Vehicular Charges on Highway Toll Facilities

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THIS study examines the variation of toll charges with vehicle type, size, and weight on 137 publicly owned toll facilities. The great variety in the methods of assessing toll charges, in the levels thereof, and in their graduation with vehicle type and size impedes precise measurement of the relation it is sought to develop.

Toll charges on each facility were determined for each of 15 selected vehicles and combinations ranging in size from a light passenger car to a truck-trailer combination having a maximum gross vehicle weight of 72,000 lb. Since the primary emphasis is on the variation of toll charges with type and weight of vehicle, the toll charges on each facility were converted to index numbers, using the charge for the light passenger car as a base.

Toll charges on publicly owned toll facilities increase with vehicle weight, although not precisely. Toll roads graduate toll charges a little more severely with the weight of vehicle than do toll bridges and tunnels but not as severely as do ferries. This situation is illustrated by the relation between the tolls charged a light passenger car and those charged a three-axle, tractor-semitrailer combination. This vehicle combination, the heaviest that can use all of the toll facilities included in the study, has a maximum gross weight of 40,000 lb. and an average operating gross weight of 27,000 lb.

Expressed as percentages of the charges made for a light passenger car, the median toll charges for the three-axle, tractor-semitrailer combination, conventionally designated by the term 2-S1, are: bridges and tunnels, 275 percent; ferries, 608 percent; and roads, 402 percent.

The median toll charges made for this combination per unit of maximum gross weight, expressed as percentages of the light-passenger-car charges per unit of maximum gross weight, are: bridges and tunnels, 24 percent; ferries, 90 percent; and roads, 36 percent.

For the average operating gross weights used in this study the median charges made per pound for the 2-S1 combination, expressed as percentages of the light-passenger-car charge per unit of average operating gross weight, are: bridges and tunnels, 36 percent; ferries, 70 percent; and roads, 50 percent.

The median indexes of toll charges per unit of load on the heaviest axle of this tractor-semitrailer combination, when loaded to its maximum gross weight of 40,000 lb., are: bridges and tunnels, 31 percent; ferries, 73 percent; and roads, 48 percent.

The charges made for a 41-passenger bus having a maximum gross weight of 27,000 lb. follow a similar pattern. The median indexes of toll charges per unit of maximum gross weight for this bus are: bridges and tunnels, 35 percent; ferries, 90 percent; and roads, 48 percent.

Detailed data in the text confirm that on toll bridges, tunnels, and roads the variation of toll charges with gross weight or axle load is definitely less than proportional.

If it is assumed that toll charges are indicative of the relative payments the operators of various types and sizes of vehicles are willing to make to provide the total revenue determined to be necessary, then one indication of the data produced by this study is that the benefit derived from a highway facility by vehicles of different sizes is not directly proportional to gross weight but increases at rates distinctly less than propor-

tional to gross weight. If the position is taken that the value of use per mile of travel is directly proportional to gross weight, the conclusion becomes inescapable that passenger-car users are currently suffering grievous discrimination on toll facilities.

● WHETHER the toll method of financing is pointed to with pride, viewed with alarm, or accepted with reluctance as an expedient, the fact remains that numerous toll facilities are now in existence and more are in prospect. Of no less importance than their number is their location "The toll roads thus far constructed and proposed, with few exceptions, occupy locations intended for routes of the Interstate Highway System" (*1*). Similarly, most of the existing and proposed toll bridges, tunnels, and ferries lie athwart the more-important traffic arteries.

The contributions exacted from highway users in the form of tolls are not insignificant. The Automobile Manufacturers Association estimated the 1951 receipts from public and private toll facilities to be $170 million (*2*). During the 1951 calendar year, publicly owned toll facilities alone collected an estimated $140 million for highway purposes (*3*) and an additional $7 million for nonhighway purposes (*4*). Several lucrative toll projects, among them the Delaware Memorial Bridge, the western extension of the Pennsylvania Turnpike, and portions of the New Jersey Turnpike, were in operation during only a fraction of the 1951 calendar year, others were opened to traffic during 1952, and still others are in various stages of construction, planning or study.

Among the better known projects opened during 1952 are the final 9-mi. section of the New Jersey Turnpike, the Chesapeake Bay Bridge in Maryland, the George P. Coleman Bridge over the York River and the Elizabeth River Bridge and Tunnel in Virginia, and the Denver-Boulder Turnpike, in Colorado.

The 88-mi. Turner Turnpike in Oklahoma is scheduled to be opened about April 1, 1953. Nearly 50 mi. of the 535-mi. New York Thruway are in use, although no tolls will be charged until a 150-mi. section between Batavia and Utica is opened in about a year. The Ohio Turnpike, the West Virginia Turnpike, and an extension of the Pennsylvania Turnpike, to connect with the New Jersey Turnpike, are under construction. Work on other toll road projects, notably the Garden State Parkway in New Jersey and extensions of the New Jersey and Maine Turnpikes, is expected to be started soon, and several other toll road projects are under consideration.

Additional toll crossings (bridges, tunnels, or ferries) are also under construction, planned, or proposed. Among those under construction are the Bay St. Louis Bridge in Mississippi, the third tube of the Lincoln Tunnel, the Lower Tampa Bay Bridge in Florida, the Paseo Bridge between Kansas City and North Kansas City, Missouri, to name a few. Work may be started soon on several other toll crossings, among them the Delaware River Port Authority Bridge from Philadelphia, Pennsylvania to Gloucester, New Jersey, the San Rafael–Richmond Bridge across San Francisco Bay, a bridge across Mackinac Straits, and a tunnel-bridge-causeway across Hampton Roads. Others, including a bridge at New Orleans over the Mississippi and a second Lake Washington bridge at Seattle, are in the planning stage, and still others have been proposed.

It is true that in the future many existing toll facilities will become free as the bonds issued to construct them are retired, unless the tolls are continued to bolster the security of bonds issued to construct other toll facilities. Also, several of the toll crossings recently completed, under construction, or proposed are to replace existing public or private toll facilities.

With toll facilities increasing in numbers and toll collections mounting even more rapidly, the relation of the toll method of financing to over-all tax systems and financial policies is worthy of attention. To what extent may the prevalence of toll facilities and their impact on the pocketbook affect the willingness and ability of highway users to pay taxes for the construction and maintenance of toll-free highways? Will continued resort to toll financing lead to the use of motor-fuel taxes earned on toll facilities, particularly roads, on those facilities rather than on toll-free highways as is now the case? Or, at the opposite extreme, will the willingness of highway users to pay for deluxe accommodations lead to the establishment of tolls on each facility at rates as high as the traffic will bear

and the use for general highway purposes of any excess over the amount required by the facility for debt service and maintenance? The investigation of these and similar problems that arise from the growing dependence on toll financing are not within the scope of this paper. They are, however, fit subjects for study and serve to point up the need for inquiry into the implications of increasing dependence on the toll method of financing.

The present study does not encompass all of the desirable objectives of a study of toll charges but is restricted to an investigation of the variation of toll charges with the type and size of vehicles. This limited objective was chosen in the belief that it would provide much of the basic information needed for any other studies of toll charges and would also shed some light on the general problem of motor-vehicle taxation.

The relation of toll charges to the tax rates that are charged vehicles of different types and sizes for the use of toll-free roads is somewhat obscure. On the one hand, the payer of tolls also pays whatever user charges are imposed on his vehicle by his state. On the other hand, the toll facility usually expects to defray its entire cost, or most of it, out of toll charges graduated with the type and size of vehicle and, therefore, has a somewhat similar interest to that of the state government in seeing that each class of vehicle pays its way. The situation, however, is to some extent similar to that of private business, in that if maximum income is sought the upper limits of toll rates are governed more by what the traffic will bear than by considerations of equity alone. Under these conditions the optimum rate of toll charge for a given class of vehicle may be stated as that rate at which the total receipts from vehicles of that class will be a maximum. This being the case, the equity motive, whether from the standpoint of benefits received or from that of costs occasioned, is relatively much weaker in the fixing of toll charges than it is in the imposition of road-user taxes.

COLLECTION OF DATA

At the outset it was decided to limit the study to publicly owned facilities. Several factors contributed to this decision, but among the more important were the circumstance that the majority of the privately owned toll facilities are ferries, many of which carry only passenger cars and light trucks, and a belief that toll schedules and other necessary information would be more difficult to obtain for privately owned facilities than for publicly owned ones.

Number of Facilities

Since the primary interest is in the variation of toll charges with vehicle type or size, some publicly owned facilities were automatically excluded. Among those are facilities which exclude all commercial vehicles or all except light trucks, and facilities, such as those serving recreational areas, for which the toll charge is based on or includes an admission charge. A few other publicly owned toll facilities which would otherwise have been included had to be omitted from this report because toll schedules could not be obtained or interpreted in time for inclusion.

TABLE 1
PUBLICLY-OWNED TOLL FACILITIES INCLUDED IN STUDY

Type	Number	Percent
Bridges	89	65.0
Tunnels	7	5.1
Ferries	33	24.1
Roads	8	5.8
Total	137	100.0

This report covers 137 toll facilities, as shown in Table 1. Almost two thirds of the facilities, 89 to be exact, are bridges; 7 are tunnels; 33 are ferries; and 8 are roads. The relatively small number of ferries is accounted for by the fact that many of the publicly owned ferries can carry only passenger cars and small trucks of the pickup and light-delivery type, so were not included in this study.

Toll Charges

Schedules of toll charges for many facilities were available in the Washington office of the Bureau of Public Roads. Toll schedules for other facilities were obtained through the Public Roads field offices and the state highway departments.

There is great variety in the measures used to determine the toll charge for a particular vehicle. This is shown in Table 2 and Figure 1. Among the most popular single measures are

maximum gross vehicle weight, gross vehicle weight at time of crossing, number of axles or tires, chassis weight, and manufacturers' rated capacity. A number of facilities use combinations of these and other vehicle characteristics to determine the toll charges; combinations involving the number of axles being most popular.

Only number of axles or tires is common to all four types of facilities, and this measure is used on only 19 percent of the bridges, 14 percent of the tunnels, 3 percent of the ferries, and 50 percent of the roads. The only measure used by a majority of the facilities of any one type is a combination of length for passenger cars, licensed gross weight for light and medium trucks and combinations, and gross weight at time of crossing for heavy trucks and combinations. This measure is used on a number of public ferries but is not used by any other type of facility.

This table does not exactly tell the whole story with respect to the variety of methods used in arriving at the toll charge for a given vehicle, because facilities using a common vehicle characteristic as a measure may not all apply the measure in the same way. For example, charges based on the maximum gross vehicle weight may be determined by applying a single unit rate to the gross weight, by applying a different unit rate to each increment of weight, or by using a different fixed charge for each gross-weight interval. Furthermore, tractor-semitrailer and truck-trailer combinations may be considered either as a unit or as separate vehicles and may or may not be charged at rates differing from those applicable to single-unit trucks.

TABLE 2
MEASURES OF TOLL CHARGES

Measure of toll charge	Bridges		Tunnels		Ferries		Roads	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Maximum gross vehicle weight	18	20.2	—	—	—	—	2	25.0
Gross vehicle weight at crossing	2	2.3	—	—	5	15.2	—	—
Chassis weight	9	10.1	—	—	—	—	1	12.5
Vehicle type	6	6.7	—	—	1	3.0	—	—
Number of axles or tires	17	19.1	1	14.3	1	3.0	4	50.0
Number of axles and maximum gross vehicle weight	8	9.0	3	42.8	—	—	—	—
Number of axles and load capacity	5	5.6	2	28.6	—	—	—	—
Number of axles and other characteristics	6	6.7	—	—	—	—	—	—
Manufacturer's rated capacity	7	7.9	—	—	—	—	1	12.5
Wheelbase or length	—	—	—	—	3	9.1	—	—
Licensed gross weight or gross weight at crossing[a]	—	—	—	—	17	51.5	—	—
Other	11	12.4	1	14.3	6	18.2	—	—
Total	89	100.0	7	100.0	33	100.0	8	100.0

[a] Length for passenger cars; licensed gross vehicle weight for trucks to 36,000 pounds; gross vehicle weight at time of crossing or trucks 36,000 pounds and over.

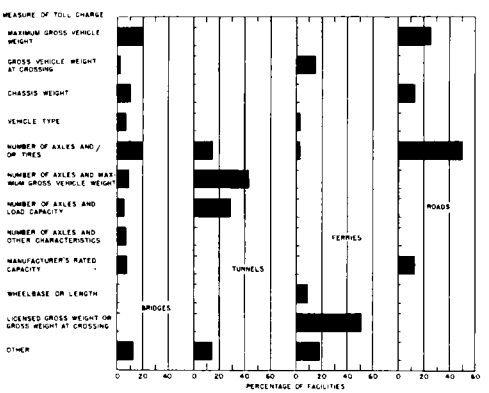

Figure 1. Measures of toll charges.

Scheme of Comparison

It is readily apparent that the variety in the measures used, as well as in their application, precludes direct comparison among the facilities on the basis of toll schedules alone. This obstacle was surmounted by selecting a series of vehicles and determining the toll charges for each vehicle on each facility.

At the time this study was started, the Public Roads Research Reports Branch had embarked on the study "Road-User and Property Taxes on Selected Vehicles," reported by E. M. Cope and R. W. Meadows in the previous papers in this volume of

TABLE 3

DESCRIPTION OF VEHICLES FOR WHICH TOLL CHARGES WERE DETERMINED

Reference Number	Make and Year	Model Number	Body Type	Empty Weight	Load Capacity	Average Operating Load	Max. Gross Vehicle Weight	Average Operating Gross Weight	Number of Axles	Tires			Axle Loads at Maximum Gross Weight				Wheelbase	Over-All Length
										Size	Arrangement		Front	Rear		Total		
											Front	Rear						
				lb.	*lb.*	*lb.*	*lb.*	*lb.*		*in.*			*lb.*	*lb.*	*lb.*	*lb.*	*in.*	*ft.*
1	Plymouth, 1951	Cam. P-23	Cl. Coupe	3,059	6 Pass.	300	3,959	3,359	2	6.70 x 15	Single	Single	1,959	-	2,000	3,959	118.5	16.0
2	Buick, 1951	51-Super	4-Door	3,755	6 Pass.	300	4,655	4,055	2	7.60 x 15	Single	Single	2,315	-	2,340	4,655	121.5	17.0
3	Ford, 1951	F-1 6 Cyl.	Pickup	3,220	1,480	380	4,700	3,600	2	6.50 x 16	Single	Single	1,900	-	2,800	4,700	114.0	15.8
4	Chevrolet, 1951	4409-UK	Stake	5,320	7,180	1,680	12,500	7,000	2	7.50 x 20	Single	Dual	3,000	-	9,500	12,500	161.0	21.6
5	Dodge, 1951	B-3-R	Van-14′	8,625	10,375	3,875	19,000	12,500	2	8.25 x 20	Single	Dual	5,000	-	14,000	19,000	172.0	24.0
6	Mack, 1951	A-50-S	Dump	18,862	21,138	10,138	40,000	29,000	3	10.00 x 20	Single	Dual	8,000	16,000	16,000	40,000	159.0	22.0
7	GMC, 1951	HCR-621	Tractor	8,825	—	-	-	—	2	10.00 x 20	Single	Dual	5,500		17,500	23,000	141.0	17.0
	Trailmobile, 1951	TA-66	Van-28′	7,320	-	-	-	—	1	10.00 x 20	—	Dual	-		17,000	17,000	—	28.0
	Combination	-	—	16,145	23,855	10,855	40,000	27,000	3	—	—	—	-	-	—	40,000	—	39.0
8	White, 1951	WC-22T	Tractor	8,400	—	—	-	—	2	10.00 x 20	Single	Dual	6,000	—	18,000	24,000	136.0	16.6
	Fruehauf, 1951	FCAL-GT-5533	Van-32′	8,700	—	-	-	—	2	10.00 x 20	—	Dual	-	13,000	13,000	26,000	—	32.0
	Combination	-	—	17,100	32,900	14,900	50,000	32,000	4	—	—	—	-	-	—	50,000	—	42.0
9	White, 1951[a]	WC-22-PLTD	Tractor	9,550	—	-	—	—	2	10.00 x 20	Single	Dual	6,000	-	18,000	24,000	134.0	16.4
	Trailmobile, 1951	A-662	Van-32′	8,990	—	-	—	—	2	10.00 x 20	—	Dual	-	13,000	13,000	26,000	—	32.0
	Combination	-	—	18,540	31,460	14,460	50,000	33,000	4	—	—	-	—	—	—	50,000	—	42.0
10	International, 1951[a]	LFD-305	Tractor	16,250	—	-	-	—	3	10.00 x 20	Single	Dual	8,000	14,000	14,000	36,000	169.0	21.8
	Fruehauf, 1951	FCAL-GT-5535	Van-35′	8,940	-	-	—	-	2	10.00 x 20	—	Dual	-	14,000	14,000	28,000	-	35.0
	Combination	-	—	25,190	38,810	18,810	64,000	44,000	5	—	—	—	—	—	—	64,000	—	49.0
11	Autocar, 1951[a]	DC-10064	Van-21′	20,300	15,700	-	36,000	—	3	10.00 x 22	Single	Dual	8,000	14,000	14,000	36,000	210.0	31.0
	Custom Built, 1951		Van-24′	8,500	27,500	—	36,000	—	3	10.00 x 22	Dual	Dual	12,000	12,000	12,000	36,000	176.0	24.0
	Combination	—	—	28,800	43,200	21,200	72,000	50,000	6	—	—	—	-	-	—	72,000	—	59.0
12	GMC, 1951	PD-4103	Bus, 41 Pass.	19,650	7,350 (41 Pass.)	3,350 (20 Pass.)	27,000	23,000 (20 Pass.)	2	11.00 x 20	Single	Dual	9,000	—	18,000	27,000	246.0	35.0
5A	Mack, 1951	A-50-S	Dump	18,862	16,138	7,138	35,000	26,000	3	10.00 x 20	Single	Dual	8,000	13,500	13,500	35,000	159.0	22.0
9A	White, 1951[a]	WC-22-PLTD	Tractor	9,550	—	—	—	—	2	10.00 x 20	Single	Dual	6,000	-	18,000	24,000	134.0	16.4
	Trailmobile, 1951	A-662	Van-32′	8,990	—	—	—	—	2	10.00 x 20	—	Dual	—	16,000	16,000	32,000	—	32.0
	Combination	—	—	18,540	37,460	18,460	56,000	37,000	4	—	—	—	—	—	—	56,000	—	42.0
10A	International, 1951	LF-210	Van-14′	11,259	12,741	-	24,000	-	2	11.00 x 20	Single	Dual	6,000	—	18,000	24,000	175.0	23.3
	Custom Built, 1951		Van-22′	7,200	28,800	—	36,000	-	2	11.00 x 20	Dual	Dual	18,000	-	18,000	36,000	216.0	22.0
	Combination	—	—	18,459	41,541	20,541	60,000	39,000	4	—	—	—	—	-	—	60,000	—	49.3

[a] Diesel-powered vehicle. All others use gasoline as fuel.

PROCEEDINGS. The 11 vehicles adopted for use in that study cover the range of vehicle types and sizes rather well, except that no bus was included. As it was considered desirable to facilitate comparison between the two studies by using the same vehicles in both, it was decided to adopt the 11 vehicles already selected for use in the study of road-user and property taxes and to add a twelfth, a large intercity bus. While the study was in progress, three other vehicles were added, because of certain situations encountered in the data used, giving 15 vehicles in all. Each vehicle was given a

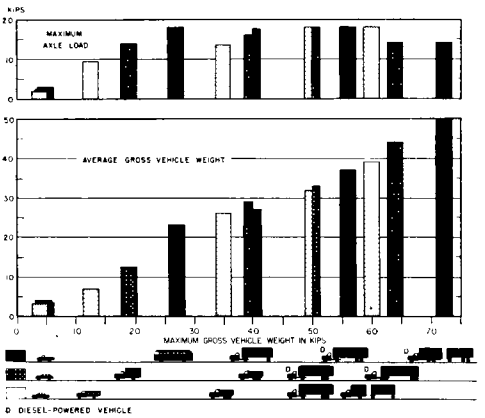

Figure 2. Maximum gross weight, average gross weight, and maximum axle load of selected vehicles.

number for convenient identification. Vehicles 5A, 9A, 10A, and 12 are the vehicles added for use in this study. The vehicles identified by 1 through 11 are the vehicles adopted from the study of road-user and property taxes.

The vehicles used are described in Table 3. The average operating gross weights shown in this table and Figure 2 were assumed for each vehicle after considering information regarding the percentage of vehicle miles traveled loaded and the average load carried by various types of trucks and truck combinations (*5*). These values, although not claimed to be typical, are believed to be not unreasonable.

The silhouettes of the 15 vehicles are located along the abscissa of Figure 2 in accordance with their maximum gross vehicle weights in kips, or thousands of lb. The average operating gross vehicle weight of each vehicle is shown by the height of the respective bar in the lower section of the chart, and the heaviest axle load produced by each vehicle is indicated by the height of the bar in the upper section. The dotted bars denote vehicles shown in the bottom row, the checkered bars apply to the middle row of silhouettes, and the solid black bars denote vehicles shown in the top row. Thus, the horizontal location of the silhouette and bars for the three-axle truck shows that this vehicle has a maximum gross vehicle weight of 40,000 lb. The height of the checkered half bar in the lower section of the chart indicates that it has an average operating gross vehicle weight of 29,000 lb., and the height of the checkered half bar in the top section of the chart shows that the maximum axle load imposed by the three-axle truck, when loaded to its maximum gross vehicle weight of 40 kips, is 16,000 lb.

The three-axle, tractor-semitrailer combination shown in silhouette in the top row of vehicles also has a maximum gross weight of 40,000 lb. The solid black half bars above this vehicle combination show that it has an average operating gross weight of 27,000 lb. and a maximum axle load of 17,500 lb.

PROCEDURE

The toll charge for each vehicle on each facility was determined from the toll schedules by applying appropriate vehicle characteristics. It is entirely possible that in some cases the toll charge assigned was not the proper one. Toll schedules are subject to misinterpretation. This is particularly true of those schedules which classify vehicles by physical characteristics, such as manufacturers' rated capacity, which are not precisely defined, or do not have a universally accepted value.

Needless to say, it was found that the charges for any given vehicle covered a wide range. In the case of toll roads, much of this dispersion reflects the disparity in the lengths of the roads. Therefore, the toll-road charges were reduced to rates per mile. Toll-crossing charges, however were not converted to rates per mile as it was thought that the level of charges established for toll crossings, particularly bridges and tunnels, were less affected by the length of the facility than by other factors, chief among which are (1) the amount of annual charges to be met out of toll revenues and (2) the volume of revenue traffic. Table 4 illustrates this point.

The George P. Coleman Bridge across the

TABLE 4
COMPARISON OF GEORGE P. COLEMAN AND DELAWARE MEMORIAL BRIDGES

Item	George P. Coleman Bridge	Delaware Memorial Bridge
Length, feet	3,750	10,750
Toll charges		
Passenger car[a]	$0.75	$0.75
Single unit trucks		
Pickup	0.75	1.00
2-axle, 12,500 pounds GVW[b]	1.00	1.00
2-axle, 19,000 pounds GVW	1.50	1.00
3-axle, 35,000 pounds GVW	1.75	1.50
3-axle, 40,000 pounds GVW	1.75	1.50
Tractor-semitrailer combinations		
3-axle, 40,000 pounds GVW	2.00	1.50
4-axle, 50,000 pounds GVW	2.50	2.00
Bus, 41 passenger[c]	3.50	1.00

[a] Charge for car with driver and passengers.
[b] As used in this report, the term "GVW" means maximum gross vehicle weight.
[c] Charge for bus with driver and 20 passengers.

York River at Yorktown, Virginia, and the Delaware Memorial Bridge over the Delaware River at Wilmington, Delaware, were chosen for this comparison because the toll schedules for these two bridges are similar and the two bridges were built at about the same time. Construction of the George P. Coleman Bridge was started in 1949 and the bridge was opened to traffic in May 1952. The Delaware Memorial Bridge was started in 1948 and was opened to traffic in August 1951.

Although the Coleman Bridge is less than a third the length of the Delaware Bridge, the toll charges for the two bridges do not differ greatly except in the case of the bus. For this vehicle, the charge for use of the George P. Coleman Bridge is 3½ times the charge for use of the Delaware Memorial Bridge, although the Coleman Bridge is the shorter of the two. Light-panel and pickup trucks are the only vehicles for which the Coleman Bridge charges are not equal to or higher than the Delaware Memorial Bridge charges.

LEVEL OF TOLL CHARGES

The next four tables show, in the form of frequency distributions, the range in toll-bridge, toll-tunnel, toll-ferry, and toll-road charges levied on vehicles of various sizes. In lieu of giving frequency distributions for each of the 15 vehicles studied, the four vehicles listed below were chosen as representative of the range in vehicle size from the light passenger car to the 40,000-lb tractor-semitrailer combination, the heaviest combination or vehicle that is not prohibited by state or facility size-and-weight regulations from using some of the toll facilities included in this study.

TABLE 5
FREQUENCY DISTRIBUTIONS OF BRIDGE TOLLS FOR PASSENGER CAR, TWO-AXLE TRUCK, BUS, AND 2-S1 COMBINATION

Toll in Dollars	Passenger Car		2-Axle Truck 19,000 Pounds GVW		41-Passenger Bus		2-S1 Combination 40,000 Pounds GVW	
	No.	%	*No.*	%	*No.*	%	*No.*	%
0–0.25	47	52.8	18	20.2	17	19.1	7	7.9
0.26–0.50	18	20.3	27	30.3	25	28.1	22	24.8
0.51–0.75	14	15.7	14	15.7	5	5.6	13	14.6
0.76–1.00	7	7.9	9	10.1	13	14.6	13	14.6
1.01–1.25	1	1.1	5	5.6	4	4.5	10	11.2
1.26–1.50	1	1.1	6	6.8	6	6.8	6	6.8
1.51–1.75	1	1.1	1	1.1	5	5.6	1	1.1
1.76–2.00	—	—	3	3.4	3	3.4	5	5.6
2.01–2.25	—	—	1	1.1	—	—	—	—
2.26–2.50	—	—	2	2.3	—	—	2	2.3
2.51–2.75	—	—	—	—	5	5.6	—	—
2.76–3.00	—	—	2	2.3	1	1.1	2	2.3
3.01–3.25	—	—	—	—	—	—	—	—
3.26–3.50	—	—	—	—	1	1.1	3	3.3
3.51–3.75	—	—	—	—	—	—	1	1.1
3.76–4.00	—	—	—	—	—	—	1	1.1
4.01–4.25	—	—	1	1.1	1	1.1	1	1.1
4.26–4.50	—	—	—	—	—	—	—	—
4.51–4.75	—	—	—	—	—	—	—	—
4.76–5.00	—	—	—	—	2	2.3	1	1.1
Over 5.00	—	—	—	—	1	1.1	1	1.1
Total	89	100.0	89	100.0	89	100.0	89	100.0

Vehicle	*Maximum gross weight*
	lb.
Light passenger car	3,959
Two-axle truck	19,000
Bus	27,000
Three-axle tractor-semitrailer combination	40,000

On those facilities which make a separate charge for passengers, the passenger-car toll used is the charge for a passenger car with

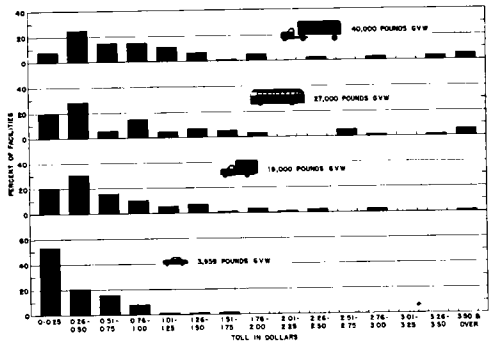

Figure 3. Percentage distributions of bridge tolls for passenger car, two-axle truck, bus, and 2-S1 combination.

driver and one passenger, and the bus toll is the charge for a bus with driver and 20 passengers.

Bridge Tolls

Table 5 and Figure 3 give frequency distributions of the bridge tolls for the four vehicles. On more than half of the bridges (53 percent) the passenger car toll is 25 cents or less. An additional 20 percent charge from 26 to 50 cents, and 16 percent charge from 51 to 75 cents. Only 3 percent of the bridges charge more than $1 and no bridge charges more than $1.75.

The bridges practice greater variety in the choice of charges for the three other vehicles. Although the most popular range of charges for the two-axle truck, the bus, and the 2-S1 combination is from 26 to 50 cents, rates within this interval are used for the truck by only 30 percent of the bridges, for the bus by only 28 percent, and for the 2-S1 combination by only 25 percent.

This table gives evidence of a variation of toll charges with vehicle size and weight. The wide range and great variety in toll charges, however, obscure the nature and amount of this variation.

Tunnel Tolls

Frequency distributions of the tunnel tolls for the four vehicles are shown in Table 6 and Figure 4. The tunnel tolls cover a much narrower range than do the bridge tolls, partly because only seven tunnels are represented in this table. The most-popular class interval of tunnel tolls for passenger cars is 26 to 50 cents, but by a margin of only one tunnel. For tunnels, the most popular range of charges for the two-axle truck is from 76 cents to $1.

TABLE 6
FREQUENCY DISTRIBUTIONS OF TUNNEL TOLLS FOR PASSENGER CAR, 2-AXLE TRUCK, BUS, AND 2-S1 COMBINATION

Toll in Dollars	Passenger Car		2-Axle Truck 19,000 Pounds GVW		41-Passenger Bus		2-S1 Combination 40,000 Pounds GVW	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
0–0.25	3	42.9	—	—	—	—	—	—
0.26–0.50	4	57.1	2	28.6	3	42.9	1	14.3
0.51–0.75	—	—	2	28.6	1	14.2	1	14.3
0.76–1.00	—	—	3	42.8	3	42.9	5	71.4
Total	7	100.0	7	100.0	7	100.0	7	100.0

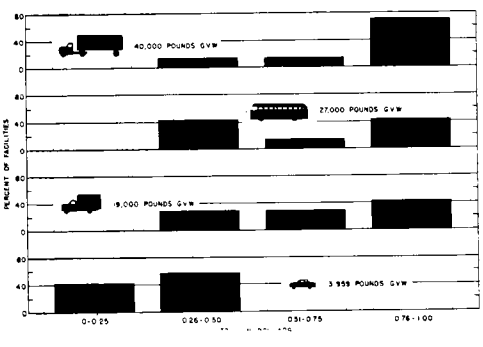

Figure 4. Percentage distributions of tunnel tolls for passenger car, two-axle truck, bus, and 2-S1 combination.

Three tunnels charge the bus 26 to 50 cents, one charges it from 51 to 75 cents, and three charge it from 76 cents to $1. The 2-S1 combination is charged from 76 cents to $1 by five tunnels.

Ferry Tolls

The frequency distributions of ferry tolls shown in Table 7 and Figure 5 differ in several important respects from those shown for bridges and tunnels in Tables 5 and 6, respectively. In the first place, the charges are generally higher for all vehicle types on ferries than are the bridge and tunnel charges, possibly because of the greater variation in the length of the crossings. Another important difference is that ferry charges appear to be graduated much more steeply with size and weight of vehicle than are bridge and tunnel charges.

TABLE 7
FREQUENCY DISTRIBUTIONS OF FERRY TOLLS FOR PASSENGER CAR, 2-AXLE TRUCK, BUS AND 2-S1 COMBINATION

Toll in Dollars	Passenger Car		2-Axle Truck		Bus		2-S1 Combination	
	No.	*%*	*No.*	*%*	*No*	*%*	*No.*	*%*
0–1.00	5	15.2	3	9.0	3	9.1	3	9.1
1.01–2.00	19	57.6	4	12.1	1	3.0	—	—
2.01–3.00	3	9.1	5	15.2	2	6.1	3	9.1
3.01–4.00	1	3.0	5	15.2	—	—	1	3.0
4.01–5.00	1	3.0	—	—	—	—	3	9.1
Subtotal	29	87.9	17	51.5	6	18.2	10	30.3
5.01–6.00	—	—	3	9.0	1	3.0	1	3.0
6.01–7.00	4	12.1	2	6.1	3	9.1	—	—
7.01–8.00	—	—	1	3.0	7	21.1	—	—
8.01–9.00	—	—	5	15.2	—	—	—	—
9.01–10.00	—	—	—	—	—	—	—	—
Subtotal	4	12.1	11	33.3	11	33.2	1	3.0
10.01–15.00	—	—	5	15.2	5	15.2	6	18.1
15.01–20.00	—	—	—	—	5	15.2	—	—
20.01–25.00	—	—	—	—	—	—	6	18.2
25.01–30.00	—	—	—	—	2	6.1	5	15.2
30.01–35.00	—	—	—	—	3	9.1	5	15.2
Over 35.00	—	—	—	—	1	3.0	—	—
Total	33	0.0	33	100.0	33	100.0	33	100.00

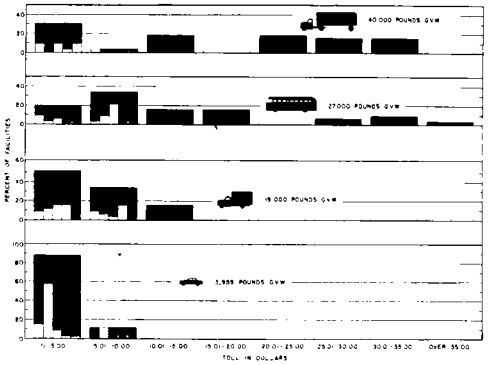

Figure 5. Percentage distributions of ferry tolls for passenger car, two-axle truck, bus, and 2-S1 combination.

than on the other two types of toll crossings. Where intervals of 25 cents were used in the tables of bridge and tunnel charges, intervals of $1 and $5 are used in this table for the ferry charges. Also, the ferry tolls are more evenly distributed over a much-wider range

As was true of bridges and tunnels, ferries are more nearly unanimous in the choice of charges for passenger cars than in the selection of charges for the larger and heavier vehicles. Of the ferries, 58 percent charge passenger cars from $1.01 to $2, an additional 15 percent charge $1 or less and 9 percent charge from $2 to $3. Only 12 percent charge more than $5 and none charge more than $7. Charges for the other vehicles are dispersed over a wider range, and no level of charge is an overwhelming favorite for any of these three vehicles. The wide range in charges is not surprising in view of the great variation in the length of ferry crossings.

Road Tolls

Frequency distributions of toll-road charges per mile for the passenger car, the two-axle truck, the bus, and the 2-S1 combination are shown in Table 8 and Figure 6. This table differs from the preceding tables in that the charges have been converted to rates per

mile and the frequencies represent miles of road rather than the number of facilities. With the exception of two toll roads, the rates per mile were obtained by dividing the charges for a full-length trip by the length of the facility. Both the Pennsylvania Turnpike and the New Jersey Turnpike, however, were divided into three sections each.

The sections used for the Pennsylvania Turnpike are the western extension from the Ohio state line to Irwin, the original turnpike from Irwin to Carlisle, and the eastern extension from Carlisle to Valley Forge. For a passenger car, the rate per mile is 1.1 cents on the western extension, 0.9 cents on the original turnpike, and 1.2 cents on the eastern extension. The sum of the charges on the three sections yields an average rate of 1.1 cents per mile, compared with a rate of 1 cent per mi. based on the charge for a full-length trip. The charges for other vehicle types are similarly reduced for full-length trips.

The variation in the rate charged per mile on the New Jersey Turnpike is much greater than that on the Pennsylvania Turnpike. The passenger car rate per mile is 1.1 cents for the southern section from the Delaware Memorial Bridge to New Brunswick, 2.4 cents from New Brunswick to Elizabeth, and 4.0 cents per mi. for the northern section from Elizabeth to the George Washington Bridge. The sum of the charges for these three sections is $2, giving an average rate per mile of 1.7 cents. The rate per mile based on the $1.75 charge for a full-length trip is 1.5 cents. The 25-cent reduction for a full-length trip also applies to the charges for tractor-semitrailer combinations having three axles. Tractor-semitrailer combinations having four or more axles are given a reduction of 50 cents. Passenger cars with trailers and single-unit trucks with dual rear tires are given no reduction for a full-length trip.

Proposed toll charges for the Ohio and West Virginia turnpikes were used in preparing this table, although it is realized that the charges finally adopted may be somewhat different.

The toll-road charges for each of the four vehicles selected cover a narrower range than do the charges for toll crossings. Also, the most-frequent charge for each of the four vehicles is favored by a greater plurality in the case of toll roads as opposed to toll cross-

TABLE 8
FREQUENCY DISTRIBUTIONS OF ROAD TOLLS PER MILE FOR PASSENGER CAR, 2-AXLE TRUCK, BUS, AND 2-S1 COMBINATION

Toll in Cents per Mile	Passenger Car		2-Axle Truck		Bus		2-S1 Combination	
	mi.	%	*mi.*	%	*mi.*	%	*mi.*	%
0–1.0	401.0	46.8	83.2	9.9	—	—	—	—
1.1–2.0	413.8	48.0	—	—	83.2	9.5	—	—
2.1–3.0	16.9	1.9	563.5	65.5	17.3	2.0	83.2	9.5
3.1–4.0	28.7	3.3	168.1	19.5	516.7	59.9	32.0	3.7
4.1–5.0	—	—	16.9	1.6	214.5	24.8	544.9	63.3
5.1–6.0	—	—	—	—	—	—	84.0	9.6
6.1–7.0	—	—	—	—	17.6	2.5	—	—
7.1–8.0	—	—	—	—	—	—	87.6	10.1
8.1–9.0	—	—	17.6	2.2	—	—	—	—
9.1–10.0	—	—	—	—	—	—	—	—
10.1–11.0	—	—	—	—	—	—	17.6	2.5
11.1–12.0	—	—	—	—	—	—	—	—
12.1–13.0	—	—	—	—	—	—	—	—
13.1–14.0	—	—	—	—	—	—	—	—
14.1–15.0	—	—	11.1	1.3	—	—	—	—
15.1 and over	—	—	—	—	11.1	1.3	11.1	1.3
Total.....	860.4	100.0	860.4	100.0	860.4	100.0	860.4	100.0

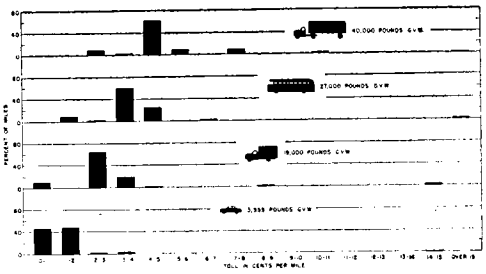

Figure 6. Percentage distributions of road tolls per mile for passenger car, two-axle truck, bus, and 2-S1 combination.

ings. This is not surprising. Toll roads are competitive with toll-free roads and enjoy much less freedom in establishing rates than do toll crossings, which are almost always monopolies or near monopolies. It is also true that the expression of toll-road charges in cents per mile factors out one of the major elements contributing to variation of tolls.

The most-popular charge for the passenger car is in the neighborhood of 1 cent per mi. On 47 percent of the toll-road mileage, the passenger-car rate is 1 cent per mi. or less and on 48 percent of the mileage the rate is from 1 to 2 cents per mi.

The two-axle truck is charged from 2 to 3 cents per mi. on 66 percent of the mileage and from 3 to 4 cents per mi. on 20 percent. On 60 percent of the toll-road mileage the bus is charged from 3 to 4 cents per mi., and on 25 percent of the mileage it is charged from 4 to 5 cents per mi. The charge for the 2-S1 combination is from 4 to 5 cents per mi. on 63 percent of the mileage and from 5 to 6 cents per mi. on 10 percent of the mileage.

converted to index numbers, using the charge for the light passenger car as a base, in order to eliminate the effect of variations in the level of toll charges. The next three tables show frequency distributions of the indexes of toll charges on bridges and tunnels combined, ferries, and roads for a pickup truck and for the two-axle truck, bus, and 2-S1 combination used in the preceding series of tables. Frequency distributions of the indexes of passenger-car charges are not needed as, on all facilities, both the light and heavy passenger cars were charged the same toll, and this toll charge was taken as 100 in computing the index numbers.

TABLE 9

FREQUENCY DISTRIBUTIONS OF INDEXES OF BRIDGE AND TUNNEL TOLLS FOR PICKUP TRUCK, TWO-AXLE TRUCK, BUS AND 2-S1 COMBINATION

Percentage of Passenger Car Toll	Pickup Truck		2-Axle Truck		Bus		2-S1 Combination	
	No.	%	*No.*	%	*No.*	%	*No.*	%
Under 75	2	2.1	—	—	—	—	—	—
76–125[a]	67	69.8	13	13.5	7	7.3	1	1.1
126–175	17	17.7	17	17.7	17	17.7	9	9.3
176–225	5	5.2	34	35.5	27	28.1	28	29.1
226–275	5	5.2	13	13.5	8	8.2	10	10.4
276–325	—	—	5	5.5	9	9.3	13	13.5
326–375	—	—	6	6.6	3	3.1	3	3.1
376–425	—	—	2	2.2	6	6.2	6	6.2
426–475	—	—	1	1.1	3	3.1	4	4.2
476–525	—	—	1	1.1	4	4.2	7	7.2
526–575	—	—	—	—	4	4.2	2	2.2
576–625	—	—	1	1.1	2	2.2	3	3.1
626–675	—	—	—	—	1	1.1	1	1.1
676–725	—	—	—	—	—	—	4	4.2
726–775	—	—	—	—	1	1.1	—	—
776–825	—	—	—	—	—	—	1	1.1
Over 825	—	—	2	2.2	4	4.2	4	4.2
Total	96	100.0	96	100.0	96	100.0	96	100.0

[a] Of these facilities, 52 charge the pickup truck, 9 charge the two-axle truck, 5 charge the bus, and 1 charges the 2-S1 combination the same toll the passenger car is charged.

RANGE IN VARIATION OF TOLL CHARGES WITH SIZE OF VEHICLE

The tables illustrate the fact that the variation of toll charges with type and size of vehicle is somewhat obscured by the great range in the levels of toll charges. Since the primary emphasis in this study is on the variation of toll charges with type and size of vehicle, the toll charges on each facility were

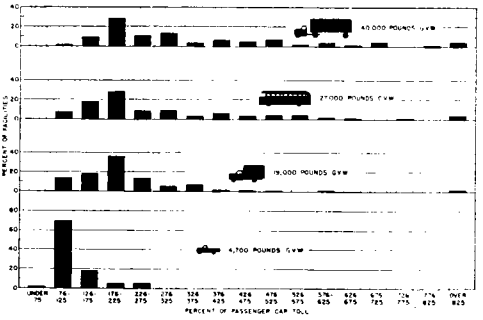

Figure 7. Percentage distributions of indexes of bridge and tunnel tolls for pickup truck, two-axle truck, bus and 2-S1 combination.

Bridges and Tunnels

The frequency distributions of indexes of toll charges shown in Table 9 and Figure 7

indicate that almost as much individuality is exercised in graduating bridge and tunnel charges with the type and size of vehicle as in choosing the level of charges. In spite of the rather broad class intervals used, the pickup truck is the only one of the four vehicles on which a majority of the bridges and tunnels agree. Seventy percent of the facilities charge the pickup truck from 76 percent to 125 percent of the passenger-car charge. For the other three vehicles, the most popular class interval of charges is from 176 to 225 percent of the passenger-car charge. This relation to the passenger-car charge is used by 36 percent of the facilities for the two-axle truck, by 28 percent for the bus, and by 29 percent for the 2-S1 combination.

Although 176 to 225 percent of the passenger-car charge is the most popular charge for the 19,000-lb. truck, the 27,000-lb. bus, and the 40,000-lb. tractor-semitrailer combination, it is significant that 31 percent of the facilities charge the two-axle truck less than 176 percent of the passenger-car charge, while only 25 percent charge the bus less than 176 percent of the passenger-car toll, and only 10 percent charge the 2-S1 combination less than 176 percent of the passenger-car charge. Only a third of the bridges and tunnels charge the two-axle truck more than 225 percent of the passenger-car charge, while 47 percent charge the bus and 60 percent charge the 2-S1 combination more than 225 percent of the amount charged the passenger car.

TABLE 10

FREQUENCY DISTRIBUTIONS OF INDEXES OF FERRY TOLLS FOR PICKUP TRUCK, TWO-AXLE TRUCK, BUS, AND 2-S1 COMBINATION

Percentage of Passenger Car Toll	Pickup Truck		2-Axle Truck		Bus		2-S1 Combination	
	No.	%	*No.*	%	*No.*	%	*No.*	%
Under 75	—	—	—	—	—	—	—	—
76–125[a]	22	66.7	7	21.2	—	—	—	—
126–175	11	33.3	4	12.1	3	9.1	1	3.0
176–225	—	—	4	12.1	1	3.0	4	12.1
226–275	—	—	3	9.1	—	—	2	6.0
276–325	—	—	10	30.5	—	—	5	15.2
326–375	—	—	2	6.0	—	—	1	3.0
376–425	—	—	2	6.0	1	3.0	—	—
426–475	—	—	—	—	3	9.1	2	6.1
476–525	—	—	—	—	3	9.1	1	3.0
526–575	—	—	—	—	1	3.0	—	—
576–625	—	—	—	—	—	—	3	9.1
626–675	—	—	—	—	3	9.1	1	3.0
676–725	—	—	—	—	10	30.5	4	12.1
726–775	—	—	—	—	6	18.1	5	15.2
776–825	—	—	—	—	1	3.0	2	6.1
Over 825	—	—	1	3.0	1	3.0	2	6.1
Total	33	100.0	33	100.0	33	100.0	33	100.0

[a] Of these facilities three charge the pickup and two charge the two-axle truck the same toll the passenger car is charged.

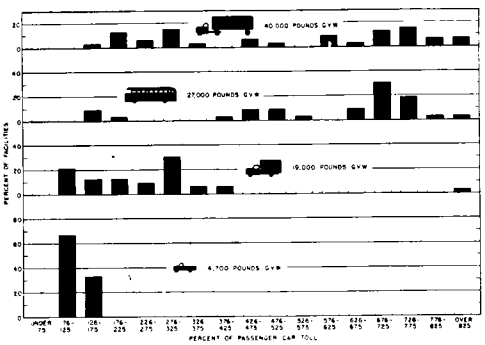

Figure 8. Percentage distributions of indexes of ferry tolls for pickup truck, two-axle truck, bus, and 2-S1 combination.

Ferries

Frequency distributions of the indexes of ferry charges for the four vehicles are shown in Table 10 and Figure 8. Two thirds of the ferries charge the pickup truck from 76 to 125 percent of the passenger-car charge and one third charged this vehicle from 126 to 175 percent of the passenger-car charge. The frequency distributions for the other three vehicles are of little significance, except to illustrate the great variety in the steepness with which the toll charges are graduated with the weight of vehicles. It is only in the frequency distribution for the bus that the two most-favored charges are in adjacent intervals.

Thirty percent of the ferries charge the two-axle truck from 276 to 325 percent of the passenger-car charge, but almost as many (21 percent) charge only 76 to 125 percent of the passenger-car charge. The frequency distribution for the 2-S1 combination is bimodal and the two modal classes are widely separated.

Roads

Table 11 and Figure 9 give frequency distributions of the indexes of toll-road charges for the four vehicles used in the two preceding tables. The passenger car charge is again used as 100 percent. For each of the four vehicles the indexes of toll road charges, in contrast to those for toll crossings, cover a relatively narrow range. Also, a majority of the toll road mileage is concentrated in adjacent index intervals for each vehicle. As a result, the graduation of toll charges with vehicle weight is rather clearly defined.

The Brunswick–St. Simons highway in Georgia graduates charges much more steeply with the size of vehicle than do the other toll roads and is the only toll road on which a charge is made for passengers. This road differs from the other toll roads in that it does not compete with toll-free roads but provides the only means of access to a portion of the Georgia coast.

The pickup truck is charged from 76 to 125 percent of the passenger-car charge on 97 percent of the toll road mileage. The remaining three percent of the mileage is almost equally divided between the two adjacent intervals. The mileage in the lowest interval represents the Brunswick–St. Simons road mentioned above.

With the exception of the Brunswick–St. Simons toll road, the charges for the two-axle truck range from 126 to 325 percent of the passenger-car charge. On 32 percent of the mileage the charge is 176 to 225 percent of the passenger-car charge. The most popular charge for the bus, 276 to 325 percent of the passenger-car charge, is used on 40 percent of the toll-road mileage. On 50 percent of the mileage the charge for the 2-S1 combination is from 376 to 425 percent of the passenger-car

TABLE 11
FREQUENCY DISTRIBUTIONS OF INDEXES OF ROAD TOLLS FOR PICKUP TRUCK, TWO-AXLE TRUCK, BUS, AND 2-S1 COMBINATION

Percentage of Passenger Car Toll	Pickup Truck		2-Axle Truck		Bus		2-S1 Combination	
	mi.	%	*mi.*	%	*mi.*	%	*mi.*	%
Under 75	11.1	1.3	—	—	—	—	—	—
76–125[a]	834.6	97.0	—	—	—	—	—	—
126–175	14.7	1.7	230.6	26.8	16.9	2.0	—	—
176–225	—	—	276.3	32.2	118.1	13.7	—	—
226–275	—	—	115.7	13.5	130.5	15.2	177.9	20.7
276–325	—	—	226.7	26.3	342.4	39.8	—	—
326–375	—	—	—	—	81.8	9.5	14.7	1.7
376–425	—	—	11.1	1.3	159.6	18.5	430.0	50.0
426–475	—	—	—	—	—	—	67.1	7.8
476–525	—	—	—	—	11.1	1.3	159.6	18.5
526–575	—	—	—	—	—	—	—	—
576–625	—	—	—	—	—	—	—	—
626–675	—	—	—	—	—	—	—	—
676–725	—	—	—	—	—	—	—	—
726–775	—	—	—	—	—	—	—	—
776–825	—	—	—	—	—	—	—	—
Over 825	—	—	—	—	—	—	11.1	1.3
Total	860.4	100.0	860.4	100.0	860.4	100.0	860.4	100.0

[a] The pickup truck is charged the same as the passenger car on 834.6 mi.

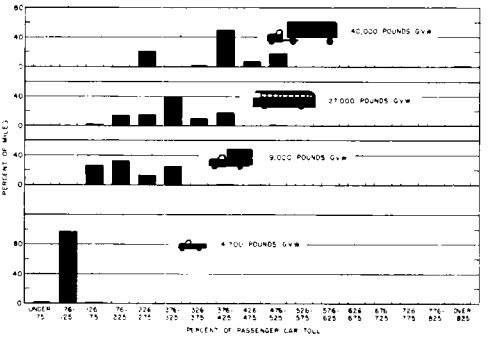

Figure 9. Percentage distributions of indexes of road tolls per mile for pickup truck, two-axle truck, bus, and 2-S1 combination.

charge. The lowest interval of charge for this vehicle is 226 to 275 percent of the passenger-car charge, and except for the Brunswick–St. Simons toll road, the highest interval of charge is 476 to 525 percent of the passenger-car charge. In the order named, these intervals account for 21 percent and 18 percent of the toll road mileage.

RELATION OF TOLL CHARGES TO VEHICLE WEIGHT

The preceding tables illustrate the wide variety in the levels of toll charges and in the manner in which toll charges are graduated with vehicle type or size. The following tables are intended to shed additional light on the relation between vehicle weight and toll charges. The value of these tables is somewhat impaired by the circumstance that state or facility size-and-weight regulations limit the number of facilities that can be used by the larger vehicles. The heaviest vehicle that can use all facilities is the three-axle, tractor-semitrailer combination.

Toll Charges per Vehicle

Bridges and Tunnels. The median and modal indexes of bridge and tunnel tolls for the 15 vehicles previously described are given in Table 12 and Figure 10. It is apparent that the charges increase with vehicle weight, although not very precisely. The heavy passenger car is charged the same toll as the light passenger car on all facilities. The median charge for the pickup truck, which is but little heavier than the heavy passenger car, is about 115 percent of the passenger-car charge. Median charges for the combinations range from about 275 percent of the passenger-car charge for the 40,000-lb. tractor-semitrailer combination to about four times the passenger-car charge for the 60,000-lb. truck-trailer combination and about six times the passenger-car charge for the 72,000-lb. truck-trailer combination.

TABLE 12
MEDIAN AND MODAL INDEXES OF BRIDGE AND TUNNEL TOLLS

Reference Number	Vehicle Type	Vehicle Maximum Gross Weight Amount	Vehicle Maximum Gross Weight Index of Passenger Car Weight	Index of Passenger Car Charge Median	Index of Passenger Car Charge Mode
		lb.	*%*	*%*	*%*
1	Passenger car	3,959	100.0	100.0	100.0
2	Passenger car	4,655	117.6	100.0	100.0
3	Pickup truck	4,700	118.7	114.0	102.0
4	Stake truck	12,500	315.7	164.0	150.0
5	Van truck	19,000	479.9	200.0	197.2
12	Bus, 41 passenger capacity	27,000	682.0	207.7	192.3
5A	Dump truck, 3-axle	35,000	884.1	230.0	202.7
6	Dump truck, 3-axle	40,000	1,010.4	237.5	200.0
7	2-S1 combination	40,000	1,010.4	275.0	201.1
8	2-S2 combination	50,000	1,262.9	280.0	211.4
9	2-S2 combination	50,000	1,262.9	280.0	211.4
9A	2-S2 combination	56,000	1,414.5	308.3	300.0
10A	2-2 combination	60,000	1,515.5	405.7	Bimodal
10	3-S2 combination	64,000	1,616.6	375.0	Bimodal
11	3-3 combination	72,000	1,818.6	608.3	625.0

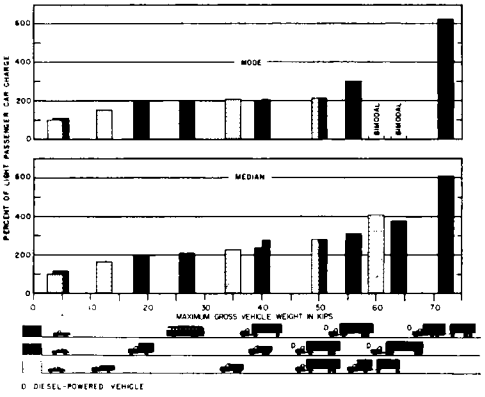

Figure 10. Median and modal indexes of bridge and tunnel tolls.

Ferries. Table 13 and Figure 11 give the median and modal indexes of ferry charges. The median for the three-axle truck having a maximum gross weight of 40,000 lb. deserves special mention. This vehicle, because of state

or ferry size-and-weight limitations is prevented from using more than two thirds of the ferries. It so happens that the ferries which it can use do not graduate tolls as steeply with the vehicle size and weight as do the other ferries. The median charge for this vehicle is only 137 percent of the passenger-car charge, while the median charges for the 35,000-lb. truck and the 40,000-lb. tractor-semitrailer combination are, respectively, 425 percent and 608 percent of the passenger-car charge.

The bus also deserves special mention—but for a different reason. Most ferries make a charge for bus passengers, and as a result, the road tolls are graduated more severely with vehicle size and weight than are bridge and tunnel tolls but not as steeply as are ferry tolls. The toll charge for the 41-passenger bus is about 300 percent of the passenger-car charge on roads, about 200 percent of the passenger-car charge on bridges and tunnels, and more than 650 percent of the passenger-car charge on ferries. For the heavier vehicles and combinations, the indexes of road tolls bear a similar relation to the indexes of bridge and tunnel tolls and ferry tolls.

The 3–S2 combination appears to receive preferential treatment on roads. This combination, however, is excluded by state limita-

TABLE 13
MEDIAN AND MODAL INDEXES OF FERRY TOLLS

Reference Number	Vehicle Type	Vehicle Maximum Gross Weight Amount	Vehicle Maximum Gross Weight Index of Passenger Car Weight	Index of Passenger Car Charge Median	Index of Passenger Car Charge Mode
		lb.	%	%	%
1	Passenger car	3,959	100.0	100.0	100.0
2	Passenger car	4,655	117.6	100.0	100.0
3	Pickup truck	4,700	118.7	114.6	109.6
4	Stake truck	12,500	315.7	225.0	250.0
5	Van truck	19,000	479.9	241.6	298.7
12	Bus, 41 passenger capacity	27,000	682.0	640.0	707.9
5A	Dump truck, 3-axle	35,000	884.1	425.0	525.0
6	Dump truck, 3-axle	40,000	1,010.4	137.5	135.0
7	2-S1 combination	40,000	1,010.4	608.3	Bimodal
8	2-S2 combination	50,000	1,262.9	700.0	701.0
9	2-S2 combination	50,000	1,262.9	700.0	701.0
9A	2-S2 combination	56,000	1,414.5	1,242.7	1,566.0
10A	2-2 combination	60,000	1,515.5	1,342.7	1,525.0
10	3-S2 combination	64,000	1,616.6	1,442.7	1,601.0
11	3-3 combination	72,000	1,818.6	1,675.0	Bimodal

tolls for this vehicle are higher than those for trucks of comparable weight.

On the whole, ferry tolls increase much more steeply with vehicle size and weight than do bridge and tunnel tolls. Whereas the median bridge and tunnel toll for the 40,000-lb. tractor-semitrailer combination, the heaviest of the vehicles that can use all toll facilities, is 275 percent of the passenger-car charge, the median ferry charge is 608 percent of the passenger-car toll. The 56,000-lb. 2-S2 combination is charged about three times as much as the passenger car on bridges and tunnels and more than 12 times as much as the passenger car on ferries.

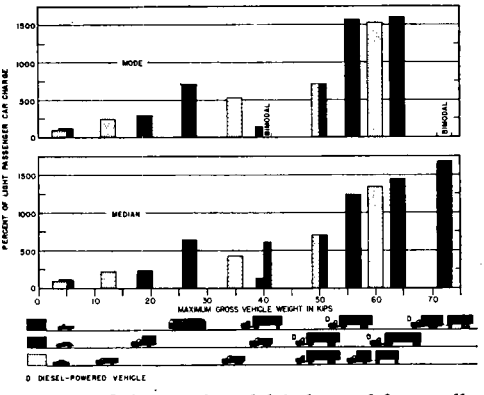

Figure 11. Median and modal indexes of ferry tolls.

Roads. Table 14 and Figure 12 give the median and modal indexes of road tolls per mile for the same 15 vehicles. On the whole, tions on size or weight from all of the toll roads except the 17.3-mi. Denver-Boulder

Turnpike, which graduates toll charges less severely with vehicle size and weight than do some of the other toll roads.

Toll Charges per Unit of Maximum Gross Vehicle Weight

The preceding tables indicate that the increases in toll charge with vehicle sizes are somewhat less than proportional to the increases in maximum gross vehicle weight. The three tables which follow compare the indexes of toll charges per unit of maximum gross vehicle weight for the 15 vehicles.

Bridges and Tunnels. Modal and median indexes of bridge and tunnel tolls per unit of maximum gross weight are shown in Table 15 and Figure 13. As in the preceding tables, the value for the light passenger car was used as 100 percent. Because of the difference in weight, the heavy passenger car pays a little less per pound than the light passenger car, although charged the same toll.

The pickup truck, which is charged the same toll as a passenger car on most facilities and has about the same gross weight as the heavy passenger car, pays a little less per pound of maximum gross weight than the light passenger car but a little more than the heavy passenger car. For vehicles heavier than the pickup the charge per unit of weight decreases as the maximum gross weight increases. The erratic behavior of both the mode and median after a weight of 56,000 lb. is reached may be caused by the small number of bridges and tunnels that can be used by the heavier vehicles. However, it is significant that both of the truck-trailer combinations apparently are charged a higher rate per pound than the heavy tractor-semitrailer combinations.

Ferries. The relation of ferry tolls per pound of maximum gross weight indicated in Table 16 and Figure 14 is quite different from that shown in Table 15 for bridge and tunnel tolls. The probable reasons for the bus and the 40,000-lb. truck differing from the general pattern set by the neighboring vehicles has been pointed out.

The most prominent differences between

TABLE 14
MEDIAN AND MODAL INDEXES OF ROAD TOLLS

Reference Number	Vehicle Type	Maximum Gross Weight: Amount	Maximum Gross Weight: Index of Passenger Car Weight	Index of Passenger Car Charge: Median	Index of Passenger Car Charge: Mode
		lb.	%	%	%
1	Passenger car	3,959	100.0	100.0	100.0
2	Passenger car	4,655	117.6	100.0	100.0
3	Pickup truck	4,700	118.7	100.0	100.0
4	Stake truck	12,500	315.7	163.6	158.8
5	Van truck	19,000	479.9	186.5	194.8
12	Bus, 41 passenger capacity	27,000	682.0	300.0	298.4
5A	Dump truck, 3-axle	35,000	884.1	397.9	402.7
6	Dump truck, 3-axle	40,000	1,010.4	397.9	402.7
7	2-S1 combination	40,000	1,010.4	402.5	402.7
8	2-S2 combination	50,000	1,262.9	417.1	551.0
9	2-S2 combination	50,000	1,262.9	417.1	551.0
9A	2-S2 combination	56,000	1,414.5	528.4	551.0
10A	2-2 combination	60,000	1,515.5	561.5	553.8
10	3-S2 combination	64,000	1,616.6	401.0	401.0
11	3-3 combination	72,000	1,818.6	699.2	701.0

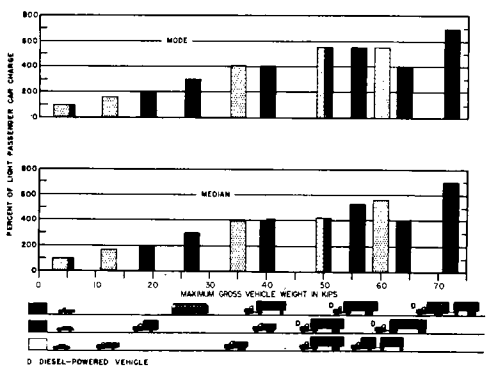

Figure 12. Median and modal indexes of road tolls.

this table and the preceding one are that the ferry charges per unit of weight do not decrease as rapidly or to as low a point as do the bridge and tunnel tolls and the charges for vehicles having a maximum gross weight of 40,000 lb. or more remain relatively stable

TABLE 15
MEDIAN AND MODAL INDEXES OF BRIDGE AND TUNNEL TOLLS PER UNIT OF MAXIMUM GROSS WEIGHT

Reference Number	Vehicle Type	Maximum Gross Weight	Index of Passenger Car Charge: Median	Index of Passenger Car Charge: Mode
		lb.	%	%
1	Passenger Car	3,959	100.0	100.0
2	Passenger Car	4,655	85.0	85.0
3	Pickup truck	4,700	92.1	90.0
4	Stake truck	12,500	53.7	55.0
5	Van truck	19,000	46.8	43.7
12	Bus, 41 passenger capacity	27,000	35.1	30.4
5A	Dump truck, 3-axle	35,000	31.4	29.8
6	Dump truck, 3-axle	40,000	19.0	15.6
7	2-S1 Combination	40,000	23.6	20.0
8	2-S2 Combination	50,000	24.6	24.4
9	2-S2 Combination	50,000	24.6	24.4
9A	2-S2 Combination	56,000	21.8	17.3
10A	2-2 Combination	60,000	31.6	28.6
10	3-S2 Combination	64,000	24.0	20.0
11	3-3 Combination	72,000	46.7	40.0

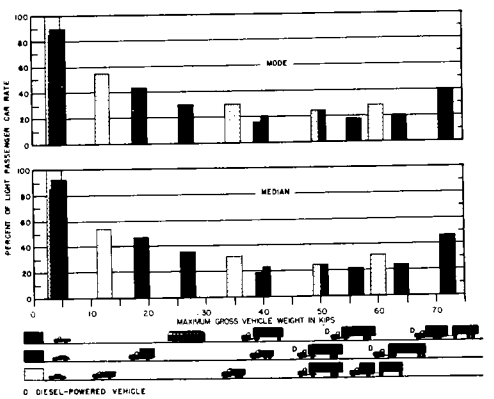

Figure 13. Median and modal indexes of bridge and tunnel tolls per unit of maximum gross weight.

road tolls per unit of maximum gross vehicle weight shown in Table 17 and Figure 15 follow a pattern similar to that of the bridge and tunnel toll indexes given in Table 15. In terms of toll per unit of maximum gross weight, the medium-weight passenger car and

TABLE 16
MEDIAN AND MODAL INDEXES OF FERRY TOLLS PER UNIT OF MAXIMUM GROSS WEIGHT

Reference Number	Vehicle Type	Maximum Gross Weight	Index of Passenger Car Charge: Median	Index of Passenger Car Charge: Mode
		lb.	%	%
1	Passenger Car	3,959	100.0	100.0
2	Passenger Car	4,655	85.0	85.0
3	Pickup truck	4,700	98.3	92.7
4	Stake truck	12,500	62.0	60.0
5	Van truck	19,000	48.0	60.0
12	Bus, 41 passenger capacity	27,000	90.0	102.0
5A	Dump truck, 3-axle	35,000	51.7	50.7
6	Dump truck, 3-axle	40,000	16.0	11.1
7	2-S1 Combination	40,000	90.0	103.3
8	2-S2 Combination	50,000	85.0	97.1
9	2-S2 Combination	50,000	85.0	97.1
9A	2-S2 Combination	56,000	88.6	100.0
10A	2-2 Combination	60,000	85.6	96.0
10	3-S2 Combination	64,000	91.4	100.0
11	3-3 Combination	72,000	91.4	100.0

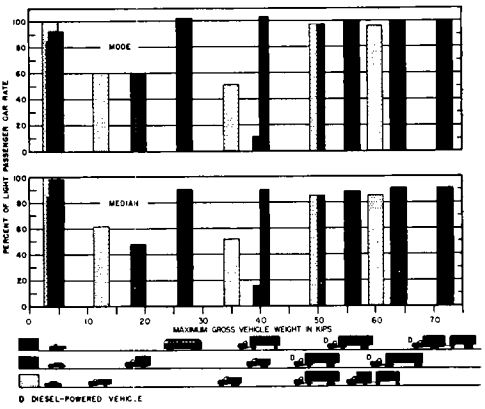

Figure 14. Median and modal indexes of ferry tolls per unit of maximum gross weight.

at about 85 to 100 percent of the passenger-car charge per pound. This is inherent in the toll schedules of a large number of ferries, as the schedules provide a fixed charge per pound of gross weight for all vehicles exceeding a certain weight, generally 35,000 to 40,000 lb.

Roads. The median and modal indexes of

the pickup truck are charged a little less than the light passenger car and heavier vehicles are charged progressively less. On the whole, it appears that the charges per pound of gross weight are a little higher for the heavier vehicles on roads than on bridges and tunnels.

Toll Charges per Unit of Average Gross Vehicle Weight

As vehicles do not always operate at the maximum gross vehicle weight, it is appropriate to compare the toll charges per unit of average gross vehicle weight. This is done in the three tables which follow.

TABLE 17
MEDIAN AND MODAL INDEXES OF ROAD TOLLS PER UNIT OF MAXIMUM GROSS WEIGHT

Vehicle			Index of Passenger Car Charge	
Reference Number	Type	Maximum Gross Weight	Median	Mode
		lb.	%	%
1	Passenger Car	3,959	100.0	100.0
2	Passenger Car	4,655	85.0	85.0
3	Pickup truck	4,700	87.4	90.2
4	Stake truck	12,500	54.6	52.9
5	Van truck	19,000	48.2	48.1
12	Bus, 41 passenger capacity	27,000	47.5	48.4
5A	Dump truck	35,000	45.8	46.8
6	Dump truck	40,000	35.5	37.9
7	2-S1 Combination	40,000	36.5	34.9
8	2-S2 Combination	50,000	48.9	43.9
9	2-S2 Combination	50,000	48.9	43.9
9A	2-S2 Combination	56,000	30.0	30.0
10A	2-2 Combination	60,000	36.5	32.5
10	3-S2 Combination	64,000	30.6	30.0
11	3-3 Combination	72,000	30.0	30.0

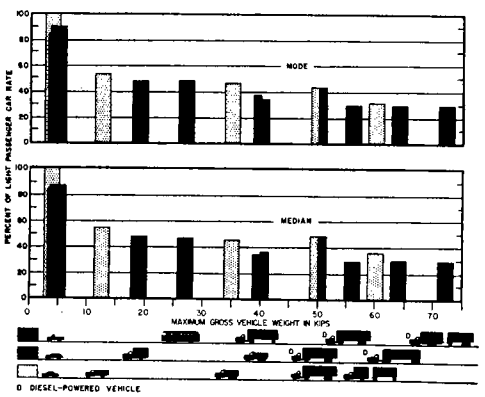

Figure 15. Median and modal indexes of road tolls per unit of maximum gross weight.

Bridges and Tunnels. Median and modal indexes of bridge and tunnel tolls per unit of average gross vehicle weight are given in Table 18 and Figure 16. These indexes do not differ greatly from those for maximum gross vehicle weight in Table 15, except that for the freight vehicles heavier than the pickup truck the charges per unit of average gross vehicle weight are greater in relation to the passenger-car charge than are the charges per unit of maximum gross weight. The indexes for the pickup truck and the bus, on the other hand, differ but little from those given in Table 15. This situation results from the circumstance that, as shown below, the load capacity of the pickup truck or the bus, like that of the passenger car, is much smaller in relation to the empty weight of the vehicle than is that of the heavier freight vehicles.

Vehicle	Empty Weight	Load Capacity	Maximum Gross Weight
Light passenger car	3,059	900	3,959
Pickup truck	3,220	1,480	4,700
Two-axle truck	8,625	10,375	19,000
Bus	19,650	7,350	27,000
2-S1 combination	16,145	23,855	40,000

Thus, the charges per unit of weight for the pickup truck and the passenger vehicles are affected much less by the amount of load carried than are those of the heavier trucks and combinations.

Ferries. Median and modal indexes of ferry tolls per unit of average gross weight are given for each of the 15 vehicles and vehicle combinations in Table 19 and Figure 17. This table, like the other tables dealing with ferry charges, indicates that many of the ferries graduate toll charges with vehicle type and size in such a manner that the charge per unit of gross weight remains relatively constant. As mentioned before, however, this is not a universal practice.

Roads. Median and modal indexes of toll-road charges per unit of average gross vehicle weight are given in Table 20 and Figure 18 for each of the 15 vehicles. The charge per pound of average gross weight decreases rather rapidly as the size of vehicle increases for single-unit vehicles having maximum gross weights up to about 27,000 lb. The charge per pound of average gross weight for the 27,000-lb. bus, the 35,000-lb. dump truck, and the 40,000-lb. dump truck is about 45 percent of the passenger-car charge. For the vehicle combinations, all of which have maximum gross combination weight of 40,000 lb. or more, the charge per unit of average gross weight remains relatively stable at about 45 to 50

TABLE 18
MEDIAN AND MODAL INDEXES OF BRIDGE AND TUNNEL TOLLS PER UNIT OF AVERAGE GROSS WEIGHT

Vehicle				Index of Passenger Car Charge	
Reference Number	Type	Maximum Gross Weight	Average Gross Weight	Median	Mode
		lb.	*lb.*	%	%
1	Passenger Car	3,959	3,359	100.0	100.0
2	Passenger Car	4,655	4,055	82.8	82.8
3	Pickup truck	4,700	3,600	93.6	89.8
3	Stake truck	12,500	7,000	74.7	70.3
5	Van truck	19,000	12,500	48.6	37.6
12	Bus, 41 passenger capacity	27,000	23,000	36.4	30.1
5A	Dump truck, 3-axle	35,000	26,000	34.9	30.5
6	Dump truck, 3-axle	40,000	29,000	33.6	29.8
7	2-S1 Combination	40,000	27,000	36.0	31.2
8	2-S2 Combination	50,000	32,000	33.5	30.5
9	2-S2 Combination	50,000	33,000	33.0	30.3
9A	2-S2 Combination	56,000	37,000	29.3	28.2
10A	2-2 Combination	60,000	39,000	38.5	31.1
10	3-S2 Combination	64,000	44,000	40.0	32.0
11	3-3 Combination	72,000	50,000	50.0	26.0

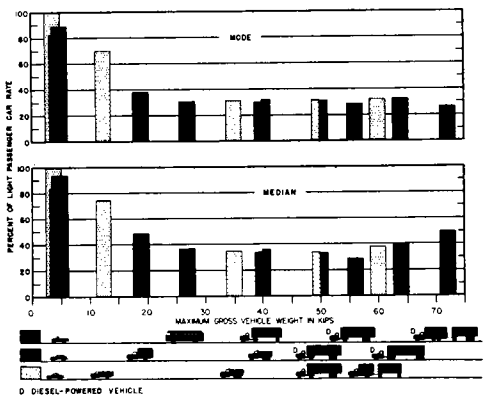

Figure 16. Median and modal indexes of bridge and tunnel tolls per unit of average gross weight.

percent of the passenger-car charge per unit of average gross weight. A notable exception is the 3-S2 combination which, as mentioned before, is excluded from all except one of the toll roads.

Toll Charges Per Unit of Maximum Axle Load

For roads, axle loads are the principal consideration, but not the only consideration, in determining the structural requirements and, therefore, the costs of pavements. "The axle load of vehicles is the principal determinant of the supporting capacity that must be provided in the surfaces and foundations of roads" (*6*). Bridges, on the other hand, are affected not only by the axle load of a vehicle

TABLE 19
MEDIAN AND MODAL INDEXES OF FERRY TOLLS PER UNIT OF AVERAGE GROSS WEIGHT

Vehicle				Index of Passenger Car Charge	
Reference Number	Type	Maximum Gross Weight	Average Gross Weight	Median	Mode
		lb.	*lb.*	%	%
1	Passenger Car	3,959	3,359	100.0	100.0
2	Passenger Car	4,655	4,055	82.8	82.8
3	Pickup truck	4,700	3,600	111.4	Bimodal
4	Stake truck	12,500	7,000	100.0	51.3
5	Van truck	19,000	12,500	71.4	85.0
12	Bus, 41 passenger capacity	27,000	23,000	84.0	Bimodal
5A	Dump truck, 3-axle	35,000	26,000	65.7	85.0
6	Dump truck, 3-axle	40,000	29,000	16.6	12.0
7	2-S1 Combination	40,000	27,000	70.0	89.3
8	2-S2 Combination	50,000	32,000	70.0	Bimodal
9	2-S2 Combination	50,000	33,000	72.0	88.3
9A	2-S2 Combination	56,000	37,000	80.0	90.0
10A	2-2 Combination	60,000	39,000	82.0	88.7
10	3-S2 Combination	64,000	44,000	84.0	90.9
11	3-3 Combination	72,000	50,000	84.0	89.3

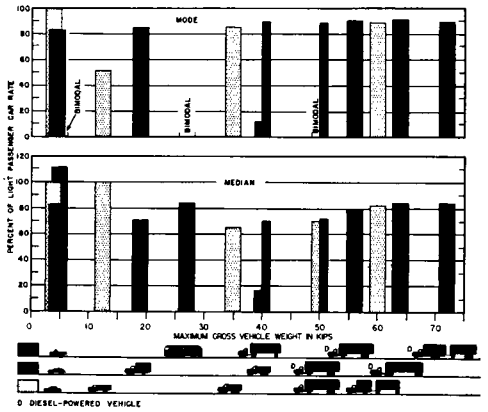

Figure 17. Median and modal indexes of ferry tolls per unit of average gross weight.

loads at or near that of the heaviest axle. As in the preceding tables dealing with indexes, the value for the light passenger car is taken as 100.

Bridges and Tunnels. The median and modal indexes of bridge and tunnel tolls per unit of load on the heaviest axle for each of the 15 vehicles are given in Table 21 and Figure 19. The apparent deviation of the five-axle, tractor-semitrailer combination and the six-axle, truck-trailer combination from the pattern established by the other vehicles deserves special mention. Although these are the two heaviest vehicle combinations used in the study, they impose axle loads lighter than those imposed by any of the other combinations and no heavier than the 14,000-lb. axle

TABLE 20
MEDIAN AND MODAL INDEXES OF ROAD TOLLS PER UNIT OF AVERAGE GROSS WEIGHT

Vehicle				Index of Passenger Car Charge	
Reference Number	Type	Maximum Gross Weight	Average Gross Weight	Median	Mode
		lb.	*lb.*	*%*	*%*
1	Passenger Car	3,959	3,359	100.0	100.0
2	Passenger Car	4,655	4,055	82.8	82.8
3	Pickup truck	4,700	3,600	89.9	90.1
4	Stake truck	12,500	7,000	78.2	85.0
5	Van truck	19,000	12,500	63.6	73.3
12	Bus, 41 passenger capacity	27,000	23,000	47.5	42.1
5A	Dump truck, 3-axle	35,000	26,000	41.7	46.8
6	Dump truck, 3-axle	40,000	29,000	45.6	47.3
7	2-S1 Combination	40,000	27,000	50.4	50.6
8	2-S2 Combination	50,000	32,000	44.5	45.9
9	2-S2 Combination	50,000	33,000	44.5	45.9
9A	2-S2 Combination	56,000	37,000	45.8	47.2
10A	2-2 Combination	60,000	39,000	48.6	48.3
10	3-S2 Combination	64,000	44,000	30.5	30.0
11	3-3 Combination	72,000	50,000	49.9	49.6

but also by the load on any group of axles and by the total weight of the vehicle. For ferries, the axle load imposed by a vehicle is probably of less importance than either the space occupied or the gross weight of the vehicle.

In spite of the tenuous or nonexistent relation between the axle loads imposed by a vehicle and the bridge or ferry costs occasioned by the vehicle, the following series of tables compare the toll charges per unit of weight on the heaviest axle for the 15 vehicles studied. The axle loads used for each vehicle are those imposed by the heaviest axle when the vehicle or combination is loaded to its maximum gross weight. These tables do not take into account the number of axles having

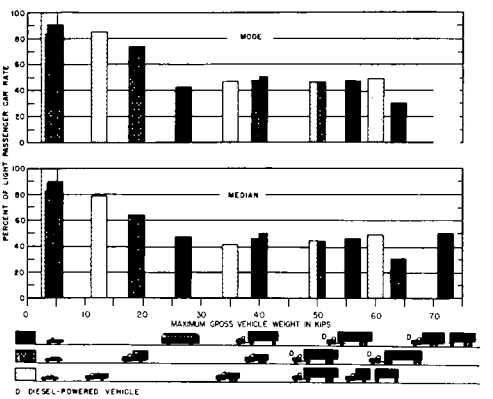

Figure 18. Median and modal indexes of road tolls per unit of average gross weight.

TABLE 21
MEDIAN AND MODAL INDEXES OF BRIDGE AND TUNNEL TOLLS PER UNIT OF MAXIMUM AXLE LOAD

Vehicle				Index of Passenger Car Charge	
Reference Number	Type	Maximum Gross Weight	Maximum Axle Load	Median	Mode
		lb.	*lb.*	%	%
1	Passenger Car	3,959	2,000	100.0	100.0
2	Passenger Car	4,655	2,340	85.4	85.4
3	Pickup truck	4,700	2,800	72.8	68.6
4	Stake truck	12,500	9,500	37.1	33.9
5	Van truck	19,000	14,000	29.2	28.4
12	Bus, 41 passenger capacity	27,000	18,000	31.6	30.2
5A	Dump truck, 3-axle	35,000	13,500	35.2	31.4
6	Dump truck, 3-axle	40,000	16,000	30.4	29.6
7	2-S1 Combination	40,000	17,500	30.8	31.2
8	2-S2 Combination	50,000	18,000	36.2	30.6
9	2-S2 Combination	50,000	18,000	36.2	30.6
9A	2-S2 Combination	56,000	18,000	33.3	30.6
10A	2-2 Combination	60,000	18,000	27.5	34.4
10	3-S2 Combination	64,000	14,000	80.0	35.0
11	3-3 Combination	72,000	14,000	86.6	90.0

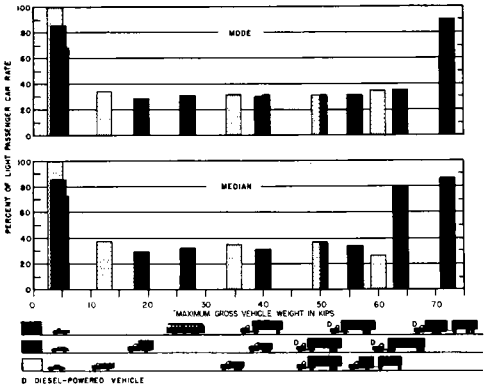

Figure 19. Median and modal indexes of bridge and tunnel tolls per unit of maximum axle load.

load imposed by the 19,000-lb. single-unit truck. However, the tractor-semitrailer combination has four axles at 14,000 lb., while the truck-trailer combination has two axles at 14,000 lb. and three axles at 12,000 lb.

The bus, which has only one axle with a load of 18,000 lb., is charged about 30 percent of the passenger-car charge per unit of weight on the heaviest axle, while the 2-S1 combination, which has two 17,500-lb. axles, and the 2-2 combination, which has three axles at 18,000 lb., are also charged about 30 percent of the passenger-car charge per pound of maximum axle load.

Ferries. Table 22 and Figure 20, which show the median and modal indexes of ferry tolls

TABLE 22
MEDIAN AND MODAL INDEXES OF FERRY TOLLS PER UNIT OF MAXIMUM AXLE LOAD

Vehicle				Index of Passenger Car Charge	
Reference Number	Type	Maximum Gross Weight	Maximum Axle Load	Median	Mode
		lb.	*lb.*	%	%
1	Passenger Car	3,959	2,000	100.0	100.0
2	Passenger Car	4,655	2,340	85.4	85.4
3	Pickup truck	4,700	2,800	78.6	73.3
4	Stake truck	12,500	9,500	41.5	36.8
5	Van truck	19,000	14,000	42.5	44.8
12	Bus, 41 passenger capacity	27,000	18,000	65.4	64.0
5A	Dump truck, 3-axle	35,000	13,500	73.3	65.0
6	Dump truck, 3-axle	40,000	16,000	26.6	16.0
7	2-S1 Combination	40,000	17,500	72.5	68.7
8	2-S2 Combination	50,000	18,000	100.0	151.4
9	2-S2 Combination	50,000	18,000	100.0	151.4
9A	2-S2 Combination	56,000	18,000	145.9	155.5
10A	2-2 Combination	60,000	18,000	165.0	185.7
10	3-S2 Combination	64,000	14,000	210.0	245.0
11	3-3 Combination	72,000	14,000	244.0	246.7

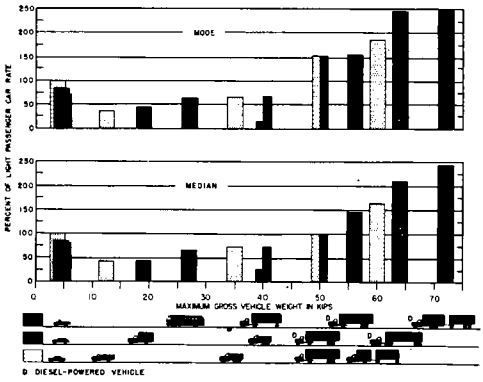

Figure 20. Median and modal indexes of ferry tolls per unit of maximum axle load.

load. The 2-S1 combination with two axles at 17,500 lb. and the 2-2 combination with 3 axles at 18,000 lb. are charged, respectively, about 50 percent and 60 percent of the passenger-car charge per unit of weight on the heaviest axle.

CONCLUSION

In this paper we have inquired briefly into the variation of toll charges with type and size of vehicles. There is infinite variety in the methods of assessing toll charges, the levels of toll charges, and the graduation of toll charges with vehicle type and size. This variety impedes precise measurement of the relation

TABLE 23
MEDIAN AND MODAL INDEXES OF ROAD TOLLS PER UNIT OF MAXIMUM AXLE LOAD

Reference Number	Vehicle Type	Maximum Gross Weight	Maximum Axle Load	Index of Passenger Car Charge: Median	Index of Passenger Car Charge: Mode
		lb.	*lb.*	%	%
1	Passenger Car	3,959	2,000	100.0	100.0
2	Passenger Car	4,655	2,340	85.4	85.4
3	Pickup truck	4,700	2,800	68.6	68.7
4	Stake truck	12,500	9,500	34.4	32.9
5	Van truck	19,000	14,000	33.9	31.5
12	Bus, 41 passenger capacity	27,000	18,000	35.1	35.3
5A	Dump truck, 3-axle	35,000	13,500	52.8	63.1
6	Dump truck, 3-axle	40,000	16,000	49.1	47.6
7	2-S1 Combination	40,000	17,500	47.5	48.3
8	2-S2 Combination	50,000	18,000	45.5	45.8
9	2-S2 Combination	50,000	18,000	45.5	45.8
9A	2-S2 Combination	56,000	18,000	49.5	49.8
10A	2-2 Combination	60,000	18,000	59.5	Bimodal
10	3-S2 Combination	64,000	14,000	50.0	50.0
11	3-3 Combination	72,000	14,000	89.3	98.6

per unit of load on the heaviest axle for each of the 15 vehicles, are similar to the other tables and figures dealing with indexes of ferry tolls per unit of weight. For the smaller vehicles, the indexes of unit charge decrease as the weight and axle loads increase; but for vehicles having a gross weight of more than 12,500 lb., the indexes increase with the vehicle weight.

Roads. Median and modal indexes of toll-road charges per unit of maximum axle load are given for the 15 vehicles in Table 23 and Figure 21. The bus, with a maximum gross vehicle weight of 27,000 lb. and one 18,000-lb. axle, is charged about 35 percent of the passenger-car charge per unit of maximum axle

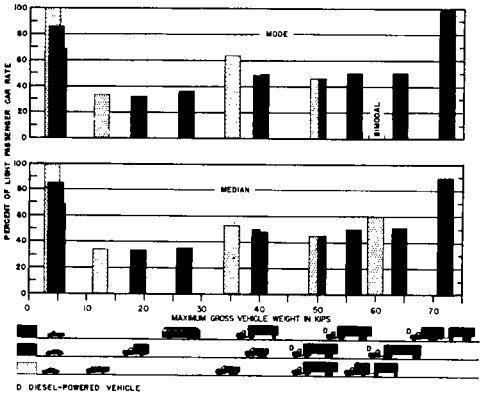

Figure 21. Median and modal indexes of road tolls per unit of maximum axle load.

between the toll charged and the size of vehicle.

However, patterns of toll charges are discernible, and these patterns are not the same for all of the three major types of facilities. Toll roads graduate toll charges a little more severely with the size of vehicle than do bridges and tunnels, but even on toll roads the heaviest vehicles and combinations are charged only about a third as much per unit of maximum gross weight as are passenger cars. It is only on ferries that the larger vehicles are charged almost as much per pound of maximum gross weight as passenger cars are charged.

This study has not inquired directly into the relation between the toll charged a vehicle and either the costs occasioned by it or the benefits conferred on it. In the case of toll roads, however, it can be accepted that the toll charges are not greater than the benefits received. Otherwise, the toll roads would not be used in preference to toll-free roads. For commercial vehicles, it can be assumed that the toll charges are less than the additional monetary cost incurred by using inferior toll-free roads. The relation of passenger-car tolls to measurable monetary benefits is less direct because of the value placed by passenger-car operators on time savings, relief from driving discomforts, the pleasure of travel unimpeded by slow-moving vehicles or urban congestion, and other factors not subject to exact monetary evaluation. Even so, it appears that toll-road charges can be accepted as at least indicative of the relative payments the owners and operators of various types and sizes of vehicles are willing to make.

If this general concept be accepted, then the indication of the data produced by this study is that the benefit (or value of use) derived from a highway facility by vehicles of different sizes is not, as is often claimed, directly proportional to gross weight but, rather, increases at rates distinctly less than proportional to gross weight. If, on the other hand, it is insisted that the value of use per mile of travel is directly proportional to gross weight, the conclusion becomes inescapable that passenger-car users are currently suffering grevious discrimination on highway toll facilities.

Although a study designed to determine the relationships that exist between toll charges imposed and costs occasioned or benefits gained by the vehicles that use the toll facilities would involve many complex and difficult analyses, it is believed that such a study would have great value. The investigations reported in this paper provide a starting point, and it is hoped that they can be broadened to produce something significant regarding the relation between toll charges and costs or benefits.

ACKNOWLEDGMENTS

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