Recent Observations on the Effect of Gasoline Price and Supply

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This paper addresses the economic effects of the gasoline shortage of 1974 and the ensuing gasoline price increases. Further, the investigation covers what is commonly thought of as two separate markets: the work or peak-hour travel market and the off-peak or nonwork travel market. Observations were made at the six port authority vehicle crossings: the Holland and Lincoln Tunnels and the George Washington Bridge, which provide access across the Hudson River between New Jersey and Manhattan, and the Bayonne and Goethals Bridges and Outerbridge Crossing which connect New Jersey and Staten Island. Traffic observations in the 6 months of 1974 showed that (a) traffic volumes declined much less in the second quarter of 1974 than in the first quarter; (b) weekend traffic was down much more than weekday traffic in the first quarter, whereas in the second quarter there was only a slight difference in weekday and week end declines; (c) the decline in weekday peak and off-peak traffic differed little in the first and second quarters; (d) the number of passengers per vehicle decreased in weekday off-peak hours and increased during some peak hours; (e) cross elasticity between automobile and transit modes was small but not zero; and (f) longer trips decreased more than short trips.

Many things influence traffic growth, including changes in socioeconomic variables (population, employment, and income), travel systems (new highways or transit systems), and relative travel costs. In an economic sense, travel is a "normal good" that demonstrates an inverse relationship between price and quantity and a direct relationship between quantity and income.

Many forces helped to maintain the high rate of growth in traffic volumes ($3\frac{1}{2}$ to 4 percent) during the past $10\frac{1}{2}$ years. Pricing is only one explanatory variable and perhaps only a small part of the impetus to long-term growth. It could be argued then that a relative price increase in the cost of driving would have only a small effect on the growth of automobile traffic if all the other contributing forces remained constant.

In the long run, many of the other forces change, and pricing as a single force is difficult to isolate. During the first half of 1974, the short run, it may be inferred that pricing was the major cause of any changes in traffic growth.

Observations of short-run changes in traffic growth, however, must consider short-term influences. On a year-to-year comparison, weather proved to be an important variable. Minor changes caused by construction, strikes, and service disruptions in competitive modes must be taken into account as must holidays. Many of these influences were present in the raw data that were used for this paper, and attempts to adjust for them were made.

REACTION TO GASOLINE PRICE INCREASE

During the first quarter of 1974, reductions in volume due to gasoline price increases were masked by the overwhelming effects of gasoline shortages. As a result, the pattern that emerged in the first quarter showed heavy weekend losses (especially on Sundays) compared to weekdays. Following the lifting of the oil embargo in March, gas station lines virtually disappeared and with them the major problems of gasoline availability. Higher prices, however, remained as a deterrent to traffic growth.

Measurement of the effects of rising prices while all other variables are held constant can be accomplished by cross-sectional analysis, in which differential costs are typically related to differential distances, or time series analysis with cost comparisons between two time periods. In a modeling effort the cost coefficient that emerges, if it is free of the effects of the other socioeconomic variables considered, may be easily converted into an elasticity coefficient. Economists define elasticity as a measurement of the percentage of change in quantity (in this case, the number of trips per household) for a given percentage of change in price (total cost of trip). It is then a simple task to interpolate the total cost elasticities so as to consider the individual components of the cost, e.g., gasoline prices, tolls, parking costs, on the quantity of trips taken. For example, before the recent price increase, gasoline expenditure was estimated at about 20 percent of the total trip cost, the remainder being other operating and maintenance costs, parking fees, and tolls. Therefore, an elasticity coefficient of -1.0 for total cost would translate to -0.2 for gasoline alone.

Differing regions might be expected to show different elasticity coefficients, largely because the magnitude of the coefficient reflects the number of available substitutes for the good in question, including the obvious choice of doing without. Nevertheless, empirical studies around the country have yielded a remarkably stable gasoline price coefficient, ranging from -0.1 to -0.5. In this range, the effect is said to be inelastic, such that a 10 percent increase in gasoline price would yield only a 1 to 5 percent decrease in trips consumed. In cross-sectional studies done several years ago, the elasticities that emerged were related to trip purpose. The elasticity coefficient of the work trip was higher than that of the nonwork, leisure trip. The elasticity coefficients used were total cost coefficients and were estimated at -1.2 for the work trip and -0.7 for the nonwork trip. The effects of prices on work and nonwork trips translated into a 12 percent decrease in work trips and a 7 percent decrease in leisure trips for each 10 percent rise in total trip cost. Although it seems unusual that work trips are more responsive to price changes than nonwork trips, it should be noted that, in the New York-New Jersey metropolitan region, the availability of rail and bus transit, especially during peak periods, provides greater ease of substitution than in many other regions. For nonwork trips, most often made in other than the weekday peak period, transit alternates are not so readily available, and, as a result, the traveler's reaction to a price increase may be to change the destination or leisure activity to avoid the higher cost. This may take the form of substituting shorter trips for longer ones, e.g., a trip to a nearby beach rather than a camping trip.

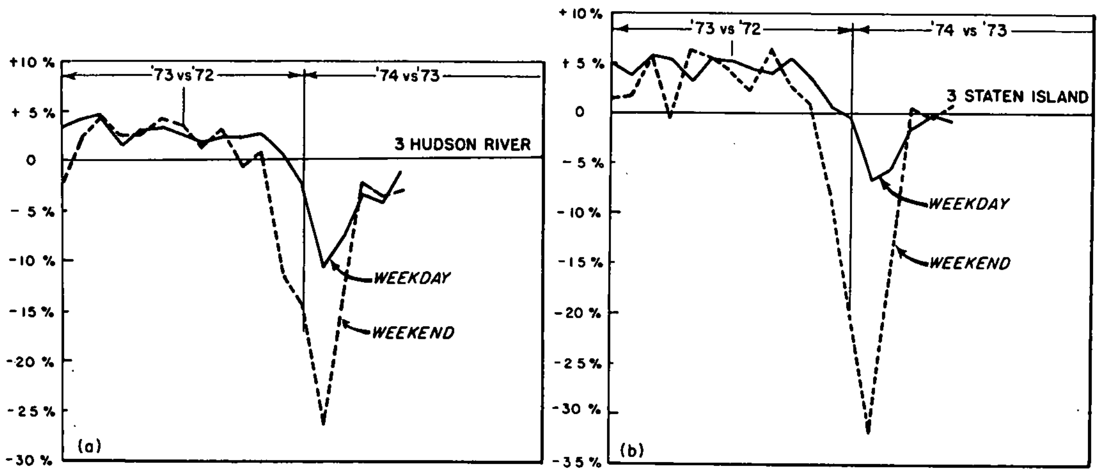
As of June 1974, gasoline prices had increased in the New York-New Jersey region by 35 to 40 percent. Feeding this range of price increases into the price elasticity coefficients yields an expected decline on the order of 6 to 7 percent in total trips. We may infer from the data given in Table 1 that, after the gasoline shortage in the first quarter of the year, April, May, and June traffic volumes fell short of 1973 volumes by about 2.8 percent. When the expected 3 to 4 percent growth from 1973 to 1974, which would have been anticipated in the absence of energy constraints (Fig. 1), is added to this, the resulting decrease in volume is about 6 to 7 percent, which the price effects lead us to expect.

Table 1. Adjusted decreases from 1973 to 1974 at six port authority crossings.

Month	Percentage Decrease Weekday	Weekend	Monthly
January	3.9	14.2	6.4
February	10.4	27.7	15.1
March	7.3	13.6	9.0
April	3.0	2.0	2.9
May	3.5	3.4	3.4
June	2.4	1.3	2.1

Note: Erratic factors such as unusual weather, holidays, and strikes have been compensated for.

Figure 1. Adjusted monthly growth rates for 1973 and 1974 for (a) Hudson River crossings and (b) Staten Island crossings.



It should be noted that this 6 to 7 percent loss is measured in vehicle trips and measured from expected traffic. The estimated distribution of this traffic loss is discussed later. In brief, whereas some of the traffic loss is from trips that have been discontinued, some is accounted for by carpooling and the remainder by shifts to public transit.

PEAK VEHICULAR TRAFFIC CHANGES

Observations of peak traffic volumes both during the height of the gas shortage and in the second quarter of 1974 showed no difference between the change in peak traffic and the change in weekday traffic. The peaking pattern has remained similar. It seems that the effects of the gas price increase, or overall price increase, on peak-hour work traffic and on off-peak nonwork traffic have been similar.

Before we address the magnitude of the changes observed in the peak, some relationships must be established between peak travel and work travel: Are the two terms really synonymous?

Figure 2 shows automobile volumes by time of day and trip purpose. The data for this figure are from a 1972 port authority continuous-sample origin-destination survey. Figure 2 shows eastbound traffic only: New Jersey residents going to work in the a.m. peak and New York residents returning from work in the p.m. peak. The business trips bulk up in the middle of the day; other trips continue throughout the day into the night. It is apparent that not all the peak travel (particularly the p.m. peak) is work travel and conversely not all the work travel occurs in the peak periods. Data given in

Figure 2. 1972 average weekday trip purposes for (a) Hudson River crossings and (b) Staten Island crossings.

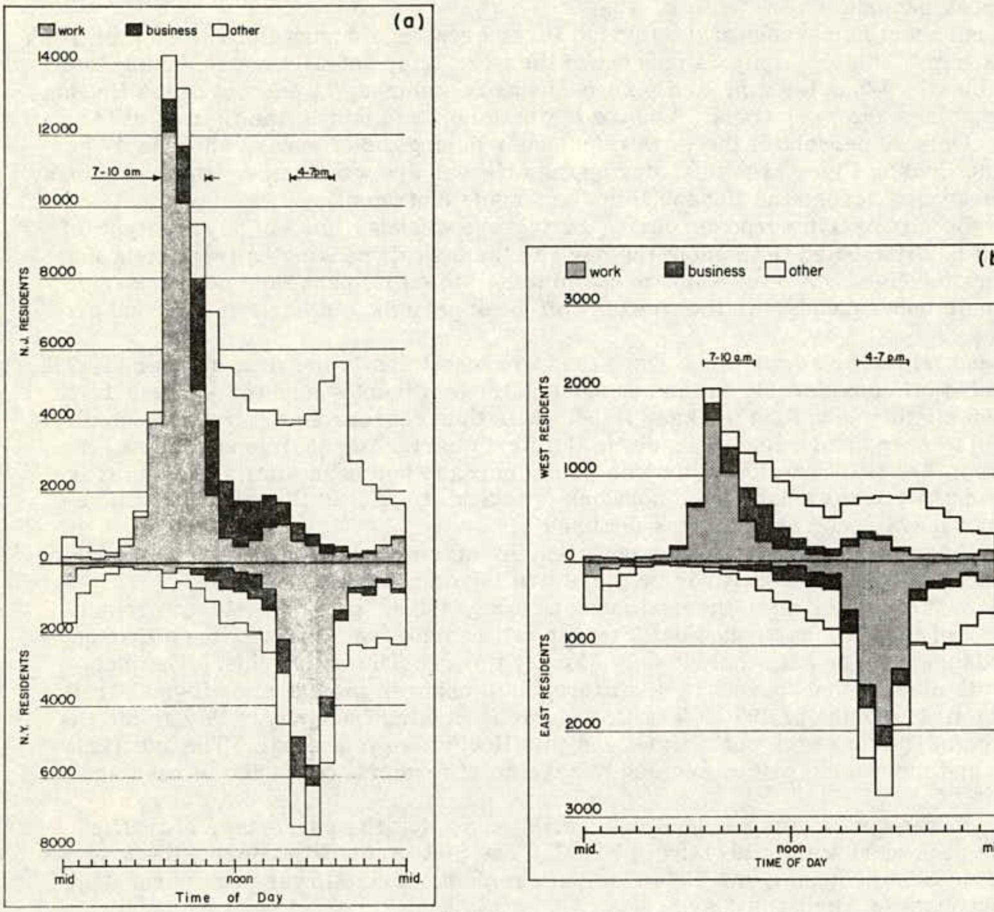


Table 2. Percentage distribution of eastbound trips by trip purpose.

Time Period	Hudson River Crossings		Staten Island Crossings	
	Work	Nonwork	Work	Nonwork
Weekday				
7 to 10 a.m.	83.7	16.3	82.0	18.0
4 to 7 p.m.	55.9	44.1	65.4	34.6
7 to 10 and 4 to 7	70.8	29.2	71.4	28.6
Off-peak	43.9	56.1	38.4	61.6
24 hours	56.6	43.4	52.9	46.1
Weekend				
Saturday	19.5	80.5	25.0	75.0
Sunday	8.9	91.5	9.0	91.0

Table 3. Percentage distribution of weekday eastbound trips by time period.

Time Period	Hudson River Crossings		Staten Island Crossings	
	Work	Nonwork	Work	Nonwork
7 to 10 a.m.	33.6	9.5	24.6	6.2
4 to 7 p.m.	19.5	22.4	34.2	20.8
Off-peak	46.9	68.1	30.2	73.0
24 hours	100.0	100.0	100.0	100.0

Tables 2 and 3 show the percentage distribution of work and nonwork trips during peak and off-peak periods.

Although about 84 percent of the Hudson River crossings during the 7 to 10 a.m. peak are work trips (Table 2), only 34 percent of the work trips actually occur during that peak (Table 3). When the a.m. and p.m. peaks are combined, 71 percent of the Hudson River crossings are work trips. For the Staten Island crossings, the figures differ slightly. Only 30 percent of the work trips occur during the off-peak, whereas 47 percent of the Hudson River crossings during the off-peak are work trips. However, many of the work trips across the Hudson River are made by transit.

Given the mix of trip purposes during an average weekday, loss of any one type of trip could be distributed throughout the day and the overall peaking pattern might not change much. However, work trips predominate in the a.m. peak, and nonwork trips predominate on weekends. In the weekday off-peak periods, neither trip purpose predominates.

Weekend trips were down much more than weekday trips in the first quarter of 1974. This leveled off considerably in the second quarter to a point where the weekend trips were down slightly less than weekday trips. It is thus reasonable to attribute the difference in weekend and weekday levels in the first quarter to gasoline shortages. It would seem then that reaction to the gas price increase has been similar among travelers who make work (weekday) and nonwork (weekend) trips. Is this phenomenon reflected in weekday peak and off-peak declines?

From observation so far, we have not seen any major change in the weekday peaking pattern on either the Hudson River or the Staten Island crossings.

The data in Figure 3 show the eastbound weekday 4-hour peak (6 to 10 a.m.) as a percentage of the total eastbound daily traffic (all vehicle types) on the three Hudson River crossings. The data include only Monday through Thursday trips. The plot shows quite clearly that there was no difference in changes in peak and off-peak traffic during the first months of 1974. Traffic volume fluctuated from day to day as did the percentage of traffic in the peak hours, but this fluctuation is normal. The gasoline shortage and increasing prices seemed to have no differential effect in the peak and off-peak.

The second-quarter comparisons in Figure 3 show that the percentage of traffic during the peak was lower in 1974 than in 1973. The plot is distorted during the 3 weeks surrounding Easter Sunday, but 1974 continues to demonstrate lower peak percentages throughout most of April and May.

It would appear from this figure that the pricing effect was greater in the peak than in the off-peak; however, this is not the case. The June 1973 and 1974 comparison is similar to the first-quarter comparisons, i.e., no apparent difference in effect on peak and off-peak traffic. The traffic pattern shift that shows up in April and May is due to the PATH strike in 1973 when more peak trips were diverted to automobiles than off-peak traffic, thus raising the peak percentages to a higher level than would occur at this time of the year.

Comparison of 1973 and 1974 traffic on the Staten Island crossings also shows no basic difference between the change in peak traffic and the change in off-peak traffic. This is true even though there was a significant shift of traffic when a new section of highway opened in the period between the two counts.

It could be concluded then that the relatively higher work orientation in off-peak trips has some effect on the fact that the peak and off-peak patterns did not change significantly with the increase in gasoline price, even though other changes may have taken place in work trips and nonwork trips.

It should be noted, of course, that these traffic shifts are small in all of the second-quarter observations. Further, an assumption that trips were lost in the work or nonwork categories cannot be proved without some field surveys on trip purpose. There are, however, additional data from which further insight into the peak and off-peak, work and nonwork situation can be derived. These data are from a survey of passengers per vehicle (p/v) made in April 1974.

Figure 3. Peak-period (6 to 10 a.m.) eastbound traffic as percentage of 24-hour traffic for Hudson River crossings.

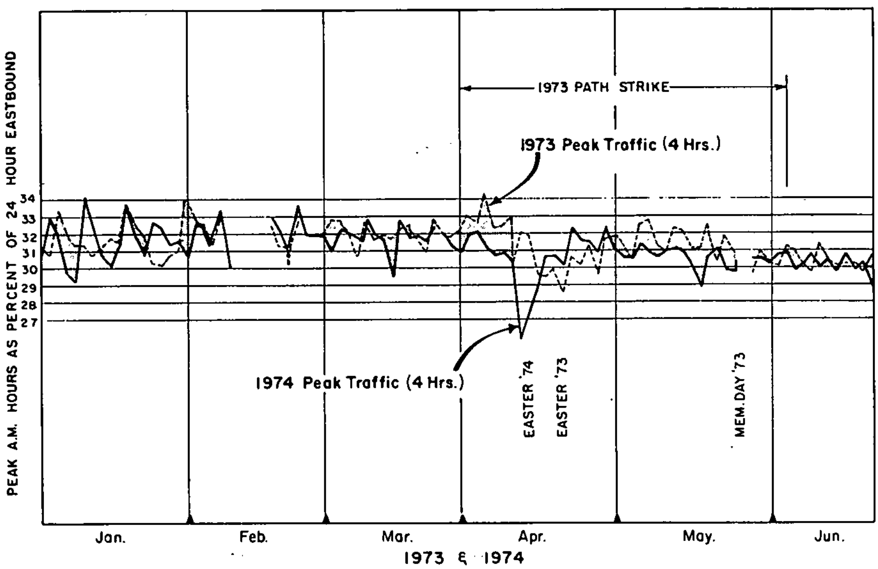


Figure 4. Passengers per car for Hudsòn River crossings.

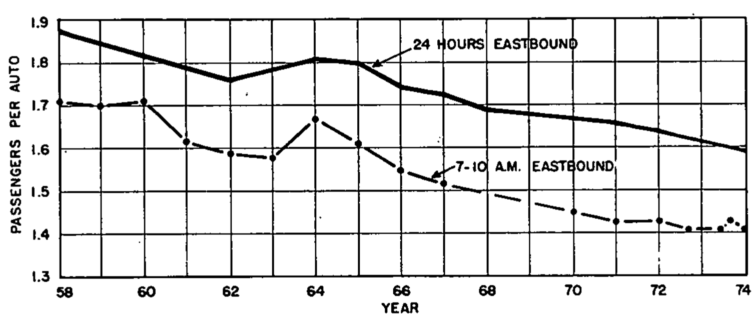
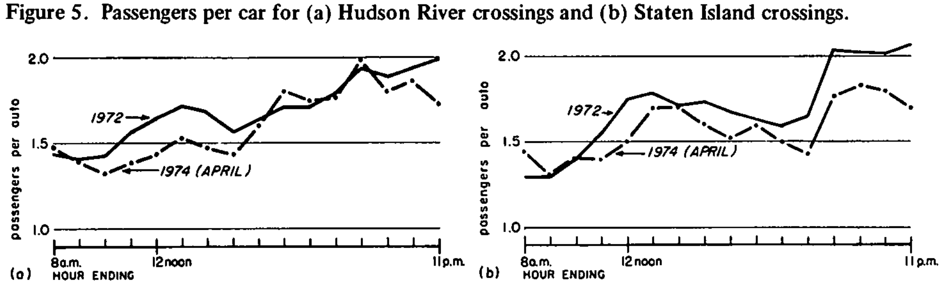


Figure 5. Passengers per car for (a) Hudson River crossings and (b) Staten Island crossings.



PASSENGERS PER AUTO

One of the methods suggested to reduce gasoline consumption during the height of the gas shortage was car pooling. Many efforts were and are being made to encourage car pools. Surveys of p/v rates were made at all six port authority facilities in April 1974 to determine whether the gas price increase or promotion of car pools effected car pooling.

Car pooling, in theory, can have a tremendous impact on peak vehicle demand reduction, on gasoline use, and not the least of all on the cost of using an automobile. The reduction in per-person cost due to 2, 3, or 4 people sharing the cost is dramatic. Car pooling is defined here as a group making a work trip. It is most prevalent where origins and destinations are dense enough to make the establishment of a car pool convenient, and it is done to reduce costs without sacrificing too much convenience.

Data collected over the years in continuous origin-destination surveys have allowed us to keep track of changes in the p/v index. The overall p/v index has been declining for many years (Fig. 4), probably because of increased affluence, increased automobile ownership, and dispersal of residences and jobs.

Data derived from the 1972 continuous origin-destination survey reveal some findings that tend to validate the statement on dispersal of activity causing lower p/v rates. First, work trips for west of Hudson residents show an increase in p/v in the a.m. peak. Also, the p/v rate of work trips at the three Hudson River crossings is greater than at the Staten Island facilities. An additional breakdown for the Hudson River crossing destined for the Manhattan CBD showed even higher p/v rates in this time period. Thus, the convenience of time and location does appear to foster car pooling. For residents east of the Hudson, p/v is higher in the return from work trip. Actually, on the three Hudson River facilities the p/v rate for the New Yorkers returning from New Jersey work places (the reverse commuters) is significantly higher than for the typical journey to work movement. This is probably caused by a greater car pooling effort on the part of the former group for the purpose of cost savings. This is in general a lower income group, traveling to common destinations at large New Jersey factories. Public transportation is less satisfactory, which leaves car pooling as the most viable means of reducing costs.

Three surveys were taken prior to this study: December 1973, January 1974, and the end of April 1974. The first two were taken in the 7 to 10 a.m. peak period only eastbound, and the last one included part of the remainder of the day, to 11 p.m. The results of these surveys indicate little change in p/v rate during the peak, but significant decline in the off-peak p/v rate. Figure 5 shows a comparison of p/v rates for 1972 and April 1974.

In addition to classifying the p/v data by time of day, we classified the data according to whether tolls were paid by cash or ticket. The toll for automobiles is $1 round trip (collected eastbound only). Reduced tickets are available at 50 percent discount for 20 nontransferable tickets good for 30 days and at 20 percent discount for 12 tickets good for 2 years. The following observations were made:

1. Use of discount tickets (mostly for work trips) decreased slightly more than did the number of automobile users;
2. The p/v rate of discount ticket users was up in all time periods, especially in the p.m. peak; and
3. The p/v rate of cash toll payers was down noticeably, especially during off-peak periods.

At the Hudson River crossings, the work trip volume is down as much as or more than the leisure trip, verifying that the elasticity of the work trip in this market is higher than that of the nonwork trip. The fact that the p/v rate of the discount ticket user is up may be a sign of increased car pooling. The fact that it is up more in the p.m. peak indicates greater car pooling in that market. In the a.m. peak, a greater shift to public transit by the one-occupant car user is a reasonable expectation.

In addition, using discount tickets for tolls has decreased for work trips because fewer work trips are made by automobile and discount tickets have a time limit. Some of the substitute trips are possibly made by public transit. Such a shift would result in a lower overall p/v rate among those paying cash tolls.

It also appears that the greatest loss in the nonwork category is in the family-friends type of trip. These trips have historically had the highest p/v rate, and the loss of these trips in the off-peak hours explains the significant drop in the p/v of cash toll payers in the off-peak hours. It is also possible that the loss of some of these trips during peak periods is one reason why the peak p/v rate has not changed as much as the off-peak, i.e., loss of high p/v nonwork trips is counteracted by low p/v work trips.

One difference in the observations at the Hudson River and Staten Island crossings should be explained. The a.m. peak p/v rate changed significantly more on the Staten Island facilities than on the Hudson River ones. Because the market served by the Staten Island facilities has little or no public transit service, the tendency toward car pooling in an effort to reduce cost in the work trip category was greater.

The fact that the p.m. peak traffic now shows a higher p/v rate at the Hudson River facilities and a lower p/v rate at the Staten Island crossings might be explained by the exceptionally high p/v rate for work trips in that period on the Hudson River facilities and therefore a smaller difference in p/v between work and nonwork trips.

SHIFT TO PUBLIC TRANSIT

It has been shown that in the second quarter peak traffic volumes on the Hudson River crossings declined about 3 percent or roughly 4,000 to 5,000 passengers for both peaks. Based on analysis of p/v changes, it is estimated that some of the travelers, particularly for work trips, shifted to public transit.

Attempts have been made to trace this shift, but the volume is small, the public transit volume is large, and the task was difficult. The transit passenger volume crossing the Hudson River in the peak is about three times as high as the automobile passenger volume. A loss of 3 percent from automobiles then means only a 1 percent increase in public transit volumes. The special counts that would reveal a shift are expensive and cannot be made very often. As a result, a 1 percent change derived from isolated counts cannot really be recognized. Isolated counts have indicated some small increases on the public transit system in the peak period, and it is not unrealistic to attribute it to a shift from the automobile.

OTHER HIGHWAY FACILITIES IN NEW JERSEY METROPOLITAN AREA

Because traffic volumes at port authority facilities changed in certain ways during the gas shortage of the first quarter of 1974 and in other ways in the second quarter, traffic data were collected on other specific highway types throughout the area to determine whether the findings were consistent and to test ideas not readily apparent from port authority facility data.

First, we observed the dramatic decline in Sunday traffic in the first quarter and much less in the second quarter. Second, based on port authority data but not origin-destination information, we made the assumption that local trips declined less than longer trips. To check these observations, we investigated permanent count data from several highway locations in New Jersey. Different types of highways were selected to illustrate the findings.

In almost all cases, observations were consistent with findings on port authority facilities. The hypothesis that longer trips were affected to a greater extent than shorter trips was supported by interchange data from the New Jersey Turnpike. Equally supportive were the vehicle counts taken on express and competing local roadways in the region, such as I-80 approaching the George Washington Bridge.

CONCLUSIONS

In the progress on this study, observations of total traffic volumes, weekday and weekend volumes, peak traffic volumes, and automobile occupancy at various times of the day were made. Comparisons of the changes observed in these traffic data provided sufficient evidence to estimate the magnitude of the effect on the driving public of the gasoline price increases in the first half of 1974.

First, the substantial reduction in traffic volume during the first quarter of 1974 can be attributed for the most part to the gasoline shortage, not the price. When gasoline was generally available in the second quarter, traffic recovered. The recovery was not complete, and the declines in traffic volumes from a year ago can be attributed mostly to rising gasoline prices.

From previous studies, total cost elasticities were estimated in the range of -0.7 to -1.2. However, gasoline cost only accounts for about 20 percent of the total cost of driving; therefore, an expected decline in traffic from a 35 percent gas price increase would be about 7 percent. Traffic declines of 2 to 3 percent from last year were observed that, when added to a normal growth of 3 to 4 percent, result in a decline of 6 to 7 percent, as expected.

Observations of peak and off-peak weekday traffic indicated no change in the peaking pattern. Both peak and off-peak traffic reacted to the gasoline price increase. The mixture of trip purposes in both the peak and off-peak hours tends to soften any differential reaction to rising prices that may have occurred among different trip purposes. Nevertheless, there is evidence that both work and leisure trips were affected by the price increase and even some evidence that work trips were affected more than nonwork trips.

From the data available, it appears that peak-period work travelers reacted to the price increase by car pooling and by switching to public transit. Off-peak leisure travelers seem to have reduced the number of trips or made shorter trips.

Regarding peak travel demand reduction, it is apparent that pricing does have some effect. In this case, because the peak travel market is strongly work trip oriented, person trips were not reduced, but the automobile trips were. In large measure, as many trips are still being made, but some automobile trips are now being made on public transit or in car pools.