# Findings of the Indiana Highway Cost Allocation Study

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## INTRODUCTION

The 1983-84 Indiana Highway Cost Allocation Study was mandated by the House Enrolled Act 1006 of the 103rd Indiana General Assembly. The legislative requirements consisted of two parts:

1. Documentation of the full cost of building and maintaining the state's highway system, county roads and city streets.
2. Development of an equitable methodology for allocating the full costs to all users.

Although determination of the revenue contributed by each vehicle class was not within the initial scope of study, the study would not have been complete without such information. The results of a cost allocation study would be meaningful only if they were compared to the corresponding user revenue contribution. It was therefore decided to include an analysis of revenue contribution of individual highway user classes as a task of the study.

Cost allocation and revenue attribution analyses were carried out for a base period and a study period. The based period covered a span of four years, 1980 to 1983 inclusive. The study period referred to the biennial budget period of 1985-86.

## DOCUMENTATION OF COSTS

For the purpose of cost allocation analysis, it was necessary to classify all costs into expenditure areas and expenditure items. The cost categories adopted is shown in Table 1. This detailed information for the state highway system was generated by analyzing Indiana Department of Highways (IDOH) data files. These included road life records, construction reports, itemized cost estimates, monthly expenditure files, and routine maintenance files.

For the local highway system, the corresponding data were collected directly from a number of counties and cities. The IDOH local road

Table 1. Expenditure Items by Expenditure Area

| Highway Construction | Structure Construction and Replacement | Highway Rehabilitation | Structure Rehabilitation | Routine Maintenance | Other Costs |
|---|---|---|---|---|---|
| Right-of-Way | Excavation and Backfill | Grading and Earthwork | Concrete | Drainage and Erosion Control | Enforcement (policing) |
| Grading and Earthwork | Concrete | Drainage and Erosion Control | Steel Reinforcements | Pavement and Shoulder | Weight Inspection |
| Drainage and Erosion Control | Steel Reinforcements | Pavement and Shoulder | Structural Steel | Bridge | Special Railroad Crossings |
| Pavement | Structural Steel | Miscellaneous Items | Miscellaneous Items | Miscellaneous Items | |
| Shoulder | Piers and Piling | | | | |
| Miscellaneous Items | Culverts and Sign Structures | | | | |
| | Miscellaneous Items | | | | |

inventory files, local assistance project records and HPMS records were also used.

The base period cost responsibility and revenue contribution figures were computed for the fiscal year of 1983. A breakdown of the total expenditure in major cost categories for 1983 is shown in Figure 1. The corresponding expenditure data for the 1985-86 period are presented in Figure 2. The 1985-86 data were estimated from the adopted program levels.

## USER REVENUE CONTRIBUTION

Revenues considered in the study were defined as those revenues contributed by Indiana highway users which were used to support highway activities. The following sources of revenue supported these activities in Indiana:

1. State gasoline and special fuel taxes
2. State motor carrier fuel use tax
3. State vehicle license fees including specific periodic permit fees
4. State motor carrier fees including vehicle identification stamp fees
5. Reciprocity identification stamp fees
6. Oversize and overweight permit fees
7. Federal gasoline and special fuel taxes
8. Federal taxes on tires, tread rubber, inner tubes, lubricating oil, and truck parts
9. Federal tax on truck sales
10. Federal heavy vehicle use fee
11. Local option user taxes

Table 2 shows the revenue sources and the amounts of the FY 1983 and the biennial period of FY 1985-86 included in the user revenue contribution analysis. It should be noted that all changes in federal taxes resulting from STAA of 1982 and subsequent revisions were considered according to the effective dates of these changes.

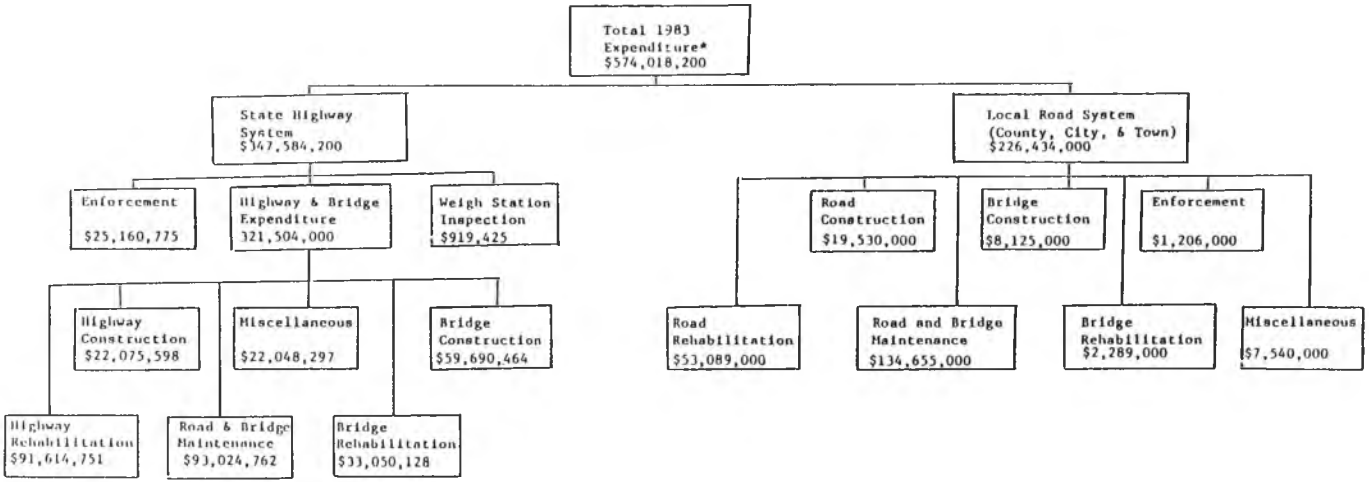
## DATA BASE FOR COST ALLOCATION ANALYSIS

Beside the cost and revenue data described earlier, the data required for cost allocation analysis also included the following:

1. Pavement inventory data
2. Traffic data
3. Pavement performance data
4. Subgrade soil data

### *Pavement Inventory Data*

Pavement inventory data included the following subcategories: pavement characteristic data, roadway geometry data and highway functional classification. Pavement characteristics considered were pavement type,




*Includes only the expenditure supported by user revenues

**Figure 1. Expenditure Distribution for Fiscal Year 1983.**

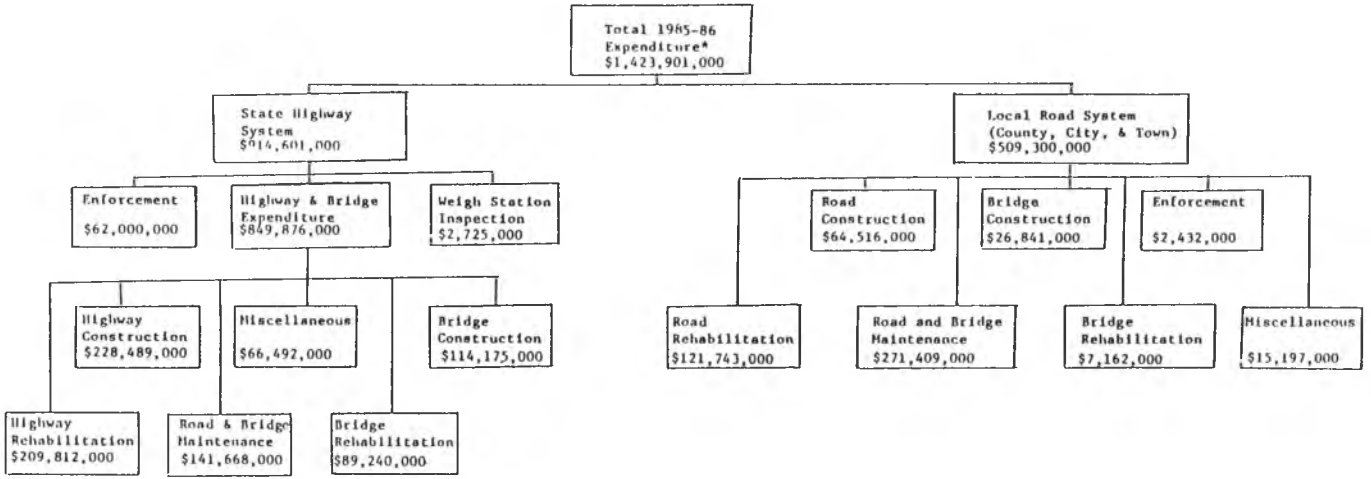



Figure 2. Expenditure Distribution for Budget Period 1985/86.

TABLE 2.

HIGHWAY USER REVENUES

| Revenue Source | Amount in Millions FY 1983 | FY 1985 | FY 1986 | 1985-86 Total |
|---|---|---|---|---|
| State Motor Fuel Taxes | 305.18 | 308.00 | 306.00 | 614.00 |
| State Vehicle Registration Fees | 109.70 | 113.80 | 112.00 | 225.80 |
| Other State and Local Fees | 3.56 | 5.35 | 5.50 | 10.85 |
| Subtotal (State and Local) | 418.44 | 427.15 | 423.50 | 850.65 |
| Federal Motor Fuel Taxes | 111.03 | 196.44 | 214.93 | 411.37 |
| Other Federal Taxes | 44.53 | 76.39 | 85.50 | 161.89 |
| Subtotal (Federal) | 155.56 | 272.83 | 299.43 | 572.26 |
| Total | 574.00 | 699.98 | 722.93 | 1,423.91 |

age and thickness information. Roadway geometry data provided information such as roadway width, shoulder width and number of lanes.

The highway functional classification system adopted for the study grouped Indiana roads into six major categories. These were:

1. Interstate Urban
2. Interstate Rural
3. State Routes Primary
4. State Routes Secondary
5. County Roads
6. City Streets

### *Traffic Data*

Traffic data encomposed traffic volume information, traffic-stream composition, truck weight data and vehicle axle configuration. One of the most critical data items necessary for the study was information on number of vehicle-miles traveled for each vehicle type on each of the highway classes.

The study team conducted a vehicle classification survey at about 60 randomly selected sites throughout Indiana during the summer of 1983. The collected data were converted to represent an average day of the year with factors developed from the FHWA report, *Vehicle Classification Case Study* [1].

To ensure accuracy of the final results of cost allocation analysis, vehicles were grouped into 14 classes as defined in Table 3. The data collected from IDOH Truck Weight Study were used to subdivide nine of the 14 classes in terms of gross operating weights. In Table 4 are listed the weight subgroups used for each of the nine vehicle classes.

## TABLE 3.

## ADOPTED VEHICLE CLASSIFICATION

| Class | Description |
|---|---|
| 1 | small passenger cars |
| 2 | standard and compact passenger cars, panel and pickup |
| 3 | 2-axle truck (2S and 2D) |
| 4 | bus |
| 5 | car with 1-axle trailer |
| 6 | 3-axle single unit truck |
| 7 | 2S1 tractor-trailer |
| 8 | car with 2-axle trailer |
| 9 | 4-axle single unit truck |
| 10 | 3S1 tractor-trailer |
| 11 | 2S2 tractor-trailer |
| 12 | 3S2 tractor-trailer |
| 13 | Other 5-axle |
| 14 | 6 or more axle |

## TABLE 4

## VEHICLE CLASS WEIGHT GROUP CLASSIFICATION

| Veh Class | Sub-Group | Gross Operating Weight in Pounds | Veh Class | Sub-Group | Gross Operating Weight in Pounds |
|---|---|---|---|---|---|
| 1 | 1 | All weights | 11 | 6 | 32,500 - 35,000 |
| | | | 11 | 7 | 35,000 - 37,500 |
| 2 | 1 | All weights | 11 | 8 | 37,500 - 40,000 |
| | | | 11 | 9 | 40,000 - 42,500 |
| 3 | 1 | < 7,500 | 11 | 10 | 42,500 - 45,000 |
| 3 | 2 | 7,500 - 10,000 | 11 | 11 | 45,000 - 47,500 |
| 3 | 3 | 10,000 - 12,500 | 11 | 12 | 47,500 - 50,000 |
| 3 | 4 | 12,500 - 15,000 | 11 | 13 | > 50,000 |
| 3 | 5 | 15,000 - 17,500 | | | |
| 3 | 6 | 17,500 - 20,000 | 12 | 1 | < 22,500 |
| 3 | 7 | 20,000 - 22,500 | 12 | 2 | 22,500 - 25,000 |
| 3 | 8 | 22,500 - 25,000 | 12 | 3 | 25,000 - 27,500 |
| 3 | 9 | > 25,000 | 12 | 4 | 27,500 - 30,000 |
| | | | 12 | 5 | 30,000 - 32,500 |
| 4 | 1 | All weights | 12 | 6 | 32,500 - 35,000 |
| | | | 12 | 7 | 35,000 - 37,500 |
| 5 | 1 | All weights | 12 | 8 | 37,500 - 40,000 |
| | | | 12 | 9 | 40,000 - 42,500 |
| 6 | 1 | < 17,500 | 12 | 10 | 42,500 - 45,000 |

**TABLE 4**—(Continued)

**VEHICLE CLASS WEIGHT GROUP CLASSIFICATION**

| Veh Class | Sub-Group | Gross Operating Weight in Pounds | Veh Class | Sub-Group | Gross Operating Weight in Pounds |
|---|---|---|---|---|---|
| 6 | 2 | 17,500 - 20,000 | 12 | 11 | 45,000 - 47,500 |
| 6 | 3 | 20,000 - 22,500 | 12 | 12 | 47,500 - 50,000 |
| 6 | 4 | 22,500 - 25,000 | 12 | 13 | 50,000 - 52,500 |
| 6 | 5 | 25,000 - 27,500 | 12 | 14 | 52,500 - 55,000 |
| 6 | 6 | 27,500 - 30,000 | 12 | 15 | 55,000 - 57,500 |
| 6 | 7 | 30,000 - 32,500 | 12 | 16 | 57,500 - 60,000 |
| 6 | 8 | 32,500 - 35,000 | 12 | 17 | 60,000 - 62,500 |
| 6 | 9 | > 35,000 | 12 | 18 | 62,500 - 65,000 |
| | | | 12 | 19 | 65,000 - 67,500 |
| 7 | 1 | < 20,000 | 12 | 20 | 67,500 - 70,000 |
| 7 | 2 | 20,000 - 22,500 | 12 | 21 | 70,000 - 72,500 |
| 7 | 3 | 22,500 - 25,000 | 12 | 22 | 72,500 - 75,000 |
| 7 | 4 | 25,000 - 27,500 | 12 | 23 | 75,000 - 77,500 |
| 7 | 5 | 27,500 - 30,000 | 12 | 24 | 77,500 - 80,000 |
| 7 | 6 | 30,000 - 32,500 | 12 | 25 | 80,000 - 82,500 |
| 7 | 7 | 32,500 - 35,000 | 12 | 26 | 82,500 - 85,000 |
| 7 | 8 | 35,000 - 37,500 | | | |
| 7 | 9 | 37,500 - 40,000 | 13 | 1 | < 42,500 |
| | | | 13 | 2 | 42,500 - 45,000 |
| 8 | 1 | All weights | 13 | 3 | 45,000 - 47,500 |
| | | | 13 | 4 | 47,500 - 50,000 |
| 9 | 1 | < 22,500 | 13 | 5 | 50,000 - 52,500 |
| 9 | 2 | > 22,500 | 13 | 6 | 52,500 - 55,000 |
| | | | 13 | 7 | 55,000 - 57,500 |
| 10 | 1 | < 27,500 | 13 | 8 | 57,500 - 60,000 |
| 10 | 2 | 27,500 - 30,000 | 13 | 9 | 60,000 - 62,500 |
| 10 | 3 | 30,000 - 32,500 | 13 | 10 | 62,500 - 65,000 |
| 10 | 4 | >32,500 | 13 | 11 | 65,000 - 67,500 |
| | | | 13 | 12 | 67,500 - 70,000 |
| 11 | 1 | < 22,500 | 13 | 13 | 70,000 - 72,500 |
| 11 | 2 | 22,500 - 25,000 | | | |
| 11 | 3 | 25,000 - 27,500 | 14 | 1 | < 40,000 |
| 11 | 4 | 27,500 - 30,000 | 14 | 2 | 40,000 - 60,000 |
| 11 | 5 | 30,000 - 32,500 | 14 | 3 | > 60,000 |

Tables 5 through 10 show the 1983 percentage VMT for the 14 vehicle classes and all the weight groups used in the study. Similar traffic data were also estimated for the years 1985 and 1986 on the basis of the projected growth rates by vehicle class.

## TABLE 5

## PERCENT VMT OF VEHICLE CLASSES ON RURAL INTERSTATE (1983)

| Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Vehicle-Mile % Sub-Group | Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Vehicle-Mile % Sub-Group |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 15.640 | 15.640 | 11 | 6 | | 0.230 |
| | | | | 11 | 7 | | 0.195 |
| 2 | 1 | 48.840 | 48.840 | 11 | 8 | | 0.180 |
| | | | | 11 | 9 | | 0.213 |
| 3 | 1 | 2.400 | 0.054 | 11 | 10 | | 0.195 |
| 3 | 2 | | 0.182 | 11 | 11 | | 0.195 |
| 3 | 3 | | 0.218 | 11 | 12 | | 0.180 |
| 3 | 4 | | 0.618 | 11 | 13 | | 0.148 |
| 3 | 5 | | 0.473 | | | | |
| 3 | 6 | | 0.346 | 12 | 1 | 27.200 | 0.054 |
| 3 | 7 | | 0.182 | 12 | 2 | | 0.272 |
| 3 | 8 | | 0.145 | 12 | 3 | | 0.944 |
| 3 | 9 | | 0.182 | 12 | 4 | | 2.657 |
| | | | | 12 | 5 | | 2.149 |
| 4 | 1 | 0.310 | 0.310 | 12 | 6 | | 1.333 |
| | | | | 12 | 7 | | 1.115 |
| 5 | 1 | 1.120 | 1.120 | 12 | 8 | | 0.979 |
| | | | | 12 | 9 | | 0.898 |
| 6 | 1 | 0.420 | 0.051 | 12 | 10 | | 0.827 |
| 6 | 2 | | 0.025 | 12 | 11 | | 0.800 |
| 6 | 3 | | 0.038 | 12 | 12 | | 0.770 |
| 6 | 4 | | 0.076 | 12 | 13 | | 0.680 |
| 6 | 5 | | 0.064 | 12 | 14 | | 0.800 |
| 6 | 6 | | 0.038 | 12 | 15 | | 0.870 |
| 6 | 7 | | 0.038 | 12 | 16 | | 1.104 |
| 6 | 8 | | 0.025 | 12 | 17 | | 0.979 |
| 6 | 9 | | 0.064 | 12 | 18 | | 0.925 |
| | | | | 12 | 19 | | 1.034 |
| 7 | 1 | 0.360 | 0.012 | 12 | 20 | | 1.496 |
| 7 | 2 | | 0.024 | 12 | 21 | | 2.258 |
| 7 | 3 | | 0.048 | 12 | 22 | | 2.394 |
| 7 | 4 | | 0.072 | 12 | 23 | | 1.170 |
| 7 | 5 | | 0.036 | 12 | 24 | | 0.552 |
| 7 | 6 | | 0.012 | 12 | 25 | | 0.044 |
| 7 | 7 | | 0.108 | 12 | 26 | | 0.101 |
| 7 | 8 | | 0.036 | | | | |
| 7 | 9 | | 0.012 | 13 | 1 | 0.760 | 0.088 |
| | | | | 13 | 2 | | 0.146 |
| 8 | 1 | 0.060 | 0.060 | 13 | 3 | | 0.029 |

TABLE 5—(Continued)

PERCENT VMT OF VEHICLE CLASSES ON RURAL INTERSTATE (1983)

| Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Vehicle-Mile % Sub-Group | Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Vehicle-Mile % Sub-Group |
|---|---|---|---|---|---|---|---|
| | | | | 13 | 4 | | 0.059 |
| 9 | 1 | 0.170 | 0.085 | 13 | 5 | | 0.029 |
| 9 | 2 | | 0.085 | 13 | 6 | | 0.029 |
| | | | | 13 | 7 | | 0.059 |
| 10 | 1 | 0.070 | 0.014 | 13 | 8 | | 0.029 |
| 10 | 2 | | 0.014 | 13 | 9 | | 0.029 |
| 10 | 3 | | 0.028 | 13 | 10 | | 0.059 |
| 10 | 4 | | 0.014 | 13 | 11 | | 0.029 |
| | | | | 13 | 12 | | 0.087 |
| 11 | 1 | 2.500 | 0.050 | 13 | 13 | | 0.087 |
| 11 | 2 | | 0.097 | | | | |
| 11 | 3 | | 0.360 | 14 | 1 | 0.160 | 0.053 |
| 11 | 4 | | 0.163 | 14 | 2 | | 0.053 |
| 11 | 5 | | 0.295 | 14 | 3 | | 0.053 |

TABLE 6

PERCENT VMT OF VEHICLE CLASSES ON URBAN INTERSTATE (1983)

| Veh Class | Sub Group | Vehicle-Mile % Veh Class | Vehicle-Mile % Sub-Group | Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Vehicle-Mile % Sub-Group |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 20.700 | 20.700 | 11 | 6 | | 0.074 |
| | | | | 11 | 7 | | 0.062 |
| 2 | 1 | 63.300 | 63.300 | 11 | 8 | | 0.058 |
| | | | | 11 | 9 | | 0.068 |
| 3 | 1 | 2.160 | 0.049 | 11 | 10 | | 0.062 |
| 3 | 2 | | 0.164 | 11 | 11 | | 0.062 |
| 3 | 3 | | 0.196 | 11 | 12 | | 0.058 |
| 3 | 4 | | 0.556 | 11 | 13 | | 0.047 |
| 3 | 5 | | 0.426 | | | | |
| 3 | 6 | | 0.311 | 12 | 1 | 10.400 | 0.021 |
| 3 | 7 | | 0.164 | 12 | 2 | | 0.104 |
| 3 | 8 | | 0.131 | 12 | 3 | | 0.361 |
| 3 | 9 | | 0.164 | 12 | 4 | | 1.016 |
| | | | | 12 | 5 | | 0.822 |
| 4 | 1 | 0.290 | 0.290 | 12 | 6 | | 0.510 |

TABLE 6—(Continued)

PERCENT VMT OF VEHICLE CLASSES ON URBAN INTERSTATE (1983)

| Veh Class | Sub Group | Vehicle-Mile % Veh Class | Sub-Group | Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Sub-Group |
|---|---|---|---|---|---|---|---|
| | | | | 12 | 7 | | 0.426 |
| 5 | 1 | 0.860 | 0.860 | 12 | 8 | | 0.374 |
| | | | | 12 | 9 | | 0.343 |
| 6 | 1 | 0.370 | 0.045 | 12 | 10 | | 0.316 |
| 6 | 2 | | 0.022 | 12 | 11 | | 0.306 |
| 6 | 3 | | 0.034 | 12 | 12 | | 0.294 |
| 6 | 4 | | 0.067 | 12 | 13 | | 0.260 |
| 6 | 5 | | 0.056 | 12 | 14 | | 0.306 |
| 6 | 6 | | 0.034 | 12 | 15 | | 0.333 |
| 6 | 7 | | 0.034 | 12 | 16 | | 0.422 |
| 6 | 8 | | 0.022 | 12 | 17 | | 0.374 |
| 6 | 9 | | 0.056 | 12 | 18 | | 0.354 |
| | | | | 12 | 19 | | 0.395 |
| 7 | 1 | 0.260 | 0.009 | 12 | 20 | | 0.572 |
| 7 | 2 | | 0.017 | 12 | 21 | | 0.863 |
| 7 | 3 | | 0.035 | 12 | 22 | | 0.915 |
| 7 | 4 | | 0.052 | 12 | 23 | | 0.447 |
| 7 | 5 | | 0.026 | 12 | 24 | | 0.211 |
| 7 | 6 | | 0.009 | 12 | 25 | | 0.017 |
| 7 | 7 | | 0.078 | 12 | 26 | | 0.038 |
| 7 | 8 | | 0.026 | | | | |
| 7 | 9 | | 0.009 | 13 | 1 | 0.400 | 0.046 |
| | | | | 13 | 2 | | 0.077 |
| 8 | 1 | 0.300 | 0.300 | 13 | 3 | | 0.015 |
| | | | | 13 | 4 | | 0.031 |
| 9 | 1 | 0.070 | 0.035 | 13 | 5 | | 0.015 |
| 9 | 2 | | 0.035 | 13 | 6 | | 0.015 |
| | | | | 13 | 7 | | 0.031 |
| 10 | 1 | 0.030 | 0.006 | 13 | 8 | | 0.015 |
| 10 | 2 | | 0.006 | 13 | 9 | | 0.015 |
| 10 | 3 | | 0.012 | 13 | 10 | | 0.031 |
| 10 | 4 | | 0.006 | 13 | 11 | | 0.015 |
| | | | | 13 | 12 | | 0.046 |
| 11 | 1 | 0.800 | 0.016 | 13 | 13 | | 0.046 |
| 11 | 2 | | 0.031 | | | | |
| 11 | 3 | | 0.115 | 14 | 1 | 0.060 | 0.015 |
| 11 | 4 | | 0.052 | 14 | 2 | | 0.022 |
| 11 | 5 | | 0.094 | 14 | 3 | | 0.022 |

## TABLE 7

## PERCENT VMT OF VEHICLE CLASSES ON STATE PRIMARY (1983)

| Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Vehicle-Mile % Sub-Group | Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Vehicle-Mile % Sub-Group |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 20.200 | 20.200 | 11 | 6 | | 0.059 |
| | | | | 11 | 7 | | 0.007 |
| 2 | 1 | 68.600 | 68.600 | 11 | 8 | | 0.008 |
| | | | | 11 | 9 | | 0.007 |
| 3 | 1 | 2.400 | 0.138 | 11 | 10 | | 0.008 |
| 3 | 2 | | 0.369 | 11 | 11 | | 0.005 |
| 3 | 3 | | 0.369 | 11 | 12 | | 0.005 |
| 3 | 4 | | 0.509 | 11 | 13 | | 0.005 |
| 3 | 5 | | 0.415 | | | | |
| 3 | 6 | | 0.230 | 12 | 1 | 5.770 | 0.017 |
| 3 | 7 | | 0.139 | 12 | 2 | | 0.121 |
| 3 | 8 | | 0.139 | 12 | 3 | | 0.563 |
| 3 | 9 | | 0.091 | 12 | 4 | | 0.733 |
| | | | | 12 | 5 | | 0.444 |
| 4 | 1 | 0.090 | 0.090 | 12 | 6 | | 0.271 |
| | | | | 12 | 7 | | 0.171 |
| 5 | 1 | 0.530 | 0.530 | 12 | 8 | | 0.185 |
| | | | | 12 | 9 | | 0.138 |
| 6 | 1 | 0.940 | 0.329 | 12 | 10 | | 0.153 |
| 6 | 2 | | 0.141 | 12 | 11 | | 0.190 |
| 6 | 3 | | 0.188 | 12 | 12 | | 0.138 |
| 6 | 4 | | 0.141 | 12 | 13 | | 0.138 |
| 6 | 5 | | 0.023 | 12 | 14 | | 0.205 |
| 6 | 6 | | 0.023 | 12 | 15 | | 0.138 |
| 6 | 7 | | 0.031 | 12 | 16 | | 0.375 |
| 6 | 8 | | 0.031 | 12 | 17 | | 0.254 |
| 6 | 9 | | 0.032 | 12 | 18 | | 0.271 |
| | | | | 12 | 19 | | 0.188 |
| 7 | 1 | 0.330 | 0.066 | 12 | 20 | | 0.171 |
| 7 | 2 | | 0.022 | 12 | 21 | | 0.375 |
| 7 | 3 | | 0.022 | 12 | 22 | | 0.306 |
| 7 | 4 | | 0.022 | 12 | 23 | | 0.171 |
| 7 | 5 | | 0.040 | 12 | 24 | | 0.017 |
| 7 | 6 | | 0.040 | 12 | 25 | | 0.017 |
| 7 | 7 | | 0.040 | 12 | 26 | | 0.017 |
| 7 | 8 | | 0.040 | | | | |
| 7 | 9 | | 0.040 | 13 | 1 | 0.150 | 0.045 |
| | | | | 13 | 2 | | 0.030 |
| 8 | 1 | 0.210 | 0.210 | 13 | 3 | | 0.022 |

TABLE 7—(Continued)

PERCENT VMT OF VEHICLE CLASSES ON STATE PRIMARY (1983)

| Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Vehicle-Mile % Sub-Group | Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Vehicle-Mile % Sub-Group |
|---|---|---|---|---|---|---|---|
| | | | | 13 | 4 | | 0.015 |
| 9 | 1 | 0.190 | 0.027 | 13 | 5 | | 0.008 |
| 9 | 2 | | 0.163 | 13 | 6 | | 0.008 |
| | | | | 13 | 7 | | 0.008 |
| 10 | 1 | 0.040 | 0.010 | 13 | 8 | | 0.003 |
| 10 | 2 | | 0.010 | 13 | 9 | | 0.003 |
| 10 | 3 | | 0.010 | 13 | 10 | | 0.003 |
| 10 | 4 | | 0.010 | 13 | 11 | | 0.003 |
| | | | | 13 | 12 | | 0.002 |
| 11 | 1 | 0.470 | 0.030 | 13 | 13 | | 0.002 |
| 11 | 2 | | 0.073 | | | | |
| 11 | 3 | | 0.117 | 14 | 1 | 0.110 | 0.037 |
| 11 | 4 | | 0.088 | 14 | 2 | | 0.037 |
| 11 | 5 | | 0.059 | 14 | 3 | | 0.037 |

TABLE 8

PERCENT VMT OF VEHICLE CLASSES ON STATE SECONDARY (1983)

| Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Vehicle-Mile % Sub-Group | Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Vehicle-Mile % Sub-Group |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 20.200 | 20.200 | 11 | 6 | | 0.084 |
| | | | | 11 | 7 | | 0.021 |
| 2 | 1 | 71.750 | 71.750 | 11 | 7 | | 0.021 |
| | | | | 11 | 9 | | 0.011 |
| 3 | 1 | 3.300 | 0.906 | 11 | 10 | | 0.011 |
| 3 | 2 | | 0.323 | 11 | 11 | | 0.011 |
| 3 | 3 | | 0.906 | 11 | 12 | | 0.011 |
| 3 | 4 | | 0.518 | 11 | 13 | | 0.021 |
| 3 | 5 | | 0.129 | | | | |
| 3 | 6 | | 0.323 | 12 | 1 | 2.500 | 0.018 |
| 3 | 7 | | 0.129 | 12 | 2 | | 0.035 |
| 3 | 8 | | 0.033 | 12 | 3 | | 0.104 |
| 3 | 9 | | 0.033 | 12 | 4 | | 0.470 |
| | | | | 12 | 5 | | 0.104 |

TABLE 8—(Continued)

PERCENT VMT OF VEHICLE CLASSES ON STATE SECONDARY (1983)

| Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Sub-Group | Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Sub-Group |
|---|---|---|---|---|---|---|---|
| 4 | 1 | 0.060 | 0.060 | 12 | 6 | | 0.190 |
| | | | | 12 | 7 | | 0.018 |
| 5 | 1 | 0.490 | 0.490 | 12 | 8 | | 0.070 |
| | | | | 12 | 9 | | 0.156 |
| 6 | 1 | 0.520 | 0.182 | 12 | 10 | | 0.140 |
| 6 | 2 | | 0.130 | 12 | 11 | | 0.035 |
| 6 | 3 | | 0.052 | 12 | 12 | | 0.052 |
| 6 | 4 | | 0.052 | 12 | 13 | | 0.070 |
| 6 | 5 | | 0.013 | 12 | 14 | | 0.052 |
| 6 | 6 | | 0.013 | 12 | 15 | | 0.052 |
| 6 | 7 | | 0.013 | 12 | 16 | | 0.035 |
| 6 | 8 | | 0.013 | 12 | 17 | | 0.052 |
| 6 | 9 | | 0.052 | 12 | 18 | | 0.190 |
| | | | | 12 | 19 | | 0.087 |
| 7 | 1 | 0.270 | 0.034 | 12 | 20 | | 0.155 |
| 7 | 2 | | 0.034 | 12 | 21 | | 0.190 |
| 7 | 3 | | 0.034 | 12 | 22 | | 0.104 |
| 7 | 4 | | 0.034 | 12 | 23 | | 0.104 |
| 7 | 5 | | 0.027 | 12 | 24 | | 0.013 |
| 7 | 6 | | 0.027 | 12 | 25 | | 0.002 |
| 7 | 7 | | 0.027 | 12 | 26 | | 0.002 |
| 7 | 8 | | 0.027 | | | | |
| 7 | 9 | | 0.027 | 13 | 1 | 0.090 | 0.027 |
| | | | | 13 | 2 | | 0.027 |
| 8 | 1 | 0.210 | 0.210 | 13 | 3 | | 0.018 |
| | | | | 13 | 4 | | 0.009 |
| 9 | 1 | 0.030 | 0.004 | 13 | 5 | | 0.009 |
| 9 | 2 | | 0.026 | 13 | 6 | | 0. |
| | | | | 13 | 7 | | 0. |
| 10 | 1 | 0.060 | 0.015 | 13 | 8 | 0. | |
| 10 | 2 | | 0.015 | 13 | 9 | | 0. |
| 10 | 3 | | 0.015 | 13 | 10 | | 0. |
| 10 | 4 | | 0.015 | 13 | 11 | | 0. |
| | | | | 13 | 12 | | 0. |
| 11 | 1 | 0.460 | 0.063 | 13 | 13 | | 0. |
| 11 | 2 | | 0.063 | | | | |
| 11 | 3 | | 0.084 | 14 | 1 | 0.060 | 0.020 |
| 11 | 4 | | 0.042 | 14 | 2 | | 0.020 |
| 11 | 5 | | 0.021 | 14 | 3 | | 0.020 |

## TABLE 9

## PERCENT VMT OF VEHICLE CLASSES ON COUNTY ROADS (1983)

| Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Vehicle-Mile % Sub-Group | Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Vehicle-Mile % Sub-Group |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 17.950 | 17.950 | 11 | 6 | | 0.049 |
| | | | | 11 | 7 | | 0.012 |
| 2 | 1 | 75.340 | 75.340 | 11 | 8 | | 0.012 |
| | | | | 11 | 9 | | 0.006 |
| 3 | 1 | 3.900 | 1.071 | 11 | 10 | | 0.006 |
| 3 | 2 | | 0.382 | 11 | 11 | | 0.006 |
| 3 | 3 | | 1.071 | 11 | 12 | | 0.006 |
| 3 | 4 | | 0.612 | 11 | 13 | | 0.012 |
| 3 | 5 | | 0.152 | | | | |
| 3 | 6 | | 0.382 | 12 | 1 | 0.630 | 0.004 |
| 3 | 7 | | 0.152 | 12 | 2 | | 0.009 |
| 3 | 8 | | 0.039 | 12 | 3 | | 0.026 |
| 3 | 9 | | 0.039 | 12 | 4 | | 0.118 |
| | | | | 12 | 5 | | 0.026 |
| 4 | 1 | 0.050 | 0.050 | 12 | 6 | | 0.048 |
| | | | | 12 | 7 | | 0.004 |
| 5 | 1 | 0.630 | 0.630 | 12 | 8 | | 0.018 |
| | | | | 12 | 9 | | 0.039 |
| 6 | 1 | 0.860 | 0.301 | 12 | 10 | | 0.035 |
| 6 | 2 | | 0.215 | 12 | 11 | | 0.009 |
| 6 | 3 | | 0.086 | 12 | 12 | | 0.013 |
| 6 | 4 | | 0.086 | 12 | 13 | | 0.018 |
| 6 | 5 | | 0.021 | 12 | 14 | | 0.013 |
| 6 | 6 | | 0.021 | 12 | 15 | | 0.013 |
| 6 | 7 | | 0.021 | 12 | 16 | | 0.009 |
| 6 | 8 | | 0.021 | 12 | 17 | | 0.013 |
| 6 | 9 | | 0.086 | 12 | 18 | | 0.048 |
| | | | | 12 | 19 | | 0.022 |
| 7 | 1 | 0.050 | 0.006 | 12 | 20 | | 0.039 |
| 7 | 2 | | 0.006 | 12 | 21 | | 0.048 |
| 7 | 3 | | 0.006 | 12 | 22 | | 0.026 |
| 7 | 4 | | 0.006 | 12 | 23 | | 0.026 |
| 7 | 5 | | 0.005 | 12 | 24 | | 0.003 |
| 7 | 6 | | 0.005 | 12 | 25 | | 0.001 |
| 7 | 7 | | 0.005 | 12 | 26 | | 0.001 |
| 7 | 8 | | 0.005 | | | | |
| 7 | 9 | | 0.005 | 13 | 1 | 0.180 | 0.054 |
| | | | | 13 | 2 | | 0.054 |
| 8 | 1 | 0. | 0. | 13 | 3 | | 0.036 |

TABLE 9—(Continued)

PERCENT VMT OF VEHICLE CLASSES ON COUNTY ROADS (1983)

| Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Sub-Group | Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Sub-Group |
|---|---|---|---|---|---|---|---|
| | | | | 13 | 4 | | 0.018 |
| 9 | 1 | 0.050 | 0.007 | 13 | 5 | | 0.018 |
| 9 | 2 | | 0.043 | 13 | 6 | | 0. |
| | | | | 13 | 7 | | 0. |
| 10 | 1 | 0. | 0. | 13 | 8 | | 0. |
| 10 | 2 | | 0. | 13 | 9 | | 0. |
| 10 | 3 | | 0. | 13 | 10 | | 0. |
| 10 | 4 | | 0. | 13 | 11 | | 0. |
| | | | | 13 | 12 | | 0. |
| 11 | 1 | 0.270 | 0.037 | 13 | 13 | | 0. |
| 11 | 2 | | 0.037 | | | | |
| 11 | 3 | | 0.049 | 14 | 1 | 0.090 | 0.030 |
| 11 | 4 | | 0.025 | 14 | 2 | | 0.030 |
| 11 | 5 | | 0.012 | 14 | 3 | | 0.030 |

TABLE 10

PERCENT VMT OF VEHICLE CLASSES ON CITY STREETS (1983)

| Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Sub-Group | Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Sub-Group |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 19.340 | 19.340 | 11 | 6 | | 0.078 |
| | | | | 11 | 7 | | 0.019 |
| 2 | 1 | 74.000 | 74.000 | 11 | 8 | | 0.019 |
| | | | | 11 | 9 | | 0.010 |
| 3 | 1 | 2.160 | 0.593 | 11 | 10 | | 0.010 |
| 3 | 2 | | 0.212 | 11 | 11 | | 0.010 |
| 3 | 3 | | 0.593 | 11 | 12 | | 0.010 |
| 3 | 4 | | 0.339 | 11 | 13 | | 0.020 |
| 3 | 5 | | 0.084 | | | | |
| 3 | 6 | | 0.212 | 12 | 1 | 2.360 | 0.017 |
| 3 | 7 | | 0.084 | 12 | 2 | | 0.033 |
| 3 | 8 | | 0.022 | 12 | 3 | | 0.098 |
| 3 | 9 | | 0.022 | 12 | 4 | | 0.444 |
| | | | | 12 | 5 | | 0.098 |

TABLE 10—(Continued)

PERCENT VMT OF VEHICLE CLASSES ON CITY STREETS (1983)

| Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Sub-Group | Veh Class | Sub-Group | Vehicle-Mile % Veh Class | Sub-Group |
|---|---|---|---|---|---|---|---|
| 4 | 1 | 0.230 | 0.230 | 12 | 6 | | 0.179 |
| | | | | 12 | 7 | | 0.017 |
| 5 | 1 | 0.480 | 0.480 | 12 | 8 | | 0.066 |
| | | | | 12 | 9 | | 0.148 |
| 6 | 1 | 0.720 | 0.252 | 12 | 10 | | 0.132 |
| 6 | 2 | | 0.180 | 12 | 11 | | 0.033 |
| 6 | 3 | | 0.072 | 12 | 12 | | 0.050 |
| 6 | 4 | | 0.072 | 12 | 13 | | 0.066 |
| 6 | 5 | | 0.018 | 12 | 14 | | 0.050 |
| 6 | 6 | | 0.018 | 12 | 15 | | 0.050 |
| 6 | 7 | | 0.018 | 12 | 16 | | 0.033 |
| 6 | 8 | | 0.018 | 12 | 17 | | 0.050 |
| 6 | 9 | | 0.072 | 12 | 18 | | 0.179 |
| | | | | 12 | 19 | | 0.082 |
| 7 | 1 | 0.060 | 0.008 | 12 | 20 | | 0.146 |
| 7 | 2 | | 0.008 | 12 | 21 | | 0.179 |
| 7 | 3 | | 0.008 | 12 | 22 | | 0.098 |
| 7 | 4 | | 0.008 | 12 | 23 | | 0.098 |
| 7 | 5 | | 0.006 | 12 | 24 | | 0.012 |
| 7 | 6 | | 0.006 | 12 | 25 | | 0.002 |
| 7 | 7 | | 0.006 | 12 | 26 | | 0.002 |
| 7 | 8 | | 0.006 | | | | |
| 7 | 9 | | 0.006 | 13 | 1 | 0.097 | 0.029 |
| | | | | 13 | 2 | | 0.029 |
| 8 | 1 | 0. | 0. | 13 | 3 | | 0.019 |
| | | | | 13 | 4 | | 0.010 |
| 9 | 1 | 0.050 | 0.007 | 13 | 5 | | 0.010 |
| 9 | 2 | | 0.043 | 13 | 6 | | 0. |
| | | | | 13 | 7 | | 0. |
| 10 | 1 | 0.045 | 0.011 | 13 | 8 | | 0. |
| 10 | 2 | | 0.011 | 13 | 9 | | 0. |
| 10 | 3 | | 0.011 | 13 | 10 | | 0. |
| 10 | 4 | | 0.011 | 13 | 11 | | 0. |
| | | | | 13 | 12 | | 0. |
| 11 | 1 | 0.430 | 0.058 | 13 | 13 | | 0. |
| 11 | 2 | | 0.058 | | | | |
| 11 | 3 | | 0.078 | 14 | 1 | 0.032 | 0.011 |
| 11 | 4 | | 0.039 | 14 | 2 | | 0.011 |
| 11 | 5 | | 0.020 | 14 | 3 | | 0.011 |

*Pavement Performance Data*

The IDOH began to record systematically yearly roadmeter roughness measurements on all Interstate and state highways in mid-1970s. These measurements could be converted into Present Serviceability Index Values by means of the following statistical relationships [2]:

| | | |
|---|---|---|
| Asphalt | PSI = 3.94 - 0.00072 C | ($R^2$ = 0.79) |
| Overlay | PSI = 4.37 - 0.00174 C | ($R^2$ = 0.77) |
| JRC | PSI = 4.69 - 0.00141 C | ($R^2$ = 0.88) |
| CRC | PSI = 4.40 - 0.00070 C | ($R^2$ = 0.59) |

where,

PSI = present serviceability index
C = roadmeter counts per kilometer
$R^2$ = coefficient of determination

*Subgrade Soil Data*

Soil support values and modulus of subgrade reaction were needed for allocation analysis of pavement costs. These values were derived from an engineering soil distribution map prepared by the Joint Highway Research Project at Purdue [3].

## COST ALLOCATION METHODOLOGY

The various cost allocation procedures developed in the study for individual expenditure items may be grouped into two major areas, namely the roadway-related area and the structure-related area [4]. In the first area, the main concern was to develop a rational unified allocation procedure for highway construction, routine maintenance and rehabilitation costs. In the second area, the main emphasis was to allocate equitably structure-related costs.

A new incremental approach was developed for the allocation of pavement construction costs to highway users [5]. It considered increments of pavement thickness rather than increments or decrements of traffic volume commonly employed in previous cost allocation studies. This thickness incremental approach eliminated the need for an iterative process to compute vehicle ESAL; it also eliminated the economy-of-scale problem present in the classical incremental cost allocation method [6].

In allocating pavement rehabilitation and maintenance costs, a performance-based methodology was used for determining the cost-responsibilities of load-related and non-load-related factors. The procedure did not require an extensive amount of data collection effort. It relied entirely on recorded pavement performance data available in IDOH

records, and hence eliminated the undesired element of subjective judgment commonly involved in most cost allocation studies [7].

Police enforcement expenditures and other common costs such as traffic signal installation costs, pavement striping costs and roadside mowing costs were distributed to all vehicle classes on the basis of VMT. The costs of those facilities that served trucks only, such as truck weigh stations, were distributed as truck-only common costs.

Structure-related costs included expenditure for bridge construction, bridge rehabilitation, bridge replacement, culvert construction and sign structure construction. In general, the classical incremental cost allocation concept was followed in allocating these costs. The procedure consisted of three steps: (1) the correlation of vehicle classes to AASHTO design loads, (2) analysis considering the incremental addition of AASHTO design loads, and (3) allocation of individual cost items among various vehicle classes.

Table 11 presents a summary of cost allocation criteria adopted for each expenditure item. All expenditure items were classified as attributable or non-attributable. Attributable costs referred to: (a) costs which were entirely attributable to single vehicle class, (b) costs which were attributable to a group of vehicle classes, and (c) costs which were occasioned by the entire traffic as a whole.

## FINDINGS OF THE STUDY

The results of the cost allocation analysis were expressed in terms of the cost-responsibilities of vehicle classes in percentages. Likewise, the results of the revenue attribution analysis provided the percentages of revenues contributed by individual vehicle classes. Table 12 and 13 present the overall statewide vehicle class cost-responsibilities for FY 1983 and biennial period 1985-86, respectively. Table 14 and 15 give the revenue contribution by vehicle classes for the two periods, respectively.

The results of cost-responsibility and revenue contribution of vehicle classes were combined to provide a revenue/cost comparison for each vehicle class. Such a comparison would indicate the equity in revenue contribution. The revenue/cost ratios for FY 1983 and the biennial period of 1985-86 are summarized for each vehicle classes in Table 16.

The major findings of the study are listed below:

1. Passenger cars as a group overpaid their cost-responsibility in 1983. There was, however, a significant imbalance between costs and revenues within the group. In particular, small cars underpaid their cost responsibility, while large cars considerably overpaid.
2. Single-unit trucks as a group also overpaid their cost-responsibility in 1983. While two-axle and four-axle single-unit

## TABLE 11

## COST ALLOCATION CRITERIA FOR EXPENDITURE ITEM

| Expenditure Item | Attributable Costs | | Non-Attributable Costs | |
|---|---|---|---|---|
| | Proportion | Allocation Procedure | Proportion | Allocation Procedure |
| *A. Highway Construction* | | | | |
| 1. Pavement | | | | |
| (minimum width) | 100% | Thickness Incremental method based on ESAL | | |
| (Additional width) | 100% | Thickness Incremental method based on PCE-ESAL | | |
| 2. Shoulder | | | | |
| (minimum width) | 100% | | | |
| (Additional width) | 100% | same as item A.1 | | |
| 3. Right-of-Way | | | | |
| (minimum width) | 100% | Proportional VMT | | |
| (Additional width) | 100% | Proportional PCE-VMT | | |
| 4. Grading & Earthwork | | | | |
| (minimum width) | 100% | Proportional VMT | | |
| (Additional width) | 100% | Proportional PCE-VMT | | |
| 5. Drainage & Erosion Control | | | | |
| (minimum width) | 100% | Proportional VMT | | |
| (Additional width) | 100% | Proportional PCE-VMT | | |

| | | |
|---|---|---|
| 6. | Miscellaneous (Traffic Service) (Administration) (Truck-Related Facilities) (Others) | 100% |
| *B.* | *Highway Rehabilitation* | |
| 1. | Pavement & Shoulder | Varies 66-98% |
| 2. | Right-of-Way | 100% |
| 3. | Grading & Earthwork | 100% |
| 4. | Drainage & Erosion control | 100% |
| 5. | Miscellaneous (Traffic Service) (Administration) (Truck-Related Facilities) (Others) | 100% |
| *C.* | *Highway Maintenance* | |
| 1. | Pavement & Shoulder | Varies 66-98% |
| 2. | Right-of-way | |
| 3. | Drainage | |
| 4. | Roadside Maintenance | |
| 5. | Miscellaneous (Traffic Service) | |

| | | |
|---|---|---|
| | 100% | Proportional VMT |
| | 100% | Proportional VMT |
| Proportional truck VMT | | |
| | 100% | Proportional VMT |
| Thickness Incremental method based on ESAL | Varies 2-34% | Proportional VMT |
| same as item A.3 | | |
| same as item A.4 | | |
| same as item A.5 | | |
| | 100% | Proportional VMT |
| | 100% | Proportional VMT |
| Proportional truck VMT | | |
| | 100% | Proportional VMT |
| Proportional Σ ESAL | Varies 2-34% | Proportional Σ ESAL |
| | 100% | Proportional VMT |
| | 100% | Proportional VMT |
| | 100% | Proportional VMT |
| | 100% | Proportional VMT |

**TABLE 11**—(Continued)

**COST ALLOCATION CRITERIA FOR EXPENDITURE ITEM**

| Expenditure Item | Attributable Costs | | Non-Attributable Costs | |
|---|---|---|---|---|
| | Proportion | Allocation Procedure | Proportion | Allocation Procedure |
| (Administration) | | | 100% | Proportional VMT |
| (Winter Emergency) | | | 100% | Proportional VMT |
| (Truck-Related Maintenance) | 100% | Proportional Truck VMT | | |
| (Others) | | | 100% | Proportional VMT |
| *D. Bridge Maintenance* | | | | |
| 1. Roadway Maintenance | Varies 66-98% | Proportional Σ ESAL | Varies 2-34% | Proportional VMT |
| 2. Structural Members | | | 100% | Proportional VMT |
| 3. Miscellaneous | | | 100% | Proportional VMT |
| *E. Bridge Construction, Replacement and Rehabilitation* | | | | |
| 1. Superstructures | 100% | Incremental Analysis | | |
| 2. Substructures | 25-35 | Incremental Analysis | 65-75 | Proportional VMT |
| 3. Drainage | | | 100% | Proportional VMT |
| 4. Excavation | | | 100% | Proportional VMT |
| 5. Miscellaneous | | | 100% | Proportional VMT |

## TABLE 12

## OVERALL STATEWIDE COST-RESPONSIBILITY FOR YEAR 1983

| Veh Class | Sub-Group | % Responsibility Veh Class | % Responsibility Sub-Group | Veh Class | Sub-Group | % Responsibility Veh Class | % Responsibility Sub-Group |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 10.869 | 10.869 | 11 | 6 | | 0.410 |
| | | | | 11 | 7 | | 0.142 |
| 2 | 1 | 41.510 | 41.510 | 11 | 8 | | 0.183 |
| | | | | 11 | 9 | | 0.133 |
| 3 | 1 | 6.766 | 0.440 | 11 | 10 | | 0.161 |
| 3 | 2 | | 0.403 | 11 | 11 | | 0.197 |
| 3 | 3 | | 0.866 | 11 | 12 | | 0.213 |
| 3 | 4 | | 0.873 | 11 | 13 | | 0.463 |
| 3 | 5 | | 0.450 | | | | |
| 3 | 6 | | 1.587 | 12 | 1 | 30.253 | 0.020 |
| 3 | 7 | | 1.179 | 12 | 2 | | 0.072 |
| 3 | 8 | | 0.388 | 12 | 3 | | 0.263 |
| 3 | 9 | | 0.580 | 12 | 4 | | 0.994 |
| | | | | 12 | 5 | | 0.455 |
| 4 | 1 | 0.448 | 0.448 | 12 | 6 | | 0.526 |
| | | | | 12 | 7 | | 0.187 |
| 5 | 1 | 0.387 | 0.387 | 12 | 8 | | 0.308 |
| | | | | 12 | 9 | | 0.581 |
| 6 | 1 | 2.605 | 0.362 | 12 | 10 | | 0.612 |
| 6 | 2 | | 0.266 | 12 | 11 | | 0.286 |
| 6 | 3 | | 0.174 | 12 | 12 | | 0.388 |
| 6 | 4 | | 0.234 | 12 | 13 | | 0.551 |
| 6 | 5 | | 0.092 | 12 | 14 | | 0.544 |
| 6 | 6 | | 0.117 | 12 | 15 | | 0.629 |
| 6 | 7 | | 0.144 | 12 | 16 | | 0.675 |
| 6 | 8 | | 0.220 | 12 | 17 | | 0.955 |
| 6 | 9 | | 0.995 | 12 | 18 | | 3.051 |
| | | | | 12 | 19 | | 1.817 |
| 7 | 1 | 0.974 | 0.029 | 12 | 20 | | 3.499 |
| 7 | 2 | | 0.035 | 12 | 21 | | 5.320 |
| 7 | 3 | | 0.049 | 12 | 22 | | 3.808 |
| 7 | 4 | | 0.072 | 12 | 23 | | 3.737 |
| 7 | 5 | | 0.077 | 12 | 24 | | 0.672 |
| 7 | 6 | | 0.137 | 12 | 25 | | 0.136 |
| 7 | 7 | | 0.156 | 12 | 26 | | 0.171 |
| 7 | 8 | | 0.191 | | | | |
| 7 | 9 | | 0.228 | 13 | 1 | 1.285 | 0.259 |
| | | | | 13 | 2 | | 0.317 |
| 8 | 1 | 0.081 | 0.081 | 13 | 3 | | 0.249 |

TABLE 12—(Continued)

OVERALL STATEWIDE COST-RESPONSIBILITY FOR YEAR 1983

| Veh Class | Sub-Group | % Responsibility Veh Class | % Responsibility Sub-Group | Veh Class | Sub-Group | % Responsibility Veh Class | % Responsibility Sub-Group |
|---|---|---|---|---|---|---|---|
| | | | | 13 | 4 | | 0.158 |
| 9 | 1 | 1.087 | 0.018 | 13 | 5 | | 0.182 |
| 9 | 2 | | 1.069 | 13 | 6 | | 0.008 |
| | | | | 13 | 7 | | 0.017 |
| 10 | 1 | 0.107 | 0.021 | 13 | 8 | | 0.009 |
| 10 | 2 | | 0.025 | 13 | 9 | | 0.009 |
| 10 | 3 | | 0.027 | 13 | 10 | | 0.016 |
| 10 | 4 | | 0.033 | 13 | 11 | | 0.009 |
| | | | | 13 | 12 | | 0.025 |
| 11 | 1 | 2.525 | 0.060 | 13 | 13 | | 0.028 |
| 11 | 2 | | 0.106 | | | | |
| 11 | 3 | | 0.224 | 14 | 1 | 1.110 | 0.095 |
| 11 | 4 | | 0.128 | 14 | 2 | | 0.249 |
| 11 | 5 | | 0.105 | 14 | 3 | | 0.765 |

TABLE 13

OVERALL STATEWIDE COST-RESPONSIBILITY FOR 1985/86

| Veh Class | Sub-Group | % Responsibility Veh Class | % Responsibility Sub-Group | Veh Class | Sub-Group | % Responsibility Veh Class | % Responsibility Sub-Group |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 11.707 | 11.707 | 11 | 6 | | 0.340 |
| | | | | 11 | 7 | | 0.122 |
| 2 | 1 | 43.610 | 43.610 | 11 | 8 | | 0.153 |
| | | | | 11 | 9 | | 0.123 |
| 3 | 1 | 5.746 | 0.409 | 11 | 10 | | 0.147 |
| 3 | 2 | | 0.240 | 11 | 11 | | 0.174 |
| 3 | 3 | | 0.783 | 11 | 12 | | 0.201 |
| 3 | 4 | | 0.793 | 11 | 13 | | 0.413 |
| 3 | 5 | | 0.435 | | | | |
| 3 | 6 | | 1.302 | 12 | 1 | 29.281 | 0.021 |
| 3 | 7 | | 0.960 | 12 | 2 | | 0.084 |
| 3 | 8 | | 0.342 | 12 | 3 | | 0.323 |
| 3 | 9 | | 0.484 | 12 | 4 | | 1.042 |
| | | | | 12 | 5 | | 0.544 |

TABLE 13 —(Continued)

OVERALL STATEWIDE COST-RESPONSIBILITY FOR 1985/86

| Veh Class | Sub-Group | % Responsibility Veh Class | % Responsibility Sub-Group | Veh Class | Sub-Group | % Responsibility Veh Class | % Responsibility Sub-Group |
|---|---|---|---|---|---|---|---|
| 4 | 1 | 0.344 | 0.344 | 12 | 6 | | 0.536 |
| | | | | 12 | 7 | | 0.241 |
| 5 | 1 | 0.427 | 12 | 8 | | | 0.337 |
| | | | | 12 | 9 | | 0.539 |
| 6 | 1 | 2.224 | 0.325 | 12 | 10 | | 0.571 |
| 6 | 2 | | 0.238 | 12 | 11 | | 0.324 |
| 6 | 3 | | 0.164 | 12 | 12 | | 0.401 |
| 6 | 4 | | 0.206 | 12 | 13 | | 0.519 |
| 6 | 5 | | 0.083 | 12 | 14 | | 0.569 |
| 6 | 6 | | 0.101 | 12 | 15 | | 0.620 |
| 6 | 7 | | 0.124 | 12 | 16 | | 0.799 |
| 6 | 8 | | 0.186 | 12 | 17 | | 0.999 |
| 6 | 9 | | 0.799 | 12 | 18 | | 2.670 |
| | | | | 12 | 19 | | 1.718 |
| 7 | 1 | 0.804 | 0.031 | 12 | 20 | | 3.155 |
| 7 | 2 | | 0.032 | 12 | 21 | | 4.910 |
| 7 | 3 | | 0.044 | 12 | 22 | | 3.851 |
| 7 | 4 | | 0.062 | 12 | 23 | | 3.453 |
| 7 | 5 | | 0.066 | 12 | 24 | | 0.736 |
| 7 | 6 | | 0.109 | 12 | 25 | | 0.130 |
| 7 | 7 | | 0.132 | 12 | 26 | | 0.190 |
| 7 | 8 | | 0.152 | | | | |
| 7 | 9 | | 0.176 | 13 | 1 | 1.218 | 0.222 |
| | | | | 13 | 2 | | 0.274 |
| 8 | 1 | 0.090 | 0.090 | 13 | 3 | | 0.226 |
| | | | | 13 | 4 | | 0.148 |
| 9 | 1 | 1.146 | 0.020 | 13 | 5 | | 0.161 |
| 9 | 2 | | 1.126 | 13 | 6 | | 0.016 |
| | | | | 13 | 7 | | 0.027 |
| 10 | 1 | 0.093 | 0.018 | 13 | 8 | | 0.012 |
| 10 | 2 | | 0.021 | 13 | 9 | | 0.013 |
| 10 | 3 | | 0.025 | 13 | 10 | | 0.024 |
| 10 | 4 | | 0.029 | 13 | 11 | | 0.015 |
| | | | | 13 | 12 | | 0.037 |
| 11 | 1 | 2.287 | 0.059 | 13 | 13 | | 0.044 |
| 11 | 2 | | 0.104 | | | | |
| 11 | 3 | | 0.218 | 14 | 1 | 1.030 | 0.089 |
| 11 | 4 | | 0.124 | 14 | 2 | | 0.217 |
| 11 | 5 | | 0.111 | 14 | 3 | | 0.724 |

## TABLE 14

## REVENUE CONTRIBUTION BY VEHICLE CLASS (1983)

| Veh Class | Sub-Group | % Contribution Veh Class | % Contribution Sub-Group | Veh Class | Sub-Group | % Contribution Veh Class | % Contribution Sub-Group |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 8.080 | 8.080 | 11 | 6 | | 0.150 |
| | | | | 11 | 7 | | 0.070 |
| 2 | 1 | 56.670 | 56.670 | 11 | 8 | | 0.073 |
| | | | | 11 | 9 | | 0.073 |
| 3 | 1 | 8.020 | 3.240 | 11 | 10 | | 0.063 |
| 3 | 2 | | 0.450 | 11 | 11 | | 0.062 |
| 3 | 3 | | 0.900 | 11 | 12 | | 0.058 |
| 3 | 4 | | 0.940 | 11 | 13 | | 0.066 |
| 3 | 5 | | 0.710 | | | | |
| 3 | 6 | | 0.580 | 12 | 1 | 18.900 | 0.043 |
| 3 | 7 | | 0.330 | 12 | 2 | | 0.166 |
| 3 | 8 | | 0.400 | 12 | 3 | | 0.536 |
| 3 | 9 | | 0.460 | 12 | 4 | | 1.370 |
| | | | | 12 | 5 | | 0.847 |
| 4 | 1 | 0.372 | 0.372 | 12 | 6 | | 0.631 |
| | | | | 12 | 7 | | 0.400 |
| 5 | 1 | 0.453 | 0.453 | 12 | 8 | | 0.419 |
| | | | | 12 | 9 | | 0.457 |
| 6 | 1 | 2.210 | 0.390 | 12 | 10 | | 0.416 |
| 6 | 2 | | 0.240 | 12 | 11 | | 1.120 |
| 6 | 3 | | 0.160 | 12 | 12 | | 0.329 |
| 6 | 4 | | 0.250 | 12 | 13 | | 0.397 |
| 6 | 5 | | 0.160 | 12 | 14 | | 0.468 |
| 6 | 6 | | 0.210 | 12 | 15 | | 0.487 |
| 6 | 7 | | 0.210 | 12 | 16 | | 0.718 |
| 6 | 8 | | 0.160 | 12 | 17 | | 0.606 |
| 6 | 9 | | 0.450 | 12 | 18 | | 0.730 |
| | | | | 12 | 19 | | 0.614 |
| 7 | 1 | 0.540 | 0.037 | 12 | 20 | | 0.782 |
| 7 | 2 | | 0.046 | 12 | 21 | | 1.442 |
| 7 | 3 | | 0.036 | 12 | 22 | | 1.799 |
| 7 | 4 | | 0.090 | 12 | 23 | | 0.952 |
| 7 | 5 | | 0.038 | 12 | 24 | | 0.454 |
| 7 | 6 | | 0.031 | 12 | 25 | | 1.337 |
| 7 | 7 | | 0.180 | 12 | 26 | | 1.355 |
| 7 | 8 | | 0.040 | | | | |
| 7 | 9 | | 0.039 | 13 | 1 | 1.260 | 0.461 |
| | | | | 13 | 2 | | 0.128 |
| 8 | 1 | 0.078 | 0.078 | 13 | 3 | | 0.080 |

TABLE 14—(Continued)

REVENUE CONTRIBUTION BY VEHICLE CLASS (1983)

| Veh Class | Sub-Group | % Contribution Veh Class | % Contribution Sub-Group | Veh Class | Sub-Group | % Contribution Veh Class | % Contribution Sub-Group |
|---|---|---|---|---|---|---|---|
| | | | | 13 | 4 | | 0.073 |
| 9 | 1 | 1.620 | 0.630 | 13 | 5 | | 0.056 |
| 9 | 2 | | 0.990 | 13 | 6 | | 0.032 |
| | | | | 13 | 7 | | 0.046 |
| 10 | 1 | 0.069 | 0.017 | 13 | 8 | | 0.037 |
| 10 | 2 | | 0.016 | 13 | 9 | | 0.037 |
| 10 | 3 | | 0.020 | 13 | 10 | | 0.049 |
| 10 | 4 | | 0.016 | 13 | 11 | | 0.038 |
| | | | | 13 | 12 | | 0.057 |
| 11 | 1 | 1.211 | 0.074 | 13 | 13 | | 0.163 |
| 11 | 2 | | 0.110 | | | | |
| 11 | 3 | | 0.200 | 14 | 1 | 0.520 | 0.189 |
| 11 | 4 | | 0.106 | 14 | 2 | | 0.068 |
| 11 | 5 | | 0.110 | 14 | 3 | | 0.264 |

TABLE 15

REVENUE CONTRIBUTION BY VEHICLE CLASS (1985-86)

| Veh Class | Sub-Group | % Contribution Veh Class | % Contribution Sub-Group | Veh Class | Sub-Group | % Contribution Veh Class | % Contribution Sub-Group |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 8.946 | 8.946 | 11 | 6 | | 0.131 |
| | | | | 11 | 7 | | 0.062 |
| 2 | 1 | 60.250 | 60.250 | 11 | 8 | | 0.065 |
| | | | | 11 | 9 | | 0.064 |
| 3 | 1 | 8.306 | 3.563 | 11 | 10 | | 0.055 |
| 3 | 2 | | 0.450 | 11 | 11 | | 0.055 |
| 3 | 3 | | 0.833 | 11 | 12 | | 0.051 |
| 3 | 4 | | 0.897 | 11 | 13 | | 0.058 |
| 3 | 5 | | 0.977 | | | | |
| 3 | 6 | | 0.556 | 12 | 1 | 15.029 | 0.038 |
| 3 | 7 | | 0.306 | 12 | 2 | | 0.148 |
| 3 | 8 | | 0.350 | 12 | 3 | | 0.490 |
| 3 | 9 | | 0.375 | 12 | 4 | | 1.195 |
| | | | | 12 | 5 | | 0.733 |

**TABLE 15**—(Continued)

**REVENUE CONTRIBUTION BY VEHICLE CLASS (1985-86)**

| Veh Class | Sub-Group | % Contribution Veh Class | % Contribution Sub-Group | Veh Class | Sub-Group | % Contribution Veh Class | % Contribution Sub-Group |
|---|---|---|---|---|---|---|---|
| 4 | 1 | 0.336 | 0.336 | 12 | 6 | | 0.547 |
| | | | | 12 | 7 | | 0.344 |
| 5 | 1 | 0.459 | 0.459 | 12 | 8 | | 0.362 |
| | | | | 12 | 9 | | 0.391 |
| 6 | 1 | 1.824 | 0.369 | 12 | 10 | | 0.358 |
| 6 | 2 | | 0.204 | 12 | 11 | | 0.490 |
| 6 | 3 | | 0.138 | 12 | 12 | | 0.279 |
| 6 | 4 | | 0.212 | 12 | 13 | | 0.307 |
| 6 | 5 | | 0.130 | 12 | 14 | | 0.353 |
| 6 | 6 | | 0.173 | 12 | 15 | | 0.357 |
| 6 | 7 | | 0.170 | 12 | 16 | | 0.546 |
| 6 | 8 | | 0.129 | 12 | 17 | | 0.476 |
| 6 | 9 | | 0.300 | 12 | 18 | | 0.573 |
| | | | | 12 | 19 | | 0.467 |
| 7 | 1 | 0.420 | 0.034 | 12 | 20 | | 0.612 |
| 7 | 2 | | 0.064 | 12 | 21 | | 1.159 |
| 7 | 3 | | 0.032 | 12 | 22 | | 1.427 |
| 7 | 4 | | 0.058 | 12 | 23 | | 0.814 |
| 7 | 5 | | 0.035 | 12 | 24 | | 0.383 |
| 7 | 6 | | 0.028 | 12 | 25 | | 1.083 |
| 7 | 7 | | 0.097 | 12 | 26 | | 1.099 |
| 7 | 8 | | 0.036 | | | | |
| 7 | 9 | | 0.035 | 13 | 1 | 1.457 | 0.813 |
| | | | | 13 | 2 | | 0.108 |
| 8 | 1 | 0.079 | 0.079 | 13 | 3 | | 0.067 |
| | | | | 13 | 4 | | 0.061 |
| 9 | 1 | 1.179 | 0.515 | 13 | 5 | | 0.041 |
| 9 | 2 | | 0.664 | 13 | 6 | | 0.027 |
| | | | | 13 | 7 | | 0.036 |
| 10 | 1 | 0.062 | 0.016 | 13 | 8 | | 0.029 |
| 10 | 2 | | 0.015 | 13 | 9 | | 0.029 |
| 10 | 3 | | 0.018 | 13 | 10 | | 0.038 |
| 10 | 4 | | 0.014 | 13 | 11 | | 0.030 |
| | | | | 13 | 12 | | 0.045 |
| 11 | 1 | 1.087 | 0.066 | 13 | 13 | | 0.134 |
| 11 | 2 | | 0.113 | | | | |
| 11 | 3 | | 0.175 | 14 | 1 | 0.566 | 0.304 |
| 11 | 4 | | 0.094 | 14 | 2 | | 0.051 |
| 11 | 5 | | 0.098 | 14 | 3 | | 0.212 |

## TABLE 16

## COST-ALLOCATION AND REVENUE ATTRIBUTION SUMMARY

| Vehicle Type | Vehicle Class | Summary for Fiscal Year 1983 Percent VMT | Percent Cost-Resp. | Percent Revenue | Revenue/Cost | Summary for Biennial Period 1985/86 Percent VMT | Percent Cost-Resp. | Percent Revenue | Revenue/Cost |
|---|---|---|---|---|---|---|---|---|---|
| Passenger | 1 | 19.124 | 10.869 | 8.080 | 0.743 | 19.176 | 11.707 | 8.946 | 0.764 |
| Car | 2 | 68.921 | 41.510 | 56.670 | 1.365 | 68.001 | 43.610 | 60.250 | 1.382 |
| | 5 | 0.623 | 0.387 | 0.453 | 1.171 | 0.641 | 0.427 | 0.459 | 1.075 |
| | 8 | 0.107 | 0.081 | 0.078 | 0.963 | 0.127 | 0.090 | 0.079 | 0.878 |
| | | 88.775 | 52.847 | 65.281 | 1.235 | 87.945 | 55.834 | 69.734 | 1.249 |
| Bus | 4 | 0.164 | 0.448 | 0.372 | 0.830 | 0.162 | 0.344 | 0.336 | 0.997 |
| Single-Unit | 3 | 2.666 | 6.766 | 8.020 | 1.185 | 2.604 | 5.746 | 8.306 | 1.446 |
| Truck | 6 | 0.692 | 2.605 | 2.210 | 0.848 | 0.646 | 2.224 | 1.824 | 0.820 |
| | 9 | 0.091 | 1.087 | 1.620 | 1.490 | 0.092 | 1.146 | 1.179 | 1.029 |
| | | 3.449 | 10.458 | 11.850 | 1.133 | 3.342 | 9.116 | 11.309 | 1.241 |
| Combination | 7 | 0.196 | 0.974 | 0.540 | 0.554 | 0.219 | 0.804 | 0.420 | 0.522 |
| Truck | 10 | 0.040 | 0.107 | 0.069 | 0.645 | 0.043 | 0.093 | 0.062 | 0.667 |
| | 11 | 0.688 | 2.525 | 1.211 | 0.480 | 0.752 | 2.287 | 1.087 | 0.475 |
| | 12 | 6.385 | 30.253 | 18.900 | 0.625 | 7.211 | 29.281 | 15.029 | 0.513 |
| | 13 | 0.224 | 1.285 | 1.260 | 0.981 | 0.245 | 1.218 | 1.457 | 1.196 |
| | 14 | 0.078 | 1.110 | 0.520 | 0.468 | 0.081 | 1.030 | 0.566 | 0.550 |
| | | 7.611 | 36.254 | 22.500 | 0.621 | 8.551 | 34.713 | 18.621 | 0.536 |

trucks overpaid, three-axle single-unit trucks underpaid their cost-responsibility.

3. Combination trucks significantly underpaid their cost-responsibility in 1983. The underpayment was consistent among all combination trucks. However, the extent of this underpayment varied within the group.
4. The same general pattern of overpayments and underpayments as in 1983 would be present in the biennial period of 1985-86. In fact, the underpayment by heavy combination trucks would be more pronounced in 1985-86 than in 1983. This implies that the subsidization of heavy vehicles by passenger cars and single-unit trucks would continue to exist if the tax structure were to remain unchanged.

A comparison of the findings of Indiana study to findings in other studies is presented in Table 17. In this table are shown the revenue/cost ratios for the generalized vehicle classes determined in Indiana study along with the corresponding figures from other cost allocation studies. The studies listed covered a wide range of procedures and geographic variations. Furthermore, the cost-responsibility and revenue contribu-

**TABLE 17**

**COMPARISON OF FINDINGS OF THE INDIANA STUDY TO FINDINGS OF OTHER STUDIES**

| | User Revenue Contribution/ Cost-Responsibility | | |
|---|---|---|---|
| | Passenger Car | SU Truck | Combination |
| Florida (1979) | 1.04 | 0.91 | 0.51* |
| Georgia (1979) | 1.03 | 0.66 | 0.44* |
| Oregon (1980) | 1.00 | 1.25 | 0.92 |
| Colorado (1981) | 1.22 | 1.24 | 0.56 |
| Kentucky (1982) | 1.57 | -- | 0.57** |
| Maryland (1982) | 1.17 | 0.83 | 0.56 |
| Connecticut (1982) | 1.11 | 1.61 | 0.63 |
| Ohio (1982) | 0.90 | 2.25 | 0.35 |
| Wisconsin (1982) | 0.94 | 1.40 | 0.89 |
| Maine (1982) | 1.02 | 1.16 | 0.97 |
| North Carolina (1983) | 0.96 | 2.14 | 0.78 |
| Federal (1982) | 1.10 | 1.50 | 0.60 |
| Indiana (Base period) | 1.24 | 1.13 | 0.62 |
| (Budget period) | 1.25 | 1.24 | 0.54 |

* five of more axles

** for all trucks

tion figures depended upon the specific expenditure patterns and revenue structures included in a study. Consequently, the results cannot be precisely compared. Nevertheless, the ratios presented in Table 17 give a broad indication of the reasonableness of the results of the Indiana study.

## CONCLUSIONS

The findings of the 1983-84 Indiana Highway Cost Allocation Study indicated that there was a definite imbalance between cost-responsibility of and revenue contribution by different vehicle classes in 1983. The net result was that passenger cars and single-unit trucks subsidized the heavy combination trucks. The study also revealed that such inequity among vehicle classes would remain if the same tax structure were retained.

The cost allocation study has provided a means to evaluate different user tax options in terms of revenue-cost comparisons. The procedure developed can be used to design an equitable tax structure where the revenue-cost ratios for various vehicle groups are close to unity.

## REFERENCES


1. MacTavish, Douglas and Neuman D.C., *Vehicle Classification Case Study for the Highway Performance Monitoring System*, Federal Highway Administration, August, 1982.
2. Metwali, E.S.W., "Framework for a Pavement Evaluation System," Joint Highway Research Project, Interim Report, FHWA/IN/JHRP-81/7, 1981.
3. Joint Highway Research Project, "Engineering Soil Parent Material Areas of Indiana," Purdue University, West Lafayette, Bulletin 87, 1950.
4. Sinha, K.C., T.F. Fwa, E.A. Sharaf, A.B. Tee and H.L. Michael, "Indiana Highway Cost Allocation Study", Draft Final Report, Joint Highway Research Project, Purdue University, Report No. FHWA/IN/JHRP-84/20, October, 1984.
5. Sinha, K.C., T.F. Fwa, E.C. Ting, R.M. Shanteau, M. Saito and H.L. Michael, "Indiana Highway Cost Allocation Study: A Report on Methodology", Joint Highway Research Project, Purdue University, Report No. FHWA/IN/JHRP-84/4, March, 1984. Revised October, 1984.
6. Fwa, T.F. and K.C. Sinha, "Thickness Incremental Method for Allocating Pavement Construction Costs in Highway Cost Allocation Study", presented at the TRB Annual Meeting, Washington, D.C., January, 1985.
7. Fwa, T.F. and K.C. Sinha, "A Performance-Based Approach for Determining Cost-Responsibilities of Load-Related and Non-Load-Related Factors in Highway pavement Rehabilitation and Maintenance Cost Allocation", presented at the TRB Annual Meeting, Washington, D.C., January, 1985.