Impact of Toll Changes on Traffic and Revenue for Bridge and Tunnel Facilities

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Traffic and toll data for six facilities of varied utilization, geographic location, and toll structures were analyzed to reveal toll-related traffic loss. Consideration of monthly and cumulative traffic trends for comparable periods before and after toll changes determined the net percentage impact on traffic of each price increase. Computation of this traffic loss in terms of each 1 percent increase in toll, averaged for the six facilities, yielded a shrinkage ratio for river-crossing facilities—0.17 percent traffic loss for each 1 percent increase in average toll. Forecasts were made for a series of future average tolls, incorporating revenue increases which allow for the 0.17 percent loss ratio. Altogether, revenue productivity was shown to range from about 65 to 87 percent of the percentage increase in tolls. Separate determinations were made for facilities competing with parallel, low-toll crossings and for truck and tractor trailer traffic.

Toll decreases generally resulted in some additional patronage, but the traffic increase has not been nearly enough to offset the reduction in tolls, with a consequent loss in toll revenue.

•THIS study was conducted to forecast the potential revenue gain from several alternate toll structures, each of which represents an increase over the existing toll levels. Such a forecast involves several areas of inquiry, the first being the collection and analysis of data concerning past experience with toll changes on river crossings in several areas of the United States.

Analysis of past experience reveals the degree to which the utilization of cross-river facilities has been affected by toll change, both for passenger cars and for truck traffic. The succeeding sections describe the methodology applied in this analysis and discuss the impact of toll changes on passenger car and truck traffic.

METHODOLOGY

To assess the effect of any price change, it is necessary, insofar as possible, to eliminate the impact of other factors bearing on the use of the product, service, or facility involved. These other factors include both long- and short-term influences.

If there is a discernible trend increase or decrease in the use of a facility, the trend existing at the time of a price change must be taken into account if one is to isolate the impact of the price change itself. Thus, if an attempt were made to measure the result of a toll increase on a facility where there had been a pronounced growth trend prior to the toll change—a trend that was accelerating—consideration of annual data for a period of years before and after the toll change might well lead to the conclusion that the price increase had little or no effect on patronage. The impact, if any, would appear to be swallowed up in the continuing growth of the facility. Conversely, if there has been an accelerating downtrend, consideration of annual periods before and after a toll change would result in seriously overstating the impact of the toll increase on traffic.

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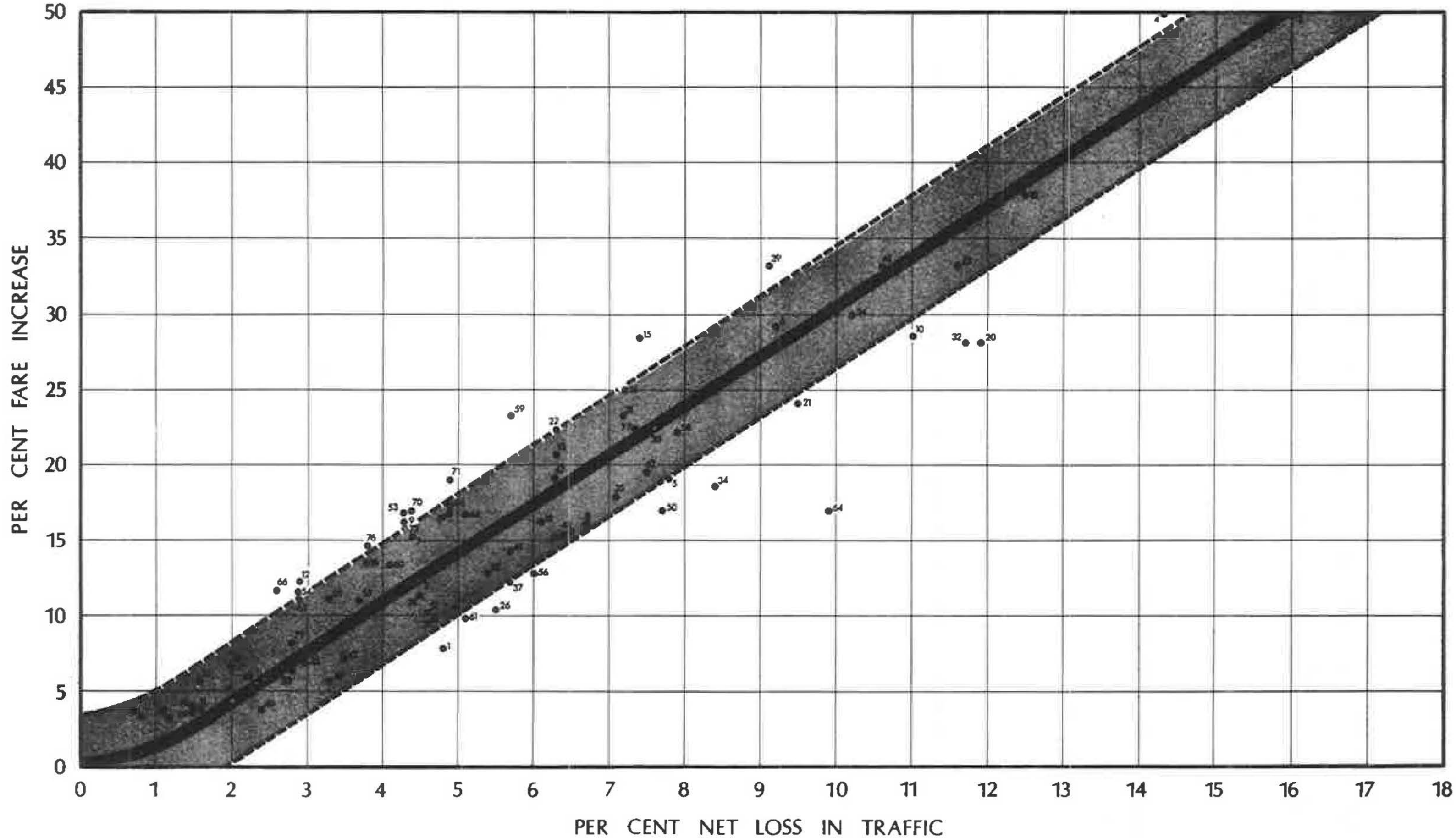

Figure 1. Shrinkage in passenger traffic due to fare increase.

Thus, it was decided that the period for analysis should be confined to no more than one year before and one year after the toll change being studied. Principal attention was directed to the experience three to six months before and after each toll increase, which was considered to be sufficiently close to the increase to eliminate, or at least to minimize, the effect on traffic of changes either in the basic trend of patronage or in economic conditions in the area.

The method employed must also eliminate distortion due to seasonal variations. For this reason, the comparisons made in this study related the traffic and revenue for the same months in succeeding years. Thus the monthly trend before and after each toll change was measured against the corresponding months one year earlier.

THE SIMPSON AND CURTIN FORMULA

For more than 20 years, Simpson and Curtin has conducted continuing studies of the impact of fare changes on patronage throughout the transit industry. In analyzing transit fare changes, it has been our practice to examine the trend of traffic for a period immediately prior to the fare change, usually three months, in relation to the same period of the preceding year. We then determine the traffic trend for a corresponding period following the fare change in relation to the same months of the prior year. Figure 1 shows a study on some 79 fare increases on transit systems throughout the United States. Each of the plotted points represents a particular fare change, relating the percent increase in fare to the percent net loss in patronage resulting from that fare increase. We then determined the overall trend line. The formula expressed by this line is that there will be a loss of 0.33 percent in traffic for each 1.0 percent increase in fare. For example, a 25 percent fare increase would result in a loss of 8.25 percent in traffic.

The traffic loss ratio of one-third of one percent for each one percent increase in fare has become known as the "Simpson and Curtin formula." It has been widely accepted in the industry and is applied by many governmental regulatory agencies dealing with transit fare changes.

Figure 2, based on data from Figure 1, depicts the formula as it pertains to revenue yield, showing the percent increase in passenger revenue resulting from various amounts of fare increase. The solid black line and the parallel dash lines correspond to the lines in Figure 1. In the range of most fare increases, i.e., between 15 and 30 percent, the increase in passenger revenue is generally between 55 and 60 percent of the percent increase in fare. In other words, by reason of shrinkage in traffic because of passenger resistance to the fare increase and aside from traffic changes from economic or other causes, a 20 percent fare increase produces about 12 percent more passenger revenue, while a 30 percent fare increase produces about 17 percent more passenger revenue.

PASSENGER CAR TOLL INCREASES

Analysis of the before and after experience in a number of instances on bridge and tunnel facilities indicates that passenger car and, to a lesser extent, truck traffic are affected by a change in toll levels. In order to determine what has actually taken place when toll changes were inaugurated, requests for detailed information were sent to the agencies administering a number of bridge or tunnel facilities on which toll changes had been made. To permit the type of examination required it was necessary to obtain monthly data by class of vehicle for a period of at least three years in each instance. Adequate detail was obtained to make possible full analysis of toll changes on six facilities.

The passenger car toll increases that were studied in depth are given in Table 1. The first was the 25 percent increase in cash and commutation rates effective June 1953 on the Benjamin Franklin Bridge between Philadelphia and Camden. Table 1 also includes toll increases on the Delaware Memorial Bridge as well as on facilities in Nebraska, Michigan, Massachusetts, and Virginia. The increases in average tolls ranged from about 15 to nearly 87 percent.

TABLE 1

IMPACT OF TOLL INCREASES ON PASSENGER CAR TRAFFIC AND REVENUE

Facility	Toll Structure Before Increase				Effective Date of Increase	Toll Structure After Increase				Toll Increase (%)			Net Loss in Traffic (%)	Net Traffic Loss for Each 1% Increase in Toll (%)[a]
	Cash	Commutation		Average Toll		Cash	Commutation		Average Toll	Cash	Commutation Unit Rate	Average Toll		
		Package	Unit Rate				Package	Unit Rate						
Benjamin Franklin Bridge	$0.20	40 for $6.00	$0.15	$0.195	6/20/53	$0.25	40 for $7.50	$0.1875	$0.2436	25.0	25.0	24.9	3.4	0.14
Percent of traffic	89.96		10.04	100.00		89.76		10.24	100.00					
Delaware Memorial Bridge	$0.25	50 for $5.00	$0.10	$0.2359	7/1/63	$0.50	50 for $5.00	$0.10	$0.4409	100.0	None	86.9	6.1	0.07
Percent of traffic	89.95		9.11	100.00		84.20		11.72	100.00					
		10 for $2.00	$0.20 0.94%				20 for $4.00	$0.20 4.08%						
Leavenworth Centennial Bridge	$0.15	None	—	$0.1500	11/1/57	$0.25	15 for $2.25	$0.15	$0.2058	66.7	—	37.20	5.0	0.13
Percent of traffic	100.00			100.00		55.81		44.19	100.00					
Mackinac Bridge	3.25	None	—	$3.25	1/1/61	$3.50	None	—	$3.50	14.7	—	14.7	2.0	0.14
					5/1/61	$3.75	None	—	$3.75		(1961 over 1960)			
Mystic River Bridge	$0.15	—	$0.10	$0.1117	1/1/53	$0.25	—	$0.15	$0.1710	66.7	50.0	53.1	12.0	0.23
Percent of traffic	20.83		79.17	100.00		18.11		81.89	100.00					
Norfolk Elizabeth River Tunnel	$0.30	None	—	$0.3000	4/1/60	$0.40	None	—	$0.4000	33.3	—	33.3	9.5	0.29

[a]Average net traffic loss for each 1 percent toll increase was 0.17 percent.

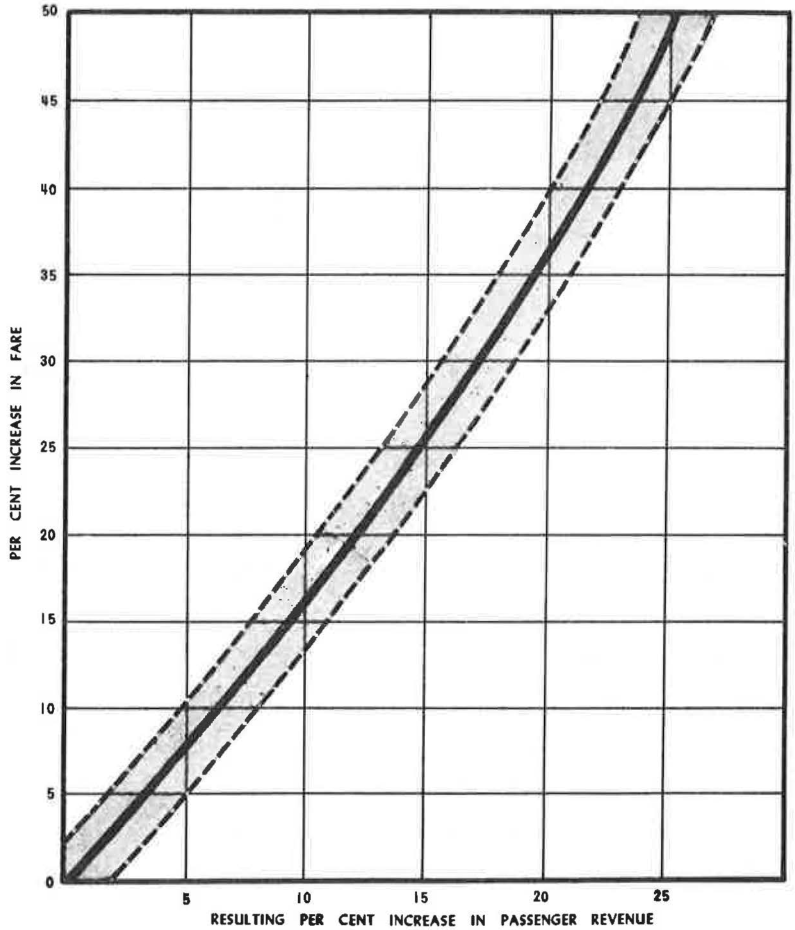

Figure 2. Percent increase in passenger revenue resulting from various amounts of fare increase.

Individual analyses of these toll changes and their impact were compiled as Appendixes A-1 through A-6.* Each briefly describes the facility, the toll structure before and after the change, and the monthly trend of traffic before the increase—for both individual months and cumulatively—computed for periods of one to 12 months, beginning with the month immediately preceding the increase and accumulating in reverse from that point. The next step in the analysis was a corresponding examination of the monthly trend after the toll increase, together with a calculation of the cumulative post-change trend. The before and after percentage trends were then compared for varying periods. Finally, the conclusions reached from the analysis were presented in each instance, culminating in a numerical expression of the percent net loss in traffic and the increase in revenues attributed specifically to the toll change.

*Appendixes are not presented here but are available at cost of reproduction and handling from the Highway Research Board. When ordering, refer to XS-21, Highway Research Record 252.

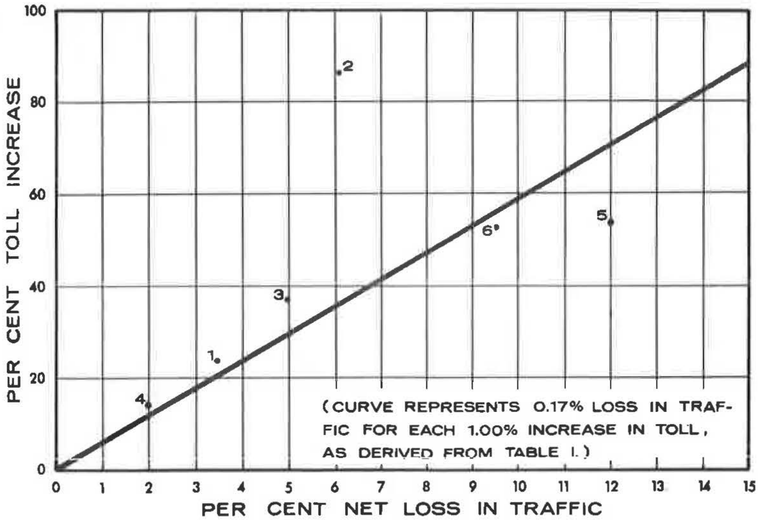

Figure 3. Shrinkage in passenger car traffic due to toll increases on bridge and tunnel facilities.

IMPACT OF PASSENGER CAR TOLL INCREASES ON TRAFFIC AND REVENUE

A summary of the findings resulting from the individual analyses of traffic is shown in Figure 3. In Table 1, the average tolls and percent toll increases are indicated, and the percent net loss in traffic resulting from each toll increase is given. The relationship of the traffic loss to the toll increase was computed in terms of the percent net traffic loss for each one percent increase in toll. These traffic shrinkage ratios may be compared with the Simpson and Curtin formula used in forecasting the effect of transit fare increases.

As noted earlier, the transit formula indicates a passenger loss of 0.33 percent for each 1 percent increase in fares. The impact of toll increases on bridge and tunnel traffic is considerably less than the normal impact on patronage of transit fare changes. The average shrinkage ratio among the six facilities in Table 1 is shown to be 0.17 percent for each 1 percent increase in average toll.

The impact of bridge or tunnel toll increases on passenger car traffic is only about one-half as large as the drop in business resulting from a transit fare rise. Primarily because fewer acceptable alternatives are available, toll bridges are much less vulnerable to loss in patronage resulting from price increases than are local transit systems.

Available data indicate that each increase in bridge or tunnel tolls has a discernible effect on the trend of passenger car utilization of the facility. The result in each instance has been an increase in revenue which was something less than the percentage rise in the average toll.

The revenue results of the toll increases are given in Table 2. In four of the six instances, the revenue gain was in the range of 82 to 87 percent of the increase in average toll. In the other two instances, the revenue productivity was approximately two-thirds of the potential. In these six instances, the revenue gain ranged from 65 to 87 percent of the increase in revenue which would have been realized had there been no decline in patronage as a result of the higher toll.

APPLICATION OF FORMULA TO PASSENGER CAR TOLL STRUCTURE

Table 3 and Figure 4 illustrate the application of the shrinkage ratio and revenue productivity factors developed above. These hypothetical projections are based on an average present toll level of $0.24 for passenger cars on a cross-river facility.

TABLE 2

REVENUE PRODUCTIVITY OF TOLL INCREASES
(Passenger Car Toll Increases on Bridge and Tunnel Facilities)

Facility	Increase in Toll (¢)	Increase in Revenue (¢)[a]	Revenue Productivity: Percent of Potential Revenue Gain Realized
Benjamin Franklin Bridge	24.9	20.7	83
Delaware Memorial Bridge	86.9	75.5	87
Leavenworth Centennial Bridge	37.2	30.3	82
Mackinac Bridge	14.7	12.4	84
Mystic River Bridge	53.1	34.7	65
Norfolk Elizabeth River Tunnel	33.3	22.0	66

[a]Revenue increase realized after allowing for impact of toll change on traffic.

Table 3 gives the patronage and revenue effect of toll structures that would produce average tolls ranging from $0.25 to $0.45, listed by $0.01 increments. For example, a new toll structure yielding a $0.30 average rate, 25 percent above the present average toll, would result in a traffic decline of 4.3 percent. The resulting increase in revenue is estimated at 19.6 percent.

The revenue productivity, or the revenue increase expressed as a percentage of the increase in average toll in each instance, is given in Table 2. Using the 0.17 percent shrinkage ratio (Table 1), it is estimated that the productivity of a $0.01 increase in average toll above the present $0.24 level would be 83 percent. The revenue productivity progressively declines as higher toll structures are considered. At a $0.30 average toll, the productivity is estimated at 78.5 percent of the potential, declining to slightly over 75 percent at a $0.35 average toll, and to about 68 percent at a $0.45 average toll.

Figure 4 shows the relationship between toll increase and percent gain in revenues from the present $0.24 average toll level, based on a 0.17 percent loss ratio.

TABLE 3

NET TRAFFIC LOSS AND REVENUE PRODUCTIVITY FOR PASSENGER CARS
(On Basis of a Loss Ratio of 0.17 Percent)

Average Toll Under Future Toll Plan (cents)	Increase in Average Toll Above Percent Level of 24 Cents (¢)	Net Loss in Traffic Resulting From Toll Increase (¢)	Increase in Revenue (¢)	Revenue Increase as Percent of Toll Increase
25	4.2	0.7	3.5	83.0
26	8.3	1.4	6.8	82.0
27	12.5	2.1	10.1	81.0
28	16.7	2.8	13.4	80.5
29	20.8	3.5	16.6	79.8
30	25.0	4.3	19.6	78.5
31	29.2	5.0	22.7	77.9
32	33.3	5.7	25.8	77.3
33	37.5	6.4	28.7	76.6
34	41.7	7.1	31.6	75.9
35	45.8	7.8	34.5	75.2
36	50.0	8.5	37.3	74.5
37	54.2	9.2	40.0	73.8
38	58.3	9.9	42.7	73.1
39	62.5	10.6	45.3	72.5
40	66.7	11.3	47.8	71.8
41	70.8	12.0	50.3	71.1
42	75.0	12.8	52.6	70.1
43	79.2	13.5	55.0	69.5
44	83.3	14.2	57.3	68.8
45	87.5	14.9	59.6	68.1

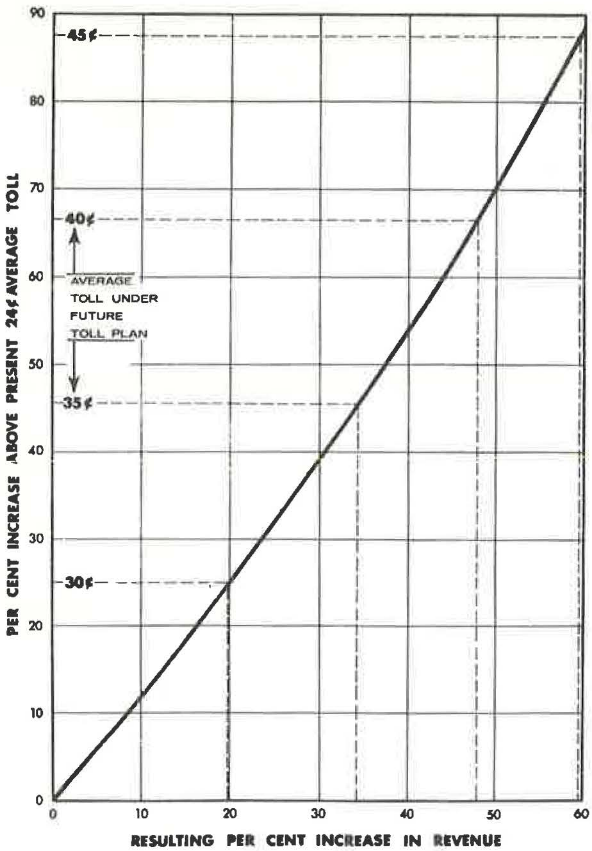

Figure 4. Percent increase in passenger car toll revenues resulting from various amounts of toll increase.

TOLL IMPACT ON FACILITY VULNERABLE TO COMPETITION

Special consideration has been given to the impact on traffic of a toll change on a cross-river facility running parallel to a bridge or tunnel having a much lower toll structure. Widening the toll differential by increasing the already higher tolls on the former can be expected to have a greater impact on traffic than the standard previously established. As a result, it is necessary to use a larger resistance factor in predicting the impact of a toll increase.

A reasonable factor to apply to a facility vulnerable to competition from a bridge or tunnel with a lower average toll level is 0.22 percent for each 1 percent increase in average toll, as opposed to a factor of 0.17 percent on other facilities. While this difference is necessarily a matter of judgment, it should be pointed out that the data in Table 1 (and presented elsewhere in Appendix A-5) lend support to this figure. The Mystic River Bridge in Boston experienced a resistance loss of 0.23 percent from the toll increase analyzed in this study, compared to an average shrinkage ratio of 0.17 percent for all of the experiences examined. The Mystic River Bridge is subject to competition both from the tunnels downstream and from the free bridges upstream from the Mystic River facility. The availability of alternative facilities in this instance resulted in a higher-than-average resistance to the toll increase.

TOLL INCREASES FOR TRUCKS AND TRACTOR-TRAILER COMBINATIONS

Information was obtained and analyzed with respect to truck toll changes on the same six facilities that were dealt with for passenger cars in the preceding section. The toll increases for trucks on these facilities (Table 4) ranged from slightly less than 10 percent on the Mackinac Bridge in Michigan to nearly 60 percent on the Leavenworth Centennial Bridge in Kansas. Table 4 gives the average toll before and after the change, as well as the percent increase in the average truck toll.

Experience indicates that the impact of toll increases on traffic is less for trucks than for passenger cars. In three of the six instances studied, there was no discernible loss of traffic by reason of truck toll increases ranging from approximately 10 to more than 23 percent (Table 4). In the three other instances examined, the net traffic loss for each 1 percent increase in toll ranged from 0.12 to 0.37 percent. The average net traffic loss for each 1 percent rise in toll was 0.13 percent.

In terms of revenue productivity, three of the six instances of truck toll increases resulted in 100 percent productivity—there was no reduction in traffic by reason of the toll increase (Table 5). In the other three instances, revenue productivity ranged from 51 to 81 percent. For the six facilities together, the average revenue productivity was 84 percent.

TABLE 4

IMPACT OF TOLL INCREASES ON TRUCK TRAFFIC

Facility	Average Toll		Toll Increase (%)	Net Loss in Traffic (%)	Net Traffic Loss for Each 1% Increase in Toll (%)[a]
	Before Increase	After Increase			
Benjamin Franklin Bridge	$0.679	$0.817	20.3	5.3	0.26
Delaware Memorial Bridge	1.051	1.296	23.3	None	None
Leavenworth Centennial Bridge	0.276	0.4390	59.1	6.9	0.12
Mackinac Bridge	7.46	8.19	9.8	None	None
Mystic River Bridge	0.297	0.341	14.8	None	None
Norfolk Elizabeth River Tunnel	0.316	0.421	33.3	12.2	0.37

[a]Average net traffic loss for each 1 percent increase was 0.13 percent.

TABLE 5

REVENUE PRODUCTIVITY OF TOLL INCREASES FOR TRUCKS

Facility	Increase in Toll (%)	Increase in Revenue (%)	Revenue Productivity: Percent of Potential Revenue Gain Realized
Benjamin Franklin Bridge	20.3	13.9	69
Delaware Memorial Bridge	23.3	23.3	100
Leavenworth Centennial Bridge	59.1	48.1	81
Mackinac Bridge	9.8	9.8	100
Mystic River Bridge	14.8	14.8	100
Norfolk Elizabeth River Tunnel	33.3	17.1	51

TABLE 6

NET TRAFFIC LOSS AND REVENUE PRODUCTIVITY FOR TRUCKS

Average Toll Under Future Toll Plan	Increase in Average Toll Above Present Level of $1.14 (%)	Net Loss in Traffic Resulting From Toll Increase (%)	Increase in Revenue (%)	Revenue Increase as Percent of Toll Increase
$1.20	5.26	0.68	4.54	86.3
1.25	9.65	1.25	8.28	85.8
1.30	14.04	1.83	11.95	85.1
1.35	18.42	2.39	15.59	84.6
1.40	22.81	2.97	19.16	84.0
1.45	27.19	3.53	22.70	83.5
1.50	31.58	4.11	26.18	82.9

Application of Formula to Truck Toll Structures

To illustrate the traffic and revenue resulting from application of a 0.13 percent loss ratio when truck toll levels are increased, a table was prepared presenting a series of hypothetical toll structures. Table 6 lists average truck tolls ranging from $1.20 to $1.50 in relation to an assumed present average of $1.14. Under a future plan that would raise the average toll from $1.14 to $1.25, an increase of 9.65 percent, the resulting net loss in traffic was estimated at 1.25 percent and the increase in revenue was projected at 8.28 percent. The revenue increase, therefore, was approximately 86 percent of the theoretical potential or the amount that would be realized if there were no loss in truck traffic as the result of the toll change. In the range of toll

TABLE 7

IMPACT OF TOLL DECREASES FOR PASSENGER CARS AND TRUCKS

Facility	Date of Change	Vehicle Type	Toll			Net Change Resulting From Toll Decrease (%)	
			Before	After	Decrease (%)	Traffic	Revenue[c]
Delaware Memorial Bridge	6/1/58	All pass. cars	\$0.686[a]	\$0.457[a]	33.4	11.7	25.6
Delaware Memorial Bridge	6/1/58	2-axle trucks	1.00[b]	0.75[b]	25.0	11.4	16.5
Delaware Memorial Bridge	6/1/58	3-axle trucks	1.50[b]	1.00[b]	33.3	14.3	23.8
Delaware Memorial Bridge	6/1/58	4-axle trucks	2.00[b]	1.50[b]	25.0	13.7	14.7
Thousand Island Bridge	3/1/56	All pass. cars	0.932[a]	0.738[a]	20.8	10.5	12.5
James River Bridge	4/1/64	All pass. cars	0.764[a]	0.662[a]	13.4	9.6	5.0
George P. Coleman Memorial Bridge	4/1/64	All pass. cars	0.684[a]	0.626[a]	8.5	None	8.5
Sunshine Skyway Bridge	12/1/58	All pass. cars	1.75[b]	1.00[b]	42.9	44.9	17.2
Sunshine Skyway Bridge	4/1/66	All pass. cars	1.00[b]	0.50[b]	50.0	26.3	36.9

[a]Average toll. [b]Cash toll. [c]Denotes decrease.

increases up to an average of \$1.50, the revenue productivity of truck toll changes was estimated at 83 to 86 percent of the theoretical potential.

The revenue productivity of a truck toll increase was somewhat higher than that anticipated from passenger car toll changes, as can be seen by comparing Table 6 with Table 3, a similar analysis for passenger car toll increases.

The reasons for the higher productivity of truck toll increases are evident. Trucks are engaged in business or commercial activity and are on essential trips. Toll charges are a business expense and, in the aggregate, represent such a small proportion of trip cost that a toll change does not have a major effect on demand.

Impact of Toll Decreases

Information was obtained concerning nine instances in which bridge or tunnel tolls were reduced (Table 7). Six of these toll decreases were for passenger cars, the remaining three for trucks.

The toll decreases ranged from 8.5 to 50 percent. In eight of the nine instances, there was some increase in traffic after the toll reductions were made effective. In all cases, the increase in traffic was not nearly adequate to offset the decrease in rate of toll, with the result that reductions in revenue ranged from 5 to 37 percent.