SPC + MIC_{over\ 4} \times MCPC + WCB_{0-4}}{CAMC_{over\ 4}}$$

$$WCD = \frac{RPD + SPD + MCPD}{CAMD}$$

Elements of Travel Costs

$$TCA = \frac{RWA + MOPA}{CVMA}$$

$$TCB = \frac{RWB + MOPB}{CVMB}$$

$$TCC = \frac{RWC + MOPC}{CVMC}$$

$$TCD = \frac{RWD + MOPD}{CVMD}$$

Elements of Nontravel, Nonweight Costs

$$FC = \frac{\text{Motor Vehicle Bureau + Petroleum Division}}{\text{Total Vehicle Registration}}$$

Definitions of Vehicle Allocation Factors Which Would Be the Same For All Vehicle Types

Costs Which Are Attributable to Weight

WCA_{0-4} = cumulative cost per axle mile of 0-4 kip load travel on A
WCA_{4-10} = cumulative cost per axle mile of 4-10 kip load travel on A
WCA_{10-14} = Cumulative cost per axle mile of 10-14 kip load travel on A
$WCA_{over\ 14}$ = cumulative cost per axle mile of over 14 kip load travel on A

WCB_{0-4} = cumulative cost per axle mile of over 0-4 kip load travel on B
WCB_{4-10} = cumulative cost per axle mile of 4-10 kip load travel on B
$WCB_{over\ 10}$ = cumulative cost per axle mile of over 10 kip load travel on B

WCC_{0-4} = cumulative cost per axle mile of 0-4 kip load travel on C
$WCC_{over\ 4}$ = cumulative cost per axle mile of over 4 kip load travel on C

WCD = cumulative cost per axle mile of all kip load travel on D

Costs Which Are Attributable to Travel

TCA = the share of the cost of right of way and maintenance of operation on A allocated to each vehicle mile of travel on A
TCB = the share of the cost of right of way and maintenance of operation B allocated to each vehicle mile of travel on B
TCC = the share of the cost of right of way and maintenance of operation on C allocated to each vehicle mile of travel on C
TCD = the share of the cost of right of way and maintenance of operation on D allocated to each vehicle mile of travel on D

Costs Not Attributable to Travel or Weight

FC = fixed cost per vehicle

Elements of Weight Costs

RIA_{0-4} = increment of A roadway costs chargeable to 0-4 kip axle loads
RIA_{4-10} = increment of A roadway costs chargeable to 4-10 kip axle loads
RIA_{10-14} = increment of A roadway costs chargeable to 10-14 kip axle loads
$RIA_{over\ 14}$ = increment of A roadway costs chargeable to over 14 kip axle loads

RIB_{0-4} = increment of B roadway costs chargeable to 0-4 kip axle loads
RIB_{4-10} = increment of B roadway costs chargeable to 4-10 kip axle loads
$RIB_{over\ 10}$ = increment of B roadway costs chargeable to over 10 kip axle loads

RIC_{0-4} = increment of C roadway costs chargeable to 0-4 kip axle loads
$RIC_{over\ 4}$ = increment of C roadway costs chargeable to 4-10 kip axle loads

There are similar series for structure costs (SI), and maintenance costs (MI).

RPA = roadway program costs for A
RPB = roadway program costs for B
RPC = roadway program costs for C
RPD = roadway program costs for D

There are similar series for structure costs (SP), and maintenance of condition costs (MCP).

$CAMA_{over\ 0}$ = cumulative axle miles of travel on A for all axle loads
$CAMA_{over\ 4}$ = cumulative axle miles of travel on A for over 4 kip axle loads
$CAMA_{over\ 10}$ = cumulative axle miles of travel on A for over 10 kip axle loads
$CAMA_{over\ 14}$ = cumulative axle miles of travel on A for over 14 kip axle loads
$CAMB_{over\ 0}$ = cumulative axle miles of travel on B for all axle loads
$CAMB_{over\ 4}$ = cumulative axle miles of travel on B for over 4 kip axle loads
$CAMB_{over\ 10}$ = cumulative axle miles of travel on B for over 10 kip axle loads
$CAMC_{over\ 0}$ = cumulative axle miles of travel on C for all axle loads
$CAMC_{over\ 4}$ = cumulative axle miles of travel on C for over 4 kip axle loads

CAMD = cumulative axle miles of travel on D for all axle loads

Elements of Travel Costs

RWA = right of way costs for A
RWB = right of way costs for B
RWC = right of way costs for C
RWD = right of way costs for D

MOPA = maintenance of operation program costs for A
MOPB = maintenance of operation program costs for B
MOPC = maintenance of operation program costs for C
MOPD = maintenance of operation program costs for D

CUMA = cumulative vehicle miles for A
CUMB = cumulative vehicle miles for B
CUMC = cumulative vehicle miles for C
CUMD = cumulative vehicle miles for D

Definitions of Vehicle Allocation Factors Which Would Change For Each Vehicle Type

Axle Miles

AMA_{0-4} = axle miles traveled per vehicle on A while carrying a 0-4 axle load
AMA_{4-10} = axle miles traveled per vehicle on A while carrying a 4-10 axle load
AMA_{10-14} = axle miles traveled per vehicle on A while carrying a 10-14 axle load
$AMA_{over\ 14}$ = axle miles traveled per vehicle on A while carrying an over 14 axle load

AMB_{0-4} = axle miles traveled per vehicle on B while carrying a 0-4 axle load
AMB_{4-10} = axle miles traveled per vehicle on B while carrying a 4-10 axle load
$AMB_{over\ 10}$ = axle miles traveled per vehicle on B while carrying an over 10 axle load
AMC_{0-4} = axle miles traveled per vehicle on C while carrying a 0-4 axle load
$AMC_{over\ 4}$ = axle miles traveled per vehicle on C while carrying an over 4 axle load
AMD = axle miles traveled per vehicle on D while carrying any axle load

Vehicle Miles

VMA = mileage per vehicle on A
VMB = mileage per vehicle on B
VMC = mileage per vehicle on C
VMD = mileage per vehicle on D