HIGHWAY MAINTENANCE COST RESPONSIBILITY FOR TAXATION PLANNING IN VIRGINIA, U.S.A.

by

A. G. Hobeika, T. K. Tran & S. M. Moussavi-Sadati
Department of Civil Engineering
Virginia Polytechnic Institute
and State University
Blacksburg, Virginia 24061
U.S.A.

INTRODUCTION

Since the mid-1970's, highway fuel tax revenue has declined significantly due to the increased effort to conserve energy. The declining fuel tax revenue, which is the major source of highway funding, has resulted in many tax increases in order to cope with the increasing highway construction and maintenance costs. Because highway facilities are supported by the general public, the two basic issues in taxation always arise in these occasions. They are (1) how much more tax is needed and (2) how much each user group must pay. The former addresses the effectiveness of taxation policies while the latter addresses the equity in tax contributions. In this paper, both issues will be analyzed
and the conditions in the Commonwealth of Virginia will be used as a case study.

PURPOSE AND OBJECTIVES

Several studies of this nature have been conducted in the U.S. [1, 2,3] and referred to as cost allocation studies. The main emphasis of these studies was on the allocation of both highway construction costs and highway maintenance costs to different classes of motor vehicles (e.g., passenger cars, light, medium and heavy trucks). A general methodology that has been applied is using past data of a reference year to perform cost allocation and then applied this result to a future year. The allocation process is thus static and not responsive to the dynamic changes of the input parameters such as travel intensity and economic conditions (e.g., inflation).

Another drawback of the present studies is that highway costs are aggregated at the highway system level (i.e., interstate, primary, secondary and urban systems); therefore suppressing the individual characteristics of each route. With this approach the projected costs for future allocation may not be accurate due to the fact that the local travel characteristics are not considered and the influence of the topographical conditions and weather conditions are not accounted for. Further, the aggregation at the highway system level does not provide any flexibility to prioritize future highway maintenance projects for each route.

In an effort to overcome the above shortcomings, the cost allocaion study conducted by the authors was structured at the route level. The main purpose of the study was to more accurately estimate the highway costs and revenue contribution over an extended period of time (from

1981 to 1990) and be able to test the impacts of various economic changes; also, to gain more insight into the importance of individual routes in the network so that innovative solutions to taxation planning and highway management may be developed.

To achieve the above purpose, the following objectives were developed:

1. To forecast the vehicle miles of travel by each class of vehicles on each route in order to estimate the revenue contributions, the highway maintenance costs incurred and the equivalent single axle loads (ESAL) to be used in the allocation process.

2. To formulate a methodology to assign cost responsibility to each class of vehicles on each route so that the amounts of under and/or over payments of the vehicle classes may be computed.

The forecasts of all parameters were made using the technique of regression analysis based on available data from the year 1970 to 1980.

SCOPE AND LIMITATIONS

The Virginia Department of Highways and Transportation is responsible for the interstate, arterial, primary, and secondary road systems which comprise of more than 52,000 centerline miles of roads (or 83,200 km). Out of this total, the interstate road system has about 990 miles (1,584 km) of roads and comprises of seven major routes; the arterial road system has approximately 1970 miles (3152 km) of roads and comprises of 13 major routes; the primary road system has more than 6,100 miles (9,760 km) of roads and comprises of more than 280 routes. The remaining road mileage of approximately 42,940 miles is scattered over the state's land area of more than 39,000 square miles. Because of this large number of miles, the route-by-route approach seems impractical for all road systems in the state. The study was therefore divided into two stages in which the route-by-route approach was applied to the interstate and arterial road systems in the first stage and the district (or zonal) approach was applied to the primary and secondary road systems in the second stage.

This two-stage approach is justified by the fact that the interstate and the arterial road systems are the major trunk lines of Virginia where the majority of travel by all types of vehicles occurs. The average daily traffic per mile on interstate and arterial roads in 1981 is 22,900 and 7,750 vehicles [4], respectively. The primary and the secondary roads carry approximately 3,800 and 450 vehicles per mile per day, respectively, in the same year [4].

The contents of this paper cover the results of the first stage of the study only; the results of the second stage are summarized in Reference [5]. Within the limit of the two highway systems selected, highway construction costs are considered as sunk costs in the study since most of the mileage needed on these systems are completed. The only type of costs considered is therefore highway maintenance costs.

With respect to revenues, two major types of highway revenues that are user-related were incorporated in this study: (1) registration fee and (2) fuel tax. The reasons for selecting these two types of revenues are:

1. They are two of the three major highway revenue sources of the state. Their combined contribution is more than 75% of the total state source revenue each year.

2. They relate directly to the intensity of highway use; and

3. They may be easily computed on an annual basis. Because of this requirement, the sales-and-use tax revenue -- the third major revenue source which contributes about 14% annually -- was not considered. (Sales-and-use tax is paid only when a vehicle is purchased, either new or used).

DESCRIPTION OF THE STUDY

The Highway Network Under Study

The total length of the network considered in this study is approximately 2,900 miles, comprising of 20 routes as shown in Table 1. Routes with an even route number run east-west while routes with an odd route number run north-south.

TABLE 1 - Description of the Interstate and Arterial Road Systems

Route Number	Length (Miles)	Avg. Daily Traffic Per Mile (1981)
Interstate:		
I-64	266.95	21,051
I-66	65.34	20,109
I-77	60.54	8,239
I-81	320.82	15,428
I-85	64.34	9,230
I-95	139.54	39,538
I-495	14.50	110,362
Arterial:		
US 7	62.71	15,714
US 13	72.41	8,049
US 17	171.63	7,574
US 19	72.12	8,495
US 23	54.74	7,236
US 29	176.07	11,371
US 33	165.05	4,837
US 58	413.91	4,669
US 211	57.72	4,081
US 220	152.27	5,792
US 301	107.17	5,467
US 360	195.82	5,499
US 460	270.94	7,905

Classification of Vehicles

Vehicles using Virginia highways are grouped into four classes which correspond to the way that traffic volume data are maintained (see Figure 1). The four classes are:

Class I, including passenger cars, panel and pickup trucks and two-axle, four-tire trucks

Class II, including two-axle, six-tire trucks (small dump and delivery trucks)

Class III, including three-axle, six to ten-tire trucks (primarily heavy dump trucks)

Class IV, including three, four and five-axle combination trucks.

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

General Methodology

Figure 2 illustrates the relationships between the major components of the study. As shown in this figure, travel is modeled as a function of the population, the total state's personal income, and the average vehicle operating cost. The forecasted travel was then used to forecast the maintenance expenditures for each route. Two other uses of the travel forecast are the estimation of fuel-tax revenues and the equivalent single axle loads. The former is a function of the fuel efficiency of each class of vehicles while the latter is a function of vehicle weights. The second component of revenues--registration--is a function of registration fees and vehicle registration. Registration fees in Virginia are based on the vehicle gross weight for vehicles not designed or used for transportation of passengers. Vehicle registration was determined as a function of the population and personal income. From these estimated parameters, the cost allocation analysis was performed.

Travel Forecast

Multiple linear regression analysis was applied to forecast the average daily vehicle miles of travel by each class of vehicles on each route. A number of independent variables were used in the regression as shown in Table 2. The vehicle miles of travel for Class I vehicles were assumed to be functions of the average household income, the number of households in the state and the auto operating cost per mile. These variables were selected based on the hypothesis that the majority of vehicles in this class are automobiles and the travel characteristics are more or less in the category of personal travel. For Classes II and III, the total state population, total state personal income, and truck operating cost per mile were used as independent variables. The truck

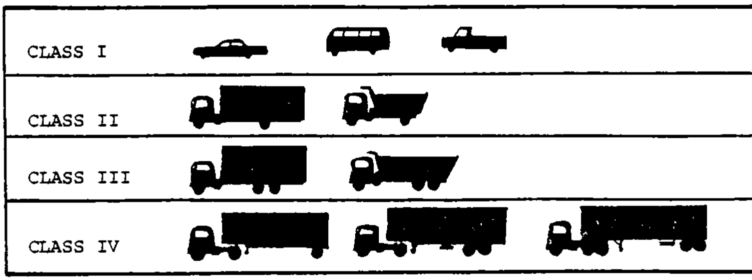

FIGURE 1 - Classification of Vehicles

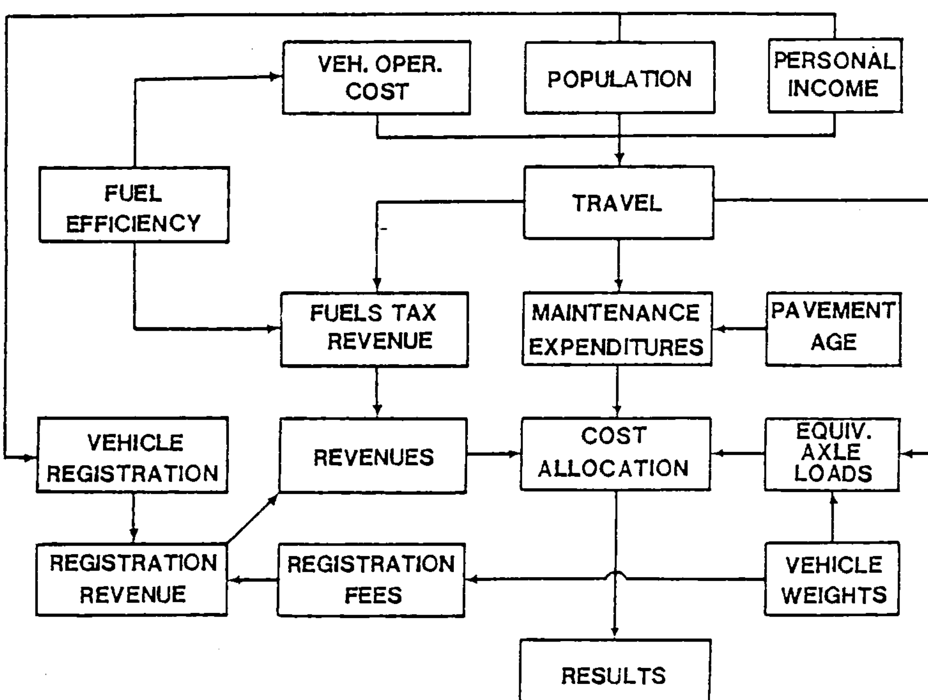

FIGURE 2 - General Methodology

operating cost per mile was used for these two classes because their travel is local in nature (short distance) and the majority of these trucks are privately owned. Finally, the variables used to forecast the travel of Class IV vehicles are the state population and the total personal income since the travel of heavy trucks is assumed to more relate to the state's economy.

TABLE 2 - Variables Used in Regression Equations

Class	Independent Variables
I	• State Average Household Income (in 1968 dollars) • Number of Households in the State • Auto Operating Cost Per Mile (cents per mile)
II	• Total State Population • Total State Personal Income (in millions of 1970 dollars) • Truck Operating Cost Per Mile (cents per mile)
III	• Total State Population • Total State Personal Income (in millions of 1970 dollars) • Truck Operating Cost Per Mile (cents per mile)
IV	• Total State Population • Total State Personal Income (in millions of 1970 dollars)

In the modeling process, the travel on two major routes was assumed to influence the travel on the minor routes that are connected to them. These major routes are Interstate 81 running north-south and located in the western part of the state; and Interstate 95 also running north-south and located in the eastern part of the state. All the regression equations have high coefficient of determination (R^2 values are above 0.90 for most interstate and primary routes; there are some primary routes with R^2 values of between 0.70 and 0.80).

Maintenance Expenditure Forecast

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

According to historical data [6], the price index of highway maintenance in Virginia increases at approximately the same rate as that of the consumer price index of all goods (CPIAG). It is therefore hypothesized that future highway general maintenance expenditures depend on the value of CPIAG, which is used as an indicator of economic changes. Maintenance replacement expenditures, on the other hand, were modeled as a function of travel, highway construction price index and average pavement age (for interstate roads only).

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

Revenue Forecast

The two sources of revenues used in the study were computed for each class of vehicles using each route. The forecasted fuel tax revenues were computed based on the forecasted vehicle miles of travel, the average fuel efficiency of each class of vehicles and the tax rate of 11 cents (state fuel tax) per gallon of fuel for Class I and Class II vehicles and 13 cents per gallon of fuel for Class III and Class IV vehicles. The projected fuel efficiency for Class I vehicles, in miles per gallon, was based on two different sources [7,8], ranging from 15.5 miles per gallon in 1980 to 25.6 miles per gallon in 1990. The average fuel efficiency for all trucks was assumed to be increased by 1.4% per year. This average figure was adjusted for Class II, III, and IV vehicles using the estimated percentages from past data [9]. The fuel efficiencies for Classes II, III and IV vehicles were assumed at 7.34, 5.17 and 4.56 miles per gallon, respectively, for the year 1980 and 8.28, 5.83 and 5.13 miles per gallon, respectively, for the year 1990.

Registration fee revenues collected from each class of vehicles on each route were estimated using the forecast of vehicle registration at the state level, which had been developed in another study [10] by the same research team. At the state level, the number of vehicles registered each year was forecasted according to three groups: auto, bus and truck. Auto registration and truck registration were then apportioned to the selected four classes mentioned previously according to the percentage of vehicles in each class reported in the Census of Transportation [11]. With these values, the registration fee revenues collected from each class of vehicles were estimated, which were then apportioned to each route according to the vehicle miles of travel on the route relative to the vehicle miles of travel in the whole state by that particular class of vehicles.

Allocation of Cost Responsibility

The procedure for allocating maintenance costs to each class of vehicles has greatly been debated. The basic issues are what percentage of the total cost may be due to environmental and weather conditions and what percentage may be due to the use of the highway (or by the impacts of axle weights).

For pavement maintenance and replacement, the Federal Highway Administration (FHWA) used an overall split of 30% as non-traffic related and 70% traffic related in its recent cost allocation study [3]. The Joint Legislative Audit and Review Commission (JLARC) used different percentages of share for different highway systems and different types of maintenance work. For the interstate road system, JLARC assigned

22.6% of the cost as environmentally-related and 77.4% as weight-related in allocating pavement maintenance and repair costs [2]. For the primary highway system, 34% and 66% of the total pavement maintenance and repair costs were used as environmentally related and weight-related, respectively [2]. Until now, a uniform split of maintenance costs has not yet been developed. The percentages used are still a judgmental factor.

In this paper, the total general maintenance costs were treated as common costs and allocated to the vehicle classes based on their respective vehicle miles of travel since the activities performed were routine in nature and more or less independent of the intensity of highway use. Replacement maintenance costs, however, were treated as occassioned costs and allocated according to the equivalent single axle loads of each vehicle class since more than 60% of replacement costs are pavement related. In order to take into account the costs incurred by weights and by environmental conditions, 30% of the replacement costs were assumed to be environmentally related and allocated according to the vehicle miles of travel; the remaining 70% were treated as weight-related and allocated according to the equivalent single axle loads. The same percentages were used for both highway systems under study.

To estimate the equivalent single axle loads (18 kips), the equations developed by the Virginia Highway Research Council [12] were used. They are;

- For Class I vehicles: ESAL = 0.003 (ADT)
- For Class II vehicles: Log(ESAL) = -0.07 x 0.99 Log(365 x ADT)
- For Class III vehicles: Log(ESAL) = -0.055 + Log (365 x ADT)
- For Class IV vehicles: Log(ESAL) = -0.0578 + Log (365 x ADT)

where ADT is the average daily traffic of the respective class of vehicles.

STUDY RESULTS

Interstate Highway System

Travel increases by about 67% in 10 years on most of the interstate highways in Virginia by all classes of vehicles (from 20.2 million VMT's per day in 1981 to 33.6 million per day in 1990). The largest shares are carried by Class I and Class IV vehicles. The travel of heavy trucks (Class IV) in Virginia is primarily conducted on I-81, I-95, and I-64 in that descending order. Those routes approximately constituted 87% of the total travel by Class IV vehicles on the interstate highways in Virginia. Class I vehicles dominate the travel on all the interstate highways with percentages ranging from 49% to 91% of all travel on individual routes.

The projected maintenance expenditures for the interstate system increase at approximately 9% per year. Class I vehicles produce the most cost with percentages ranging from 61% in 1981 ($17.8 million) to 65 % in 1990 ($39.8 million). Class IV vehicles are assigned with the second highest maintenance cost responsibility, ranging from $9.4 million (32%) in 1981 to $17.8 million (29%) in 1990. Classes II and III vehicles show a percentage share of 4% and 3% respectively in 1981 and 4% and 2% respectively in the year 1990. Consistent with the assigned cost responsibility, Class I and Class IV vehicles are the predominant generators of revenues with a share of approximately 52% ($45.8 million) and 42% ($37.2 million) respectively in the year 1981 and 49% ($52.1 million) and 44% ($46.8 million) respectively in the year 1990. Classes II and III vehicles contribute approximately 5% and 2% of the total revenues, respectively.

The total revenues and cost responsibilities over the ten period for the interstate highway system are shown in Table 3. This table shows that all classes of vehicles overpay their shares of maintenance costs on interstate highways due to their intensive use of this road system. Although Class I vehicles contribute the most revenues ($485 million) their amount of overpayment is only $211 million, which is lower than that of Class IV vehicles ($286 million). The reason for this is that Class I vehicles bear the largest maintenance burden due to their heavy use of the road system (in terms of vehicle miles of travel) whereas Class IV vehicles do not bear the same proportion of cost due to their weights but contribute more registration revenues based on the weight criterion. Secondly, Class IV vehicles have the lowest miles per gallon therefore contributing higher fuel tax revenue. Class I vehicles, on the other hand, have the highest fuel efficiency and therefore contributing a smaller amount of fuel taxes per vehicle mile.

TABLE 3 - Total Ten-Year Expenditures and Revenues for the Interstate System (Millions of Dollars)

EXPENDITURES

ROUTE	CLASS I	CLASS II	CLASS III	CLASS IV	ALL CLASSES
I - 64	115.30	4.68	2.55	28.94	151.47
I - 66	23.67	1.01	1.18	3.31	29.17
I - 77	14.31	0.84	0.24	6.79	22.18
I - 81	56.76	3.88	1.63	53.74	116.01
I - 85	12.50	1.22	0.21	7.88	21.81
I - 95	46.21	2.69	2.17	25.76	76.83
I - 495	5.40	1.41	2.05	7.34	16.20
All Routes	274.15	15.73	10.03	133.76	433.67

REVENUES

ROUTE	CLASS I	CLASS II	CLASS III	CLASS IV	ALL CLASSES
I - 64	171.45	11.04	3.93	53.32	239.74
I - 66	35.98	2.69	2.24	7.75	48.66
I - 77	13.27	1.92	0.61	20.92	36.72
I - 81	95.41	13.82	5.29	213.68	328.20
I - 85	7.72	1.86	0.45	21.04	31.07
I - 95	122.81	12.05	6.49	95.53	236.88
I - 495	38.66	3.13	1.67	7.48	50.94
All Routes	485.30	46.51	20.68	419.72	972.21
Overpaymts.	211.15	30.78	10.65	285.96	538.54

For the purpose of comparison, the ratios of revenue to assigned cost for each class of vehicles in each year and on all routes were computed as shown in Table 4.A. Also, the ratios of the sum (over the ten-year period) of revenues to the sum of assigned costs for each class of vehicles on each route were computed as shown in Table 4.B. Classes IV, II, III and I in that order provide the highest ratio of revenues to assigned costs. In 1981, according to the results, these ratios are above 2.5. However, they all decrease as time progresses. The rates of decrease of the ratios are 7.8%, 4.7%, 4.2% and 4.7% per year for Classes I, II, III and IV vehicles, respectively. The high rate of decrease of Class I vehicles is due to the increase in fuel efficiency over the study period.

The results also show that Class I vehicles on routes I-77 and I-85, and Class III vehicles on route I-495 produce revenues that are only 93%, 62% and 81% of their maintenance cost responsibilities, respectively (see Table 4.B). There are two possible reasons for this. First, the vehicle miles of travel by class I vehicles on the first two routes and Class III on I-495 are low compared to the other routes, thus causing a small contribution in gas tax revenues. Secondly, because of the geographical location of these routes, a portion of these vehicles is likely to be out-of-state vehicles, whose registration-fee could not be accounted for.

TABLE 4 - Ratios of Revenues-to-Assigned Costs

(A) By Class and By Year (Sum over all routes)

YEAR	CLASS I	CLASS II	CLASS III	CLASS IV	ALL CLASSES
1981	2.57	3.73	2.54	3.97	3.07
1982	2.46	3.63	2.44	3.81	2.94
1983	2.24	3.42	2.32	3.60	2.72
1984	2.03	3.23	2.21	3.42	2.53
1985	1.91	3.07	2.11	3.25	2.38
1986	1.73	2.88	2.01	3.07	2.19
1987	1.60	2.76	1.94	2.95	2.06
1988	1.50	2.67	1.88	2.85	1.96
1989	1.41	2.58	1.82	2.75	1.86
1990	1.31	2.46	1.76	2.63	1.74

(B) By Class and By Route (Sum over 10 Years)

ROUTE	CLASS I	CLASS II	CLASS III	CLASS IV	ALL CLASSES
I - 64	1.49	2.36	1.54	1.84	1.58
I - 66	1.52	2.65	1.90	2.35	1.67
I - 77	0.93	2.29	2.54	3.08	1.66
I - 81	1.68	3.56	3.24	3.98	2.83
I - 85	0.62	1.52	2.14	2.67	1.42
I - 95	2.66	4.47	3.00	3.75	3.10
I - 495	7.16	2.22	0.81	1.02	3.14

Arterial Highway System

The estimated travel on arterial highways in the year 1990 is approximately 1.5 times the travel in 1981. The most heavily traveled routes are US 460, US 29, US 58, US 17 and US 360 in that decreasing order. The total travel on these routes constitutes approximately 70% of all travel on arterial highways. Class I and Class IV vehicles remain to be the primary users of the network and therefore the major revenue contributors and cost bearers.

The average annual growth rate of maintenance expenditures on arterial highways is about 8% (from $32.9 million in 1981 to $67.1 million in 1990). The average annual growth rate of revenues, however, is less than 0.2% (from $50.0 million in 1981 to $50.7 million in 1990). Because of this small growth in revenues, the ratio of revenues to expenditures for all classes on the arterial system declines rapidly from 1.52 in 1981 to 0.76 in 1990.

Over the ten-year study period, the total maintenance cost is estimated to be $4B5 million while the total revenues is approximately $502 million. However, between the four classes of vehicles, Class I and Class II vehicles overpay their shares of $90.48 million and $2.27 million, respectively while Classes III and IV vehicles underpay by an amount of $15.4 million (44%) and $59.8 million (29%), respectively (see Table 5). There are also large variations in maintenance costs incurred and revenues contributed between the arterial routes. The variations in revenue range from 3.6 million dollars for Route US 33 to 92.2 million dollars for Route US 460. Maintenance expenditures, on the other hand, vary from 3.2 million dollars for Route US 33 to 116.4 million dollars for Route US 58. One of the main causes of the variations is the route length. Topographical conditions, however, are also a factor. Route US 5B, for example, has an average annual maintenance cost per mile of of approximately $2B,000 while Route US 29 has an average cost of $20,000 per mile. Route US 5B is in a mountainous terrain as opposed to the rolling terrain of Route US 29. In addition, the amount of traffic on US 29 is approximately 2.5 times that of Route 58.

The degree of revenue contribution relative to cost responsibility may be more conveniently illustrated through the revenue-to-assigned-cost ratios as shown in Table 6. These ratios are much lower than those for the interstate road system (from 0.74 to 2.18 in 19B1 and from 0.45 to 0.97 in 1990). Classes I, II, IV and III in that order have the highest ratios over the study period. The rate of decrease of the ratios is still highest for Class I vehicles (9.4% per year) then followed by Class II (6.3%), Class IV (6%) and Class III (5.7%).

With respect to individual routes, Class I vehicles pay their "fair" share on all routes except Routes US 13 and US 58. Because of the maintenance costs incurred on these routes are high compared to the level of traffic that they support, the revenue-to-cost ratios are below 1.0 for all classes of vehicles.

TABLE 5 - Total Ten-Year Expenditures and Revenues for the Arterial System (Millions of Dollars)

EXPENDITURES

ROUTE	CLASS I	CLASS II	CLASS III	CLASS IV	ALL CLASSES
US 7	5.08	0.75	1.31	2.91	10.05
US 13	22.20	3.21	1.93	30.85	58.19
US 17	24.16	2.89	2.86	22.36	52.27
US 19	4.97	1.28	3.54	3.03	12.82
US 23	8.32	2.03	3.14	7.04	20.53
US 29	19.07	1.14	0.40	15.27	35.88
US 33	1.95	0.29	0.30	0.65	3.19
US 58	53.28	5.53	6.39	51.22	116.42
US 211	3.19	0.11	0.37	0.66	4.33
US 220	12.77	0.89	0.83	9.05	23.54
US 301	16.66	1.80	1.54	21.86	41.86
US 360	15.68	0.80	1.22	8.06	25.76
US 460	34.12	2.87	11.05	32.00	80.04
All Routes	221.45	23.59	34.88	204.96	484.88

REVENUES

ROUTES	CLASS I	CLASS II	CLASS III	CLASS IV	ALL CLASSES
US 7	12.50	0.72	0.48	1.31	15.01
US 13	14.65	1.56	0.41	8.01	24.63
US 17	34.41	2.67	1.14	10.77	48.99
US 19	7.44	0.95	1.03	1.12	10.54
US 23	12.85	1.61	1.01	2.75	18.22
US 29	48.06	2.75	0.47	20.87	72.15
US 33	2.99	0.24	0.10	0.28	3.61
US 58	48.37	4.72	2.61	25.60	81.30
US 211	11.63	0.18	0.22	0.50	12.53
US 220	21.34	1.94	1.03	13.76	38.07
US 301	18.68	2.08	0.87	15.30	36.93
US 360	29.63	2.06	1.79	14.81	48.29
US 460	49.38	4.38	8.33	30.06	92.15
All Routes	311.93	25.86	19.49	145.14	502.42
Overpaymts.	90.48	2.27	-15.39	-59.82	17.54

CONCLUSION

The study's results have shown that there are significant variations in revenue contributions and assigned cost responsibilities between the highway systems, highway routes and vehicle classes. The heavily traveled Interstate road system is financially better off than the moderately traveled Arterial road system. Even on a per-mile basis, the revenue-to-assigned-cost ratios for the interstate routes are from 1.4 to 3.1 whereas, for the arterial routes, they vary from 0.4 to 2.8. This suggests that there is a "cross-subsidy" among the routes in the state. Also, Class I (passenger cars and light trucks) and Class IV vehicles (heavy trucks) contribute more revenues than the other two

TABLE 6 - Ratios of Revenues to Assigned Costs (Arterial System)

(A) By Class and By Year (Sum over all routes)

YEAR	CLASS I	CLASS II	CLASS III	CLASS IV	ALL CLASSES
1981	2.18	1.47	0.74	0.95	1.52
1982	2.00	1.38	0.69	0.89	1.40
1983	1.82	1.29	0.65	0.B3	1.29
1984	1.64	1.21	0.61	0.79	1.18
1985	1.52	1.14	0.58	0.74	1.10
1986	1.38	1.06	0.55	0.70	1.02
1987	1.26	1.00	0.53	0.66	0.94
1988	1.15	0.95	0.50	0.62	0.87
1989	1.06	0.90	0.48	0.59	0.81
1990	0.97	0.85	0.45	0.56	0.76

(B) By Class and By Route (Sum over 10 years)

YEAR	CLASS I	CLASS II	CLASS III	CLASS IV	ALL CLASSES
US 7	2.46	0.96	0.37	0.45	1.49
US 13	0.66	0.49	0.21	0.26	0.42
US 17	1.42	0.92	0.40	0.48	0.94
US 19	1.50	0.74	0.29	0.37	0.82
US 23	1.54	0.79	0.32	0.39	0.89
US 29	2.52	2.41	1.19	1.37	2.01
US 33	1.53	0.83	0.34	0.43	1.13
US 58	0.91	0.85	0.41	0.50	0.70
US 211	3.64	1.62	0.61	0.76	2.89
US 220	1.67	2.18	1.24	1.52	1.62
US 301	1.12	1.15	0.56	0.70	0.88
US 360	1.89	2.57	1.47	1.84	1.87
US 460	1.45	1.53	0.75	0.94	1.15

classes of vehicles. And among all classes, the revenue-to-assigned-cost ratios are significantly different, suggesting a "cross-subsidy" even between the classes of vehicles. Finally, if the interstate and arterial road systems are combined, the cost ratio declines from 2.24 in 1981 to 1.22 in 1990, suggesting a need for higher user charges in the near future.

The general merit of this study can be recognized from two aspects. First, it provides the information needed for the refinement of the existing tax structure so that an equitable and effective charging scheme can be developed. The fuel tax and registration fees paid by Class I vehicles are in excess of their estimated cost responsibility for the above mentioned highway systems. Trucks, on the other hand, underpay their share of costs on routes that are not heavily used. This suggests that the user fees based on weight criterion must be adjusted to compensate the discrepancy between costs and revenues.

The results of the study also indicate that for highway routes that are not heavily used, their revenue-to-cost ratios are likely to be below 1.0. Thus, on the primary and secondary road systems, the ratios of revenue to cost would very likely be below 1.0. The question that arises here is that should a different highway financing mechanism be developed for these two road systems if equity is the main concern? The authors feel that at least the secondary road system should be financed locally (through local auto ownership fees, for example). This is because the secondary roads provide services mainly to the local users, rather than the whole state's population.

The second aspect of the study is that it shows the degree of importance of the routes in the state highway system -- in terms of travel and financial viability -- which may help to formulate a priority scheme for the maintenance and improvement of the routes. This priority scheme can be provided by ranking the routes based on their expected travel intensity and financial viability.

In summary, with the present tax structure (fuels tax rate and registration fees), the revenues collected from the use of the state highways in Virginia are likely insufficient to pay for the maintenance expenses, much less for the construction of new highways in the next ten years. An increase in highway-user charges seems necessary in the near future to cope with the increasing maintenance cost.

Notes to the reader:

This study had been completed prior to the increase in highway user charges which took effect on July 1, 1982. The results presented here therefore do not reflect the new changes in highway taxation.

ACKNOWLEOGEMENT: The authors wish to thank Mr. Jay McCoy of the Virginia Oivision of Motor Vehicles for his enthusiastic interest and support of this research and also many other people who helped to provide the needed data for the study.

REFERENCES

1. "Price and Subsidy in Intercity Transportation and Issues of Benefits and Costs," Transportation Research Record No. 635, Washington, O.C., 1977.

2. "Methodology for a Vehicle Cost Responsibility Study," An Interim Report by the Joint Legislative Audit and Review Commission, Senate Document No. 12, Richmond, Virginia, 1981.

3. "Highway Cost Allocation Study," Working Paper No. 12, U.S. Oepartment of Transportation, Washington, O.C., 1981.

4. Vehicle Miles of Travel - Mileage and Average Oaily Traffic, Commonwealth of Virginia, Oepartment of Highways and Transportation, 1981.

5. Crews, C. Wayne, "A Study of Rural Highway Maintenance Expenditures in Virginia: Forecasting and Policy Testing," Master's Thesis, VPI&SU, Blacksburg, Virginia, May 1982.

6. "Composite Price Indices," Maintenance and Construction Divisions, Virginia Department of Highways and Transportation, Richmond, Virginia, 1981.

7. Green, D., Unpublished Data, Oak Ridge Research Laboratory.

8. "Profile of the 80's," U.S. Department of Transportation, Washington, D.C., Feb. 1980.

9. NCHRP No. 43, "Energy Effects, Efficiencies, and Prospects for Various Modes of Transportation," Washington, D.C., 1977.

10. Hobeika, A.G. et al., "Future Virginia's Highway Revenues and Expenditures: An Integrated Approach to Evaluating Highway Taxation Policies, Phase I," Report to the Virginia Division of Motor Vehicles, VPI&SU, Blacksburg, Virginia, 1981.

11. U.S. Department of Commerce, Bureau of the Census, "Census of Transportation: 1977."

12. Vaswani, N. K. and D. E. Thacker, "Estimation of 18-Kip Equivalent Axle Loads on Primary and Interstate Roads in Virginia," Report VHRC-R34, Virginia Highway Research Council, Charlottesville, VA, 1972.