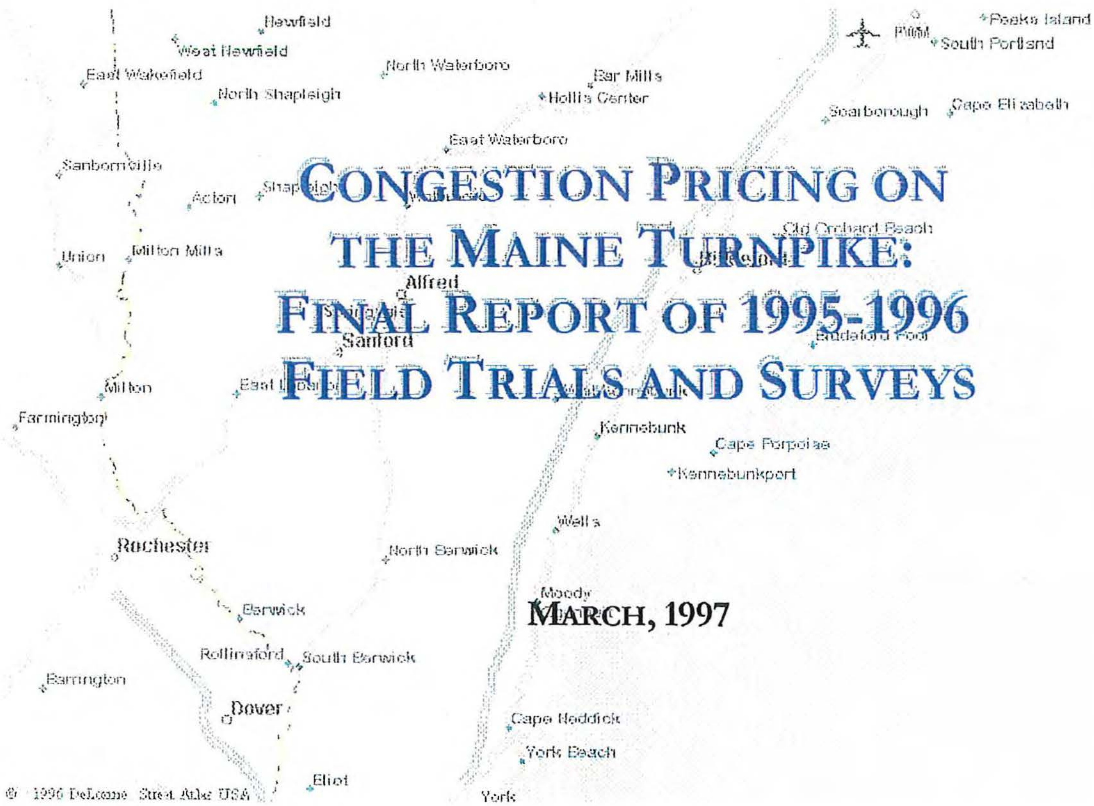

CONGESTION PRICING ON THE MAINE TURNPIKE: FINAL REPORT OF 1995-1996 FIELD TRIALS AND SURVEYS

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FINDINGS

- In 1995 and 1996, the Maine Turnpike Authority conducted two series of trials of discounted tolls in order to study the effectiveness of using incentives to reduce travel during peak hours on Summer weekends. The trials were conducted in compliance with the 1991 Sensible Transportation Act and other federal and state legislation requiring evaluation of alternatives to building a wider road.

- An initial study using peak hour tolls on Fridays and Sundays in August to Labor Day combined with off-peak toll discounts from July 4 through Labor Day was proposed for 1995. Toll discounts would be offered using coupons distributed on the Turnpike. However, the Maine Legislature prohibited the turnpike from imposing surcharges during peak hours. Nonetheless, the Turnpike Authority elected to continue a study using off-peak discounts only.

- The 1995 study consisted of five weeks of toll discounts offered on weekends in August through Labor Day. The discounts, available with coupons distributed on the Turnpike and in newspapers, provided free travel on the Turnpike from York to South Portland on Fridays and Sundays during specified off-peak hours.

  • Analysis of changes in the time vehicles exited the turnpike during the periods when discounts were in effect (Fridays and Sundays in August, 1995) compared with comparable periods during July when discounts were not in effect shows that some people were willing to change their time of travel in response to the price incentives, but the effects were not consistent across all times and days. Tests of statistical significance using regression analysis showed that only some results were significant.

  • Peak period travel was not significantly reduced on Fridays or Sundays, though some effect on Labor Day traffic (when compared with 1994) was apparent. A number of factors which could explain the observed effects were identified, but the degree of influence of each factor remains uncertain.

  • A survey of over 5,000 peak period weekend travelers conducted on the last weekend of August showed that over two-thirds of travelers are regular users of the turnpike on summer weekends, a high-enough percentage to suggest that a full congestion pricing system may be effective. The survey also revealed a clear preference among users for peak period tolls as a means to pay for revenues lost from discounted tolls.

- The 1996 study offered off-peak discounts to frequent travelers on the Turnpike using a credit card-type device called a SmartPass. The discounts were offered on the same terms as in 1995, but for the full 10 weeks of the summer and on Saturdays as well as Fridays and Sundays. Morning and afternoon/evening off-peak periods were established as periods when the discounts would be valid, but for two hours on either side of the peak, rather than three as in 1995.

• SmartPass use and distribution occurred in a timely manner and reflected the composition of traffic based on home state found in the 1995 survey. However, the rate of use was relatively low. Only 60% of SmartPass holders actually used their pass, and total transactions over 10 weeks in 1996 was significantly lower than the discount coupon program which took place over 5 weeks in 1995.

• A telephone survey of SmartPass holders showed the program was favorably received. One third of those who actually used their pass indicted they had changed the time of their travel to use their SmartPass on at least one trip. Among these, there was a slight tendency to shift their travel earlier rather than later.

• As in 1995, increases in off-peak traffic were statistically associated with SmartPass use, particularly on Sundays. But no significant effects on peak hour traffic were observed on any of the weekend days. Sundays also showed some decrease in peak traffic that may have been associated with the SmartPass program. Nonetheless, the pattern of inconsistent effects found in 1995 continued in 1996.

- The two years of study showed that congestion pricing under the current discount-only rules will not serve to effectively manage peak hour traffic on the Maine Turnpike. The question of whether congestion pricing using peak hour surcharge tolls would be more effective remains open, but the large number of hours forming the peak, combined with the varying responsiveness to tolls at different days and different times found in the 1995-96 studies, will make any use of congestion pricing alone difficult.

- However, congestion pricing, including peak surcharges, may be needed if the decision is made to widen the Turnpike. A wider road will induce new peaks to form as traffic that had formerly avoided using the road during peak congestion is attracted back to peak hours after widening increases capacity. Using peak surcharges in the financing of capacity expansion could both allow those who will receive the greatest benefit from a wider road to pay their share of the costs and help manage traffic in the future.

ACKNOWLEDGMENTS

This study was the result of a collaborative effort among a large number of people. The Study Team wishes to express its appreciation to the members of the Turnpike Authority for their support. We also want to particularly note the assistance and support provided throughout the project, and all its difficulties, by Authority staff, particularly Paul Violette, Conrad Welzel, Dan Paradee, Neil Libby, and Kelly Roberts. We were provided all of the help we could reasonably expect, and sometimes beyond, in designing and implementing the two field trials and surveys.

We also want to thank the hundreds of Turnpike toll collectors who were on the front lines throughout the two summers; their good grace in handing hundreds of thousands of coupons, brochures, and surveys, and in interacting with the public was critical to the success of the study.

An advisory committee was established to help guide the study. The members are listed in the Appendix. They provided helpful comments throughout the process.

INTRODUCTION: CONGESTION PRICING AND HIGH-WAY TRAFFIC

The 1991 Sensible Transportation Act enacted at referendum prohibited the widening of the Maine Turnpike from four to six lanes between South Portland and Wells. It also reformed the process by which decisions regarding the Turnpike and other highway projects would be made in the future, requiring that alternatives to construction of highways be thoroughly assessed. As the Maine Turnpike Authority contemplates future steps to improve traffic flows on the turnpike, it has undertaken the examination of several different approaches that might be used individually or in combination to address the congestion that occurs regularly on summer weekends.[1]

Traffic congestion is already a serious problem on the Turnpike in the four lane region between Mile 12 (where a six lane stretch ends) and Exit 6A/7 where traffic divides between Interstate 295 through Portland and the Turnpike (I-495) which continues north to Lewiston. In 1995, volume to capacity ratios for this four lane region of the Turnpike varied between .73 and .88, a level of service of D on a six point scale where A is free flowing traffic and F is bumper-to-bumper stop and go traffic. Volume/capacity ratios could exceed 1.0 as early as 2005 in the 50th highest annual hour of traffic.[2]

Traffic on the Maine Turnpike presents special challenges in reducing congestion. Congestion occurs because three different flows of traffic combine to produce significant volumes of traffic on summer weekends. Commercial and commuter traffic are added to heavy volumes of vacation travelers, some of whom are coming to Maine for a weekend, some for a week or longer. Some vacationers come from nearby states while others come from throughout the United States and Canada.

Moreover, the Maine Turnpike lacks effective alternate routes, since much of Route 1 is already congested. Thus relieving congestion using any demand management approach must focus on changing travel time, moving traffic either before or after the peak hour rather than changing routes. There are also few mass transit alternatives available, particularly for vacationers.

One of the strategies that may address the problems of traffic on the Turnpike is to use tolls to provide incentives to change travel behavior, an approach called congestion pricing. Congestion pricing is actually a fairly common economic tool for managing the demand for fixed capacity. More than sixty years ago, the Bell Telephone Company began charging higher rates during business hours and lower rates during other times in order to avoid overloading the limited capacity for long distance calls. This rate structure has stayed in place to this day.

Some form of congestion pricing is encountered almost daily by most people, not only in phone rates, but in electric rates, the price paid for airline tickets and such recreational activities as movies (matinee v. evening prices), video rentals (higher prices or shorter rentals for new movies), and ski lift tickets (higher on weekend than weekday).

The underlying logic of congestion pricing for highways is quite simple: as a road becomes crowded, each additional vehicle

[1] See Vanasse Hangen Brustlin (VHB) Inc. *Maine Turnpike Alternatives Study* (Maine Turnpike Authority, 1996) for a discussion of the alternatives in addition to congestion pricing that were examined.

[2] *Ibid.* p. 19 and p. 53.

entering the road makes it more crowded for everyone. When road congestion occurs, set tolls so that some users will find it more economical to use another time (or another route), thus increasing capacity for everyone. Only those who find it more convenient to switch will do so (at a given toll); they will save some money while everyone else who continues to drive during the peak will save some time. Toll differentials can be established by setting a higher price during peak demand times, setting lower prices during off-peak times, or a combination of the two.

Because it has been widely used in other settings, congestion pricing has been regularly suggested as an approach to improve highway traffic without some of the problems associated with additional construction. A large number of studies have examined the theory and practical problems associated with congestion pricing[3]. One of the most important developments in congestion pricing was a provision in the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) which provided funds for congestion pricing demonstration projects. A number of study projects have been undertaken in other states.[4]

The need for a national examination of congestion pricing came about because it has long been known that new highways do not always solve traffic problems by themselves. New highways built to relieve congestion quickly become congested again. The reason is that roads are subject to the same rules of economics as other goods. When a road is congested, the "price" (in terms of time) for driving on it increases. This discourages some people from using it (though not enough to keep it from becoming congested). When a new road is built (or expanded), people who formerly avoided driving on it when it was congested now drive on it, increasing traffic once again. Combined with economic and population growth, the result is quickly a return to congestion problems.[5] The implication is that expanding highway capacity as the sole strategy for solving congestion is often self-defeating.

This is not to imply that congestion pricing is without problems. Despite the expansion of pilot projects in the wake of ISTEA, there is still very little experience, particularly long term experience, to provide guidance on what the right toll should be. With the exception of a highway in France, every highway congestion pricing scheme in the world has been proposed or been implemented in metropolitan areas in order to relieve morning and evening daily commuter traffic congestion. The Maine Turnpike presents an entirely different problem which makes congestion pricing an especially difficult challenge. Since congestion on the Maine Turnpike occurs seasonally, primarily on weekends, congestion pricing on the Maine Turnpike will have to address problems not found elsewhere in either studies or actual experience.

Moreover, despite congestion pricing's well-documented advantages in the-

[3] Transportation Research Board. *Curbing Gridlock: Peak Period Fees to Relieve Traffic Congestion* (Washington: National Academy Press, 1994; 2 vols.) is the most recent major compendium of such studies.

[4] See Hubert H. Humphrey Institute of Public Affairs, *Buying Time: Final Report* University of Minnesota, 1996.

[5] Downs, Anthony 1992. *Stuck in Traffic: Coping with Peak-Hour Traffic Congestion* Washington: Brookings Institution.

ory, it has been extraordinarily difficult to actually implement congestion pricing because of public opposition to the concept. The opposition arises from several sources, including the perception that road tolls are "just another tax", that it is unfair to low income people, and that it will simply be another way for government agencies to raise revenues without benefitting those who would have to pay the tolls. [6] As discussed below, concern about the impacts of congestion pricing using peak hour surcharges on the Maine Turnpike on tourists and on tourist businesses led to an intense lobbying campaign against the peak surcharge experiment by the tourism industry. The result was legislative action that severely limited the ability of this study to examine congestion pricing fully, and may continue to limit its use in the future.

The challenge for a congestion pricing study on the Maine Turnpike, therefore, has been to address the unique traffic challenges of the highway while building a better understanding of the public's reaction to the idea. As discussed in the next section, this could only be done through a combination of actual trials of congestion pricing over two years, combined with surveys of Turnpike users.

[6] Rom, Mark "The Politics of Congestion Pricing" and Giuliano, Genevieve "Equity and Fairness in Congestion Pricing", both in *Curbing Gridlock*, note 2, *supra*.

Objectives of the Congestion Pricing Study

The study approach approved by the Maine Turnpike Authority involved two years of congestion pricing trials. As originally set out in the Spring of 1995, the objectives were:

<u>First Year</u>

- Assess whether changing tolls on the turnpike has any potential for shifting the time of travel on summer weekends.
- Identify as closely as possible how sensitive traffic is to changes in tolls.
- Determine whether a sufficient proportion of traffic regularly uses the turnpike so that changing tolls will be effective.
- Identify other issues related to the operation of congestion pricing, including the public's views on the congestion pricing programs.

<u>Second Year</u>

- Test congestion pricing developed from information gathered in first year using electronic toll system.
- Implement a congestion pricing scheme as close to what could be permanently adopted as possible and examine effects on traffic.
- Assess public reaction to congestion pricing.

As it turned out, these objectives remained, but the study approach had to be substantially modified. Legislative action in 1995 prohibited the peak hour surcharges that are the usual approach to congestion pricing.

The field trials thus could only be conducted using off-peak discounts. Delays in the implementation of the electronic toll conversion prevented the use of this technology in 1996, so both years of trials were conducted using the existing toll ticket system. Nonetheless, the trials were successfully conducted, including two surveys of users. The following sections present the detailed findings for the 1995 and 1996 studies.

THE 1995 STUDY

STUDY APPROACH

The congestion pricing trial actually undertaken in the summer of 1995 was not the approach originally envisioned. To understand the study that was done, it is first necessary to understand the study that was not done. Two basic principles underlay the initial design of the study: information needs and price differentials.

Information- A major challenge facing any use of congestion pricing on the Maine Turnpike is that potential patrons must be informed of toll rates and applicable times well in advance of their departure in order to have an opportunity to change the time of their travel. Many of those who could change their travel live outside of Maine, often several hundred miles away. Over the long term, people will learn about toll changes from actual experience, but this process can take weeks or even months. Some method had to be found to accelerate the learning process during the trials.

Price differentials- A basic characteristic of any price is that the lower it is, the less likely people are to change their behavior in response to it. (In economic terms, lower prices tend to be characterized by more inelastic demand than higher prices.) Moreover, the research that has been done on highway pricing is fairly clear that driving is not something that people will easily change in response to higher costs. Tolls on the Maine Turnpike are relatively low (on average about 3 cents per mile for passenger vehicles), and so there is a strong presumption that any shift in tolls designed to encourage alternate travel times would have to be relatively significant. This could really only be done, it was believed, through a combination of peak hour toll increases *and* off-peak toll decreases.

Together, these two principles suggested the following strategy to apply to all those traveling in the southern part of the turnpike (those using exits 1-7 as either their entering or exiting plaza).

- Increase tolls during peak hours on Fridays to Sundays using a flat $2.00 surcharge on anyone traveling in the southern part of the turnpike during peak hours. The choice of a surcharge that would be the same for all trips was dictated primarily by operational considerations; keeping transaction times at the exiting toll booth as low as possible was a key issue in designing the study. The flat surcharge would also have discouraged relatively short trips on the turnpike.

- Offer a 75 cent discount off any toll for travel in the southern region during the offpeak hours. The 75 cent figure was chosen as it is approximately 50% of the $1.55 toll between York and Exit 6A. Any trip with a regular toll less than 75 cents would be free. Again, this would encourage those with short trips to take them during the offpeak hours.

- Since commuters make up a significant portion of the Friday afternoon traffic, and already receive a substantial toll discount through the commuter pass system (by law this discount must be at least 50%), it was proposed that a $1.00 surcharge apply to commuters in single occupancy vehicles (SOV's). National research suggests that the preponderance of SOV's in commuting traffic is a major source of congestion.[1], and

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[1] Downs Anthony. 1992. *Stuck in Traffic: Coping with Peak Hour Traffic Congestion* (Washington: The Brookings Institution) p. 20.

there is relatively little flexibility in time of travel for commuters. Thus it was hoped that a price incentive might encourage additional car pooling.

In designing the study, members of the study team met regularly with affected groups. A study advisory committee was established to review study design and identify additional issues which should be considered. A number of suggestions were provided by the Advisory Committee[2], the Portland Area Comprehensive Transportation Study, the Legislature's Joint Standing Committee on Transportation, and others who reviewed the study design. A substantial amount of concern was evident about the reaction to the surcharge, which many saw as likely to anger tourists. In response to these concerns, the study design was modified to include the following elements:

1. The toll discounts would be in effect from the July 4 weekend to Labor Day, while the surcharges would be in effect only during the month of August. This would permit an additional month in which to inform people about the surcharges, and would also allow a test of whether discounts alone or discounts in combination with surcharges would work.

2. Surcharges would not be imposed on Saturdays, but on Fridays and Sundays only. Discounts would be available on all three days. Combined with imposing surcharges in August only, the result would have been over 300 hours during the summer when discounts would be in effect, and only 20 hours when surcharges would be applied.

3. Discounts would be offered using a coupon system. Two 75 cent coupons would be handed out to all entering traffic during peak hours on Fridays and Saturdays, and could be redeemed on future trips for travel during offpeak hours. Coupons provided three major benefits:

- By combining the coupons with an informational brochure, the entire congestion pricing program could be explained.
- Since only those who presented coupons would get the discount, there would be a higher likelihood of inferring that any traffic pattern change was a result of coupon (discount) usage. If all tolls had been lowered, such an inference might have been more difficult.
- By providing those who paid the \$2.00 surcharge with \$1.50 in discount coupons, the effective toll increase for many drivers for an entire trip would be reduced to as little as 50 cents.

Selection of peak and offpeak hours is obviously a critical component of any congestion pricing system. Because the Turnpike Authority did not begin keeping its daily transaction data on an hourly basis until 1994, this was the only year that could be analyzed. Figures 1 and 2 show the pattern of traffic for Fridays and Sundays from July 4 weekend through Labor Day weekend, 1994. These show the average traffic entering and exiting the turnpike in the southern region for the appropriate day for all the summer weeks. The figures also include data from a Department of Transportation traffic

[2] See Appendix for list of members.

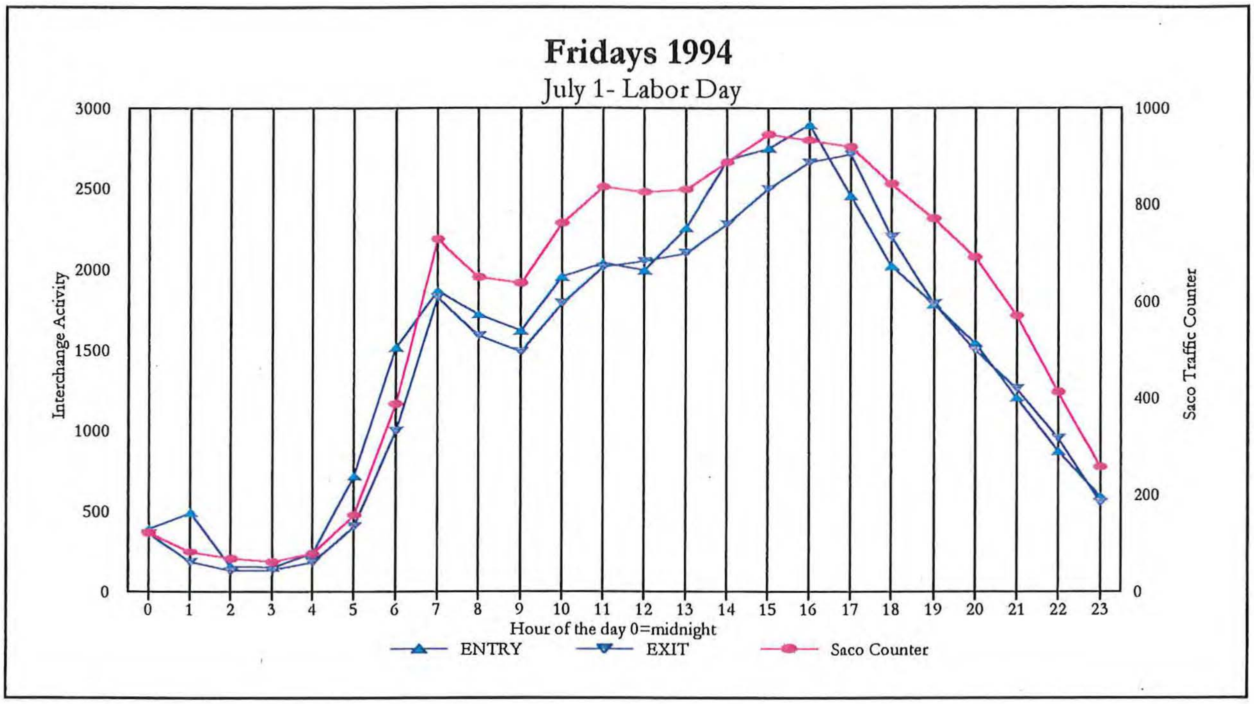

Figure 2

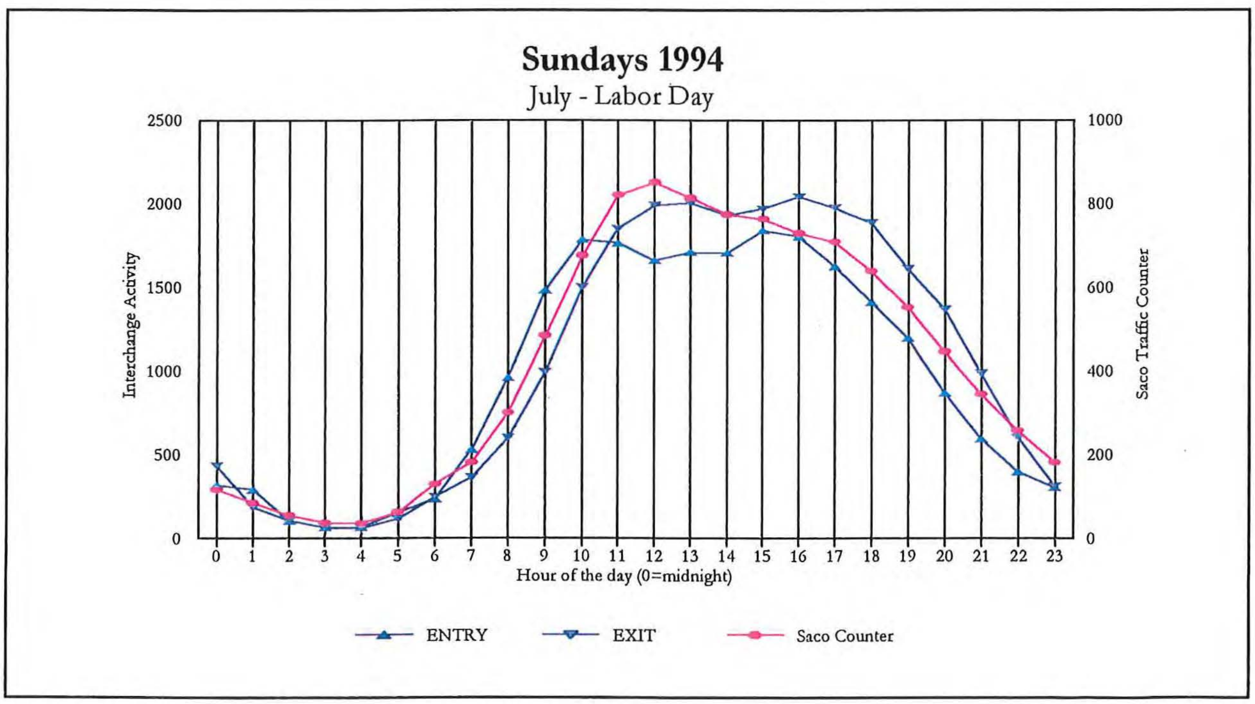

Figure 1

counter that monitored traffic on the turnpike in Saco; these data are for 1992, the last year this monitoring station was in place.[3]

[NOTE: In this and all subsequent graphs, the time of day shown on the horizontal axis represents transactions during the following hour. Twenty-four hour time is used for ease of display. Thus entry or exit transactions designated as 8:00 represent transactions from 8:00 to 9:00 am, and transactions at 20:00 are from 8:00 to 9:00pm. 0 is always midnight.]

These figures reveal another unique aspect of congestion on the Maine Turnpike. High traffic volumes extend over as much as six hours, from around noon to 6 pm (12:00-18:00) on Sundays and from around 1:00 to 7:00 pm (13:00-19:00) on Fridays. Peak hours were identified as 2:00 to 7:00 (14:00 to 19:00) on Fridays and 1:00 to 6:00 (13:00 to 18:00 on Sundays, with offpeak discount hours initially defined as the four hour time periods before and after these peaks.

This extended traffic peak contrasts with the relatively shorter (3-4 hour) commuting peaks typically associated with congestion pricing has been considered. Moreover, on the Maine Turnpike there are no sharp distinctions between the peak hours and those immediately before and after. This means there is not a lot of "room" in the offpeak hours for additional traffic.[4]

Despite these several efforts to address the concerns of the tourism industry, opposition to the surcharge component of the study mounted. Bills were introduced in the Legislature to prohibit the use of surcharges as any component of congestion pricing, including surcharges on single-occupancy-vehicles. On June 29, 1995, the first day of the Fourth of July weekend and the day that discounts would have gone into effect, the Legislature enacted legislation prohibiting all surcharges.

This forced a dramatic reconsideration of the study. The Turnpike Authority remained convinced that a congestion pricing study was essential, and together the Authority and study team agreed to several modifications to the study design:

1. The study would now focus only on providing discounts during offpeak hours.

2. Discounts would be offered during August only, to allow time for the printing of coupons and other material.

3. The discounts would be increased from 75 cents to $1.60, the toll between York and Exit 7. This allowed study of the maximum possible toll discount by making travel anywhere in the southern region free. It also reduced the toll from York to Exit 11A (New Gloucester) from $2.50 to $0.90 .

4. The lack of a surcharge presented another problem. The original study design would have been either revenue neutral or a revenue gain for the turnpike, but now there would be no offsetting revenues against the discounts. Moreover, there was no clear

[3] The traffic monitoring equipment was removed by the Maine Department of Transportation, which had been responsible for its operation.

[4] Traffic analysts often make a distinction between peak, shoulder, and offpeak hours. Peak hours are those with the highest traffic, shoulder hours are those immediately adjacent to the peak hours, and offpeak are the lowest traffic hours during the day. In this study, we have used the terms peak and offpeak to avoid confusion and to reinforce encouragement to travel in less-crowded hours.

guidance as to what the revenue losses would be, and no time in which to make any other adjustments to tolls. In order to reduce the revenue loss, the peak hours were reduced from four hour periods in the morning and evening to three hours: on Fridays from 1:00 to 7:00pm and on Sundays from 12:00 noon to 6:00pm. In addition, no discounts would be allowed on Saturdays. This had the effect of reducing the number of days when discounts would be studied from 33 in the original study to 11.

5. Discount coupons would continue to be used. The use of coupons continued to have advantages in terms of information, and now it had the added advantage of limiting the revenue loss the Authority would suffer, since the number of vehicles receiving discount tolls would be limited by coupon use.

6. An advertising campaign would be undertaken on the first and last weekend of the five-week trial period in order to partially offset the reduced time available to inform people about congestion pricing. Ads containing two coupons and explaining the opportunity to use them were placed in southern Maine and southern New Hampshire newspapers and in the Boston *Globe*. The ads in the *Globe* were backed up by radio advertising on WBZ radio, the highest rated radio station in the Boston market. The turnpike ads sponsored the traffic reports in morning and afternoon drive time on the four days before the ads appeared in the *Globe* on Thursday.

Results 1: Changes in Traffic Patterns

The first step in assessing the changes in traffic patterns is to measure changes in the time of exiting traffic at each toll station. Exiting traffic is analyzed since the discounts were based on time of exit (and toll payment). The analysis was done by examining changes in the share of traffic accounted for by each hour of the day. If the discount program were effective, the share of daily traffic in the peak hours during the experimental period in August should decrease and the share of daily traffic in the discounted hours should increase compared with comparable periods in July.

Analyzing traffic on the basis of hourly shares has several advantages. Most importantly, it avoids the complications associated with changing levels of daily traffic. Daily traffic patterns are relatively stable, even though there is usually an increase in total traffic in August compared with July. Analyzing hourly shares allows these differences in total traffic to be ignored ("controlled for"). There are also advantages in conducting the regression analyses used to test for statistical significance.

Figures 3 through 5 show the changes in hourly traffic shares for Labor Day, Fridays, and Sundays, respectively. Labor Day illustrates most clearly the nature of changes that would be expected from the discount program and so it is examined first.

Figure 3 compares traffic patterns on Labor Day, 1995 with Labor Day, 1994; traffic exiting at toll plazas between York and South Portland (measured against the left axis) are shown for the hours between 8:00am and 11:00pm. In addition, the proportion of each hour's traffic that presented coupons is shown on the right axis, and on the graph in the bars associated only with the hours when coupons were valid.

There was little change in traffic during the morning hours in 1995 compared with 1994, but there was a distinct shift in afternoon traffic. Traffic was noticeably lower in the peak period, particularly after 2:00pm, and noticeably higher in the evening period, particularly after 7:00 when coupon usage also sharply rose. The share of traffic in the 8:00pm hour also was much higher in 1995 than in 1994, and this was associated with nearly 34% of traffic using coupons; this was the highest usage of coupons in the entire experimental period. Overall, the peak hours in 1994 accounted for 49% of total daily traffic. This declined to 47% of daily traffic in 1995. The hours from 6:00pm to 8:00pm increased their share of traffic from 16 % to 17%.

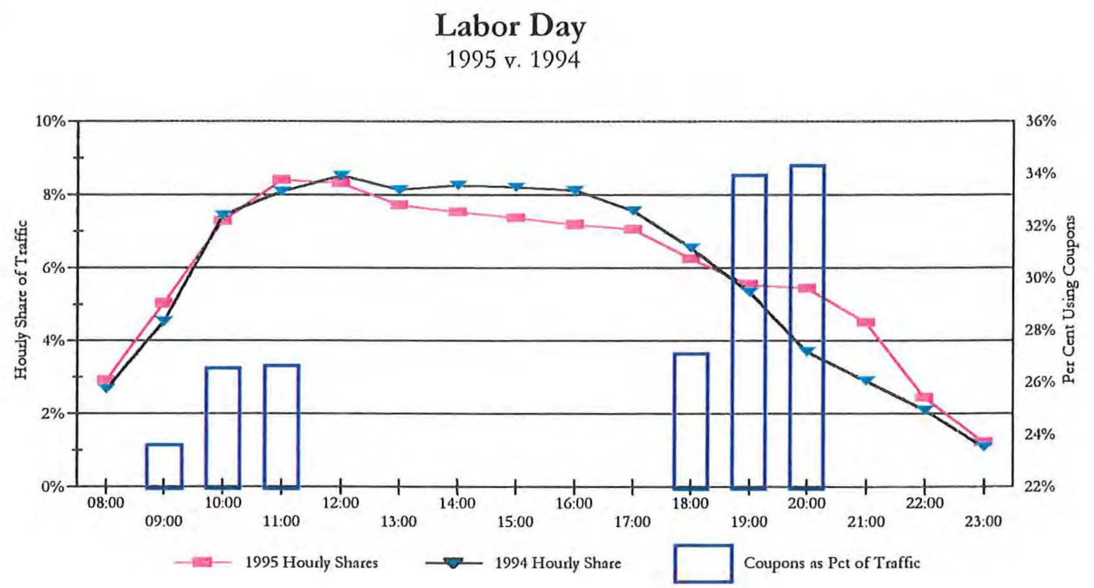

Figure 3

A confounding variable in interpreting the Labor Day results is that Labor Day 1995

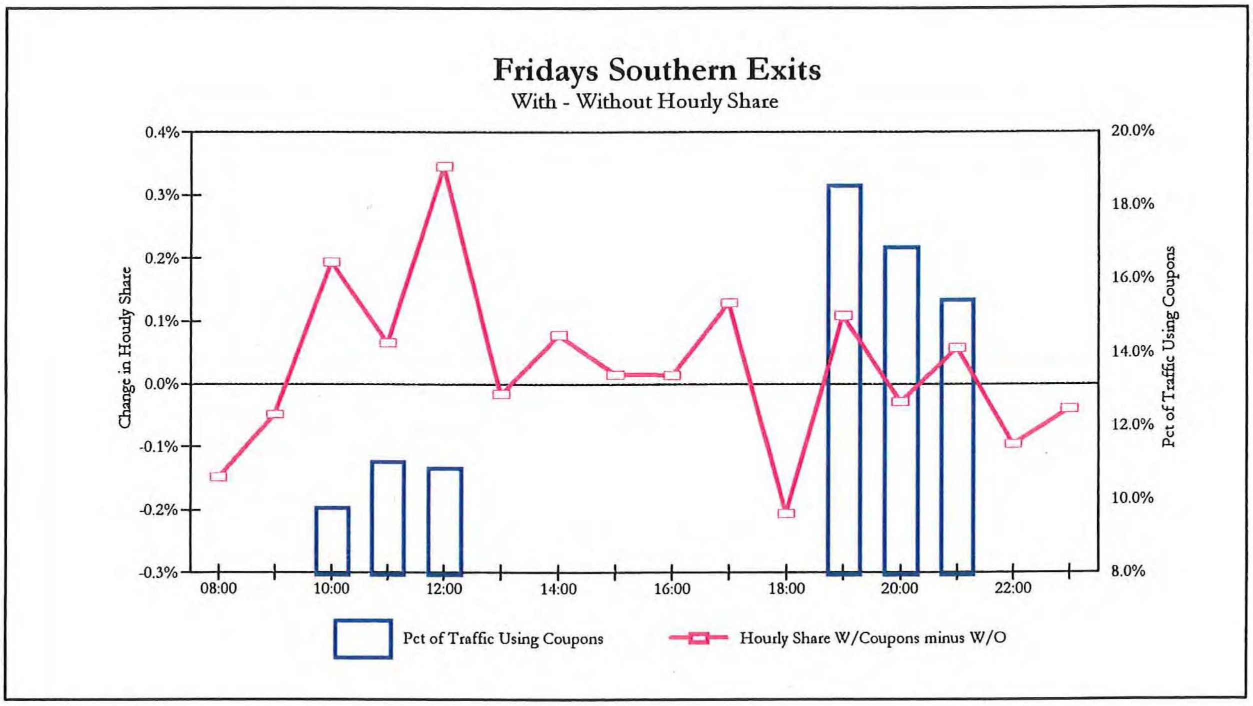

Figure 4

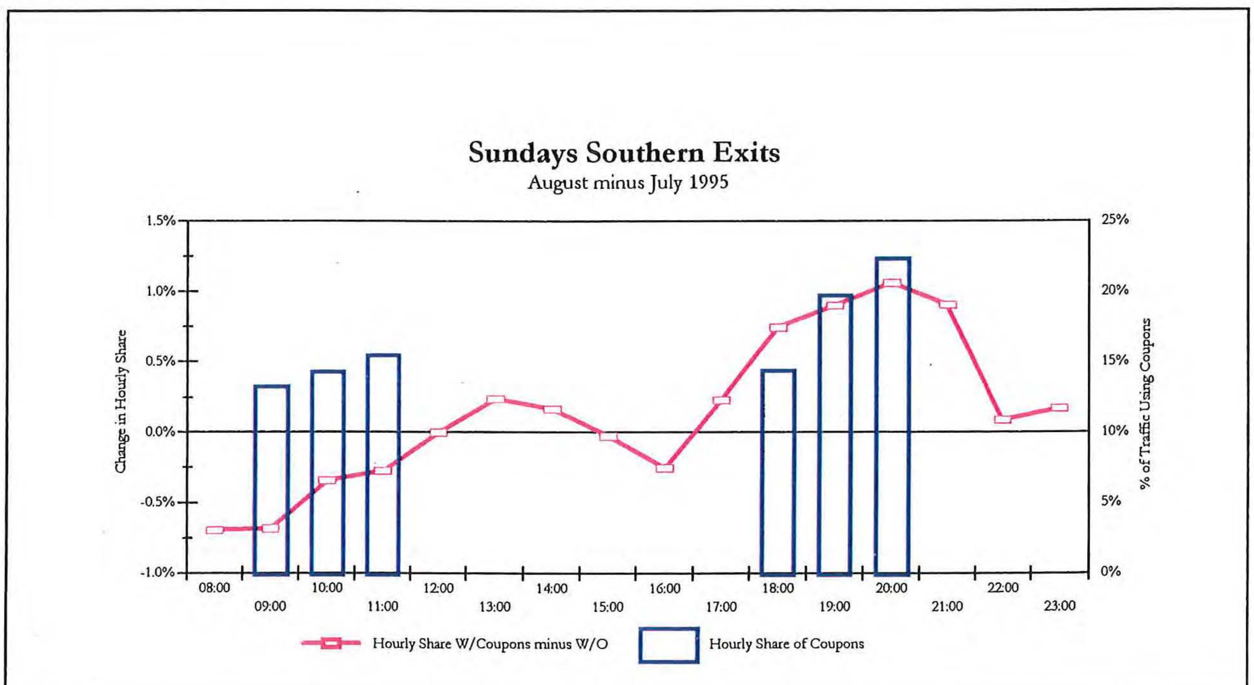

Figure 5

was sunny and dry, while Labor Day 1994 was cloudy and rainy. Poor weather would encourage earlier travel on a holiday weekend, so some shift in travel times between Labor Day 1994 and 1995 would be expected in any event. The question, then, is what was the contribution of weather and what was the contribution of the discount toll program to the observed change in travel times? Unfortunately, with only two data points there is no way to be sure.

It can be noted, however, that traffic in 1994 was clearly higher in the morning than in the afternoon, which would be expected with bad weather. Yet, in 1995 the morning's share of traffic was roughly the same as in 1994, while the shift in traffic was to the evening, and this shift was greatest when coupon usage was the greatest. It may also be noted that if discounts encouraged movement to the evening hours in good weather, they might have encouraged similar movement into the morning of a poor weather day. Either way, the effect would be to relieve peak congestion.

While the patterns of traffic on Labor Day are consistent with the kinds of changes the discount program was designed to encourage, only limited inferences can be drawn from this single day. Figures 4 and 5 show similar data for Fridays and Sundays in 1995, but organized in a different format. In these graphs, the average share of each day's traffic for the five Fridays (or five Sundays) in July are subtracted from the average hourly share from August 4 through Labor Day weekend. These are shown in the bars; a positive bar indicates that that hour's share of traffic increased during the experimental period compared with the undiscounted period in July. The line elements of the figures show the percentage of traffic using coupons.

Figure 4 shows the data for Fridays. There is clear growth in the share of daily traffic accounted for by the morning discount hours, particularly in the noon to 1:00pm hour. There is less growth in the evening discount hours, although the pattern of change in traffic is apparently consistent with the pattern of coupon usage. Nonetheless, the amount of change in hourly shares on Fridays is quite small, ranging from an increase of .06% of daily traffic in the 9:00-10:00pm hour to a shift of 0.35% from Noon to 1:00pm; there is also a very slight (0.03%) decline in traffic share from 8:00-9:00pm.

Overall, the share of traffic in the morning hours when discounts were available increased from 17.6% to 18.2%. The share of traffic in the evening traffic increased only very slightly from 13.7% to 13.8%. The peak hours' share of traffic was essentially unchanged, accounting on average for about 42.5% in July and August. There was a distinct shift in the "transition" hours, with increases in the last hour's share of traffic in the morning discount period and first hour of the evening discount period, accompanied by declines in the first and last hours of the peak period. This is consistent with the hypothesis that shifts in time are most likely in these "transition" hours since this would be the smallest time shift.

Figure 5 shows the data for Sundays. Again there is a clear pattern consistent with the discount program, but this time in the evening, and again this pattern is consistent with coupon utilization. As the proportion of evening traffic using coupons increases from just under 20% to just over 30%, the share of daily traffic increases by 0.75% to 1% in the periods when discounts were offered compared with the periods they were not. In the morning hours, however, the change is in the opposite direction from what would be expected: the share of traffic in the discounted weeks declined relative to the undiscounted weeks. The reason for this remains unclear.

The traffic share shift in the evening hours increased from 16.3% to 19%, but decreased in the morning hours from 19.8% to 18.5%. (The increase in the share of daily traffic was substantially larger on Sunday evenings than was the decrease on Sunday mornings, meaning there was not simply a shift from off-peak to off-peak. Peak hour traffic as a proportion of daily traffic showed irregular patterns. Contrary to expectations, overall peak hour traffic increased very slightly in the discounted weeks,, from 45.5% to 45.8%. This increase was primarily accounted for in the 4:00 to 5:00 hour; the reason why traffic should have been heavier in this hour with discounts than without is not clear.

Summarizing the Friday and Sunday experiences, there is support for a conclusion that people are willing to change the time of travel to offpeak hours when given an incentive to do so with lower tolls. However, this effect is not consistent across time periods. It is apparent that the discount toll program had the most success on Friday mornings and Sunday evenings, and the least success on Friday evenings and Sunday mornings; Friday evenings saw little change and Sunday mornings saw change in the opposite direction from expectations. While the discount toll program may have successfully convinced people to "come early and stay late", it is also apparent that toll discounts were more successful at times when flexibility to shift times of travel, such as Sunday evenings, was greater and less successful at times when flexibility is lower, such as on Friday evenings.

Moreover, on neither Fridays nor Sundays was there a clear and consistent decrease in peak hour traffic, though this did occur on Labor Day. The share of daily traffic in the peaks actually increased very slightly summed across all six hours of the peaks in the discounted weekends, although this was not consistent across all peak hours. On Fridays, traffic decreased in the peak period hours adjacent to the discounted periods, but this did not happen on Sundays.

There are several possible explanations for the results discovered so far:

- Different degrees of responsiveness to price at different times. This was noted earlier and means that consistent results across all time periods are not likely. The implication is that toll pricing strategies may be more effective at relieving congestion at some times than at others, or that a variety of toll strategies may be needed. Moreover, while the maximum amount toll differential allowed by the Legislature was used in the study, the maximum discount permitted was still a relatively modest $1.60.

- Discount coupons may not have been as effective as hypothesized. Coupon utilization varied greatly from hour to hour and from exit to exit, as Tables 1 and 2 show. These tables show the percentage of exiting traffic that presented coupons at each exit and in each hour. In each table there is one additional hour shown beyond the designated times for discount travel. The reason is that the Turnpike Authority chose to permit vehicles presenting coupons in the hour following the discounted period to receive the discounts. This minimized processing time and assured good customer relations. It also had the effect of dispersing the effectiveness of

FRIDAYS: PERCENT OF EXITING TRAFFIC PRESENTING COUPONS								
Plaza	10:00 am	11:00 am	12:00 pm	1:00 pm	7:00 pm	8:00 pm	9:00 pm	10:00 pm
1	11.9%	12.2%	11.6%	2.4%	23.3%	16.8%	13.0%	4.2%
2	6.8%	9.7%	9.4%	3.1%	15.1%	15.1%	15.2%	6.4%
3	9.0%	9.7%	13.4%	4.7%	16.6%	17.6%	21.4%	9.6%
4	7.4%	9.5%	8.9%	3.3%	16.2%	17.4%	17.6%	6.3%
5	7.2%	9.4%	9.6%	3.4%	14.3%	16.6%	15.6%	6.6%
6	9.2%	10.3%	11.0%	3.2%	14.5%	15.1%	15.4%	6.7%
6A	9.5%	11.8%	11.5%	2.9%	19.9%	18.0%	15.2%	4.4%
7	6.6%	7.9%	6.7%	2.6%	15.6%	13.7%	13.5%	3.9%
8	4.1%	4.3%	4.4%	1.6%	13.0%	11.4%	11.2%	4.3%
9	6.4%	5.0%	5.6%	1.6%	10.3%	8.0%	6.6%	2.5%
10	7.8%	7.1%	5.1%	1.8%	6.9%	12.6%	8.7%	4.1%
11	5.3%	5.5%	4.2%	2.1%	17.1%	17.1%	16.5%	6.3%
11A	4.6%	5.6%	4.7%	1.1%	13.3%	9.4%	7.5%	1.7%
TOTAL	9.8%	11.0%	10.8%	3.0%	18.5%	16.9%	15.4%	5.7%

Table 1

the discount program as measured by exiting traffic.

On Fridays, the average proportion of coupons used between 10:00am and 1:00pm was about 10.5%; and this rises to an average of 17% in the evening discount hours, but as noted earlier the shift in traffic was more decisive in the morning than in the evening. On Sundays, morning coupon use averaged 14.3%, rising to 18.8% in the evening. The proportion of coupon users on Sunday morning at Exit 1 remains fairly constant even in the morning hours, when the hourly share of traffic actually dropped during the discount weeks.

The problem is: what proportion of coupon users actually changed the time that they traveled in response to the incentive, and what proportion did not change the time and simply had a toll-free or reduced-toll trip? Even if a fairly high proportion of coupon users switched travel time, the total number of vehicles shifting is still limited. The survey conducted on the fourth weekend of August (and described below) asked whether a coupon was used and whether time was shifted earlier or later in response to the incentive. Of those responding to the survey and using a coupon, two thirds (66.5%) indicated they did not shift time, while 17.4% indicated they shifted their time ahead and 14.1% shifted time back (a total of 31.5% of coupon users indicating they shifted times).

These results should be interpreted with some caution since the survey was primarily designed to measure characteristics of peak hour travelers who were ineligible to use coupons. If one third of travelers actually shifted time, then even a relatively high coupon use hour such as 8:00-9:00pm on Sundays with 22.3% coupon use would result in 8% of traffic moving their travel time.

SUNDAYS: PERCENT OF EXITING TRAFFIC PRESENTING COUPONS								
	9:00 am	10:00 am	11:00 am	12:00 pm	6:00 pm	7:00 pm	8:00 pm	9:00 pm
1	27.2%	28.9%	31.5%	7.3%	24.9%	31.7%	35.3%	12.6%
2	11.8%	14.0%	14.6%	5.9%	15.0%	25.9%	24.8%	10.6%
3	14.6%	14.3%	15.6%	4.8%	18.8%	24.3%	24.6%	12.1%
4	15.0%	17.3%	21.1%	6.0%	16.4%	21.6%	21.4%	6.9%
5	12.2%	11.4%	13.0%	3.8%	13.3%	18.9%	18.4%	6.9%
6	10.2%	10.9%	14.2%	3.8%	13.9%	16.0%	15.6%	12.4%
6A	11.8%	14.6%	16.2%	4.0%	16.7%	21.6%	22.1%	7.9%
7	11.3%	12.5%	13.4%	4.9%	12.6%	16.0%	21.4%	8.7%
8	5.4%	7.1%	8.1%	1.8%	8.7%	10.5%	9.2%	3.5%
9	5.5%	5.7%	7.3%	3.0%	6.7%	8.4%	7.8%	2.2%
10	7.7%	10.0%	7.5%	2.5%	9.3%	9.0%	14.3%	4.3%
11	6.2%	8.4%	8.0%	1.9%	5.5%	8.6%	9.0%	3.2%
11A	4.4%	7.3%	8.3%	1.9%	6.6%	7.4%	8.1%	2.8%
Total	13.2%	14.2%	15.4%	3.8%	14.3%	19.7%	22.3%	8.2%

Table 2

Conversely, one could note that if the same percentage of respondents who indicated they shifted times when they received a price incentive to do so were extrapolated to a toll decrease applying to all traffic, it could mean that a third of traffic could be moved. This would imply that if the turnpike were at its 3100 vehicle capacity (one way), as many as 500 vehicles could be shifted.[5] This is almost certainly too high, but does illustrate the difference between responses to a discount coupon system and to a congestion pricing system that provides toll incentives to all travelers.

Other hours were lower in coupon use, and the proportion of time-shifters v. free-travelers could have varied at different hours and different exits. Given the constraints of the study, there was a clear tradeoff between the informational value of the coupons, the revenue-loss limitation effects, and the limits on the number of vehicles who would actually use coupons (whose numbers could not be forecast beforehand given the lack of experience with such an approach) and thus change their time of travel.

- Limited Information About the Experiment. The relatively low levels of effects could be a reflection of either a low proportion of time-shifters (a high proportion of free-travelers), the relatively short time over which the experiment was conducted and thus the time to learn about the opportunity to alter travel , or both. As noted earlier, the study team recognized very early the need for travelers to be made aware of the discount toll program in order to plan their trips to take advantage of it whenever possible. In the original study design, ten weeks of toll incentives were planned covering virtually all of the summer season. With the change in

[5] Assuming half of the travelers who shifted times were northbound and half were southbound.

study approach, actual traveler experience was cut in half.

To address the information issue, the study included two advertising campaigns on the first and last weekend. The survey found that slightly less than half (49%) of respondents were aware of the discount coupon program. This may be considered a high rate of awareness given the short time that was available and the high proportion (>60%) of respondents from out of state. It was accounted for primarily by Maine residents, 79% of whom reported awareness of the discount program. The high Maine awareness is most likely due to greater coverage in the news media (beyond advertising) and repeated use of the turnpike when coupons were being distributed. Reported awareness level for other regions were somewhat lower. Thirty nine percent of Massachusetts survey respondents said they were aware of the program, while the figures were 34% for the rest of New England, 15% for the Middle Atlantic states, and 25% for other states and provinces.

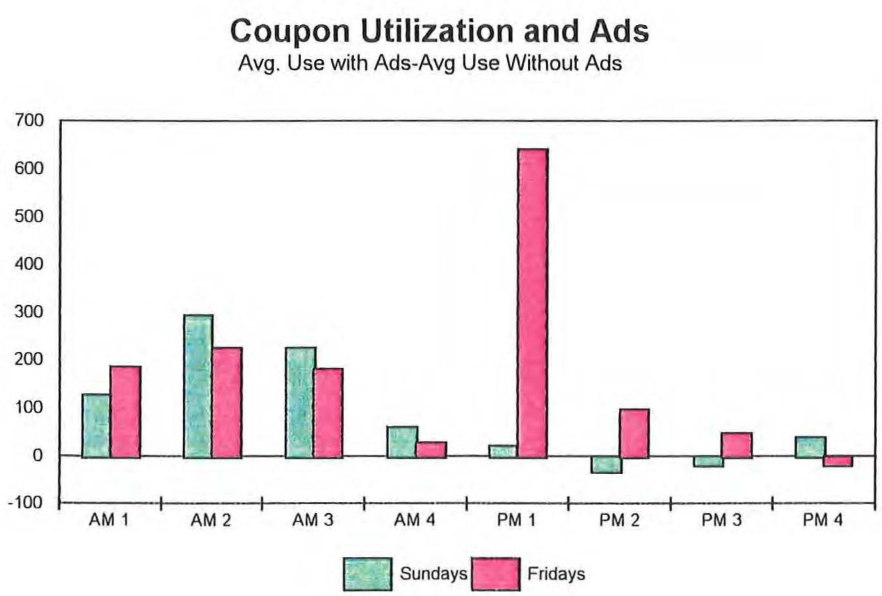

Figure 6

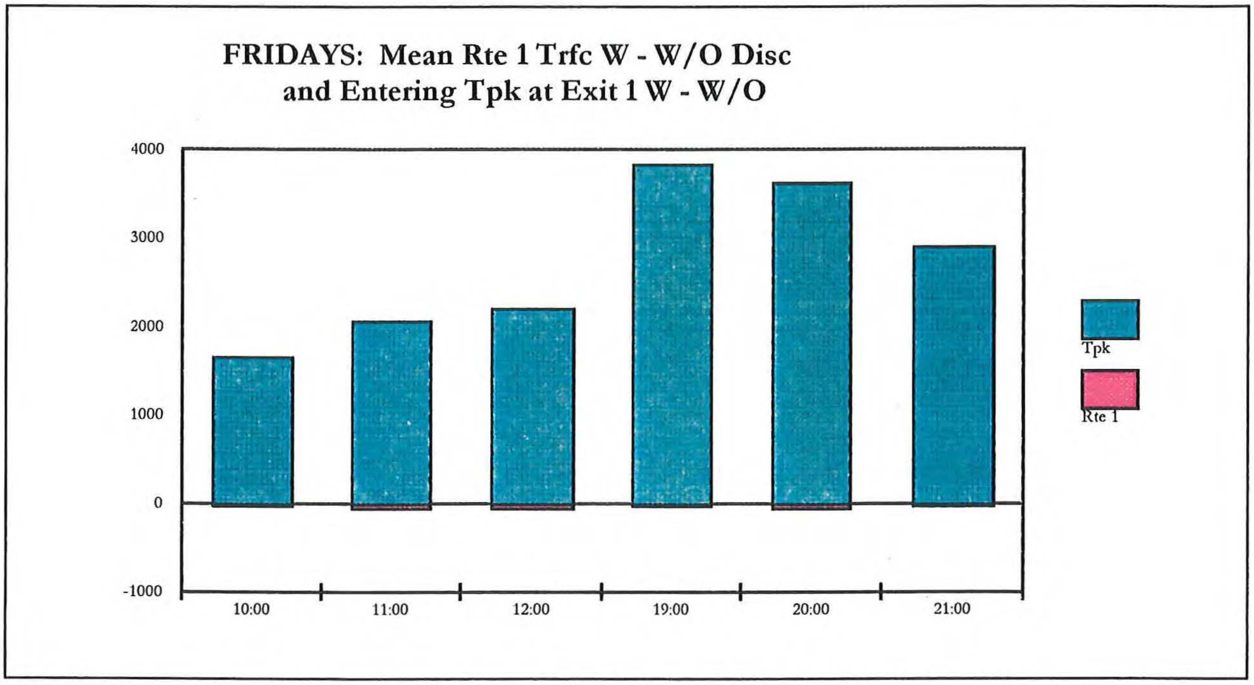

Figure 7

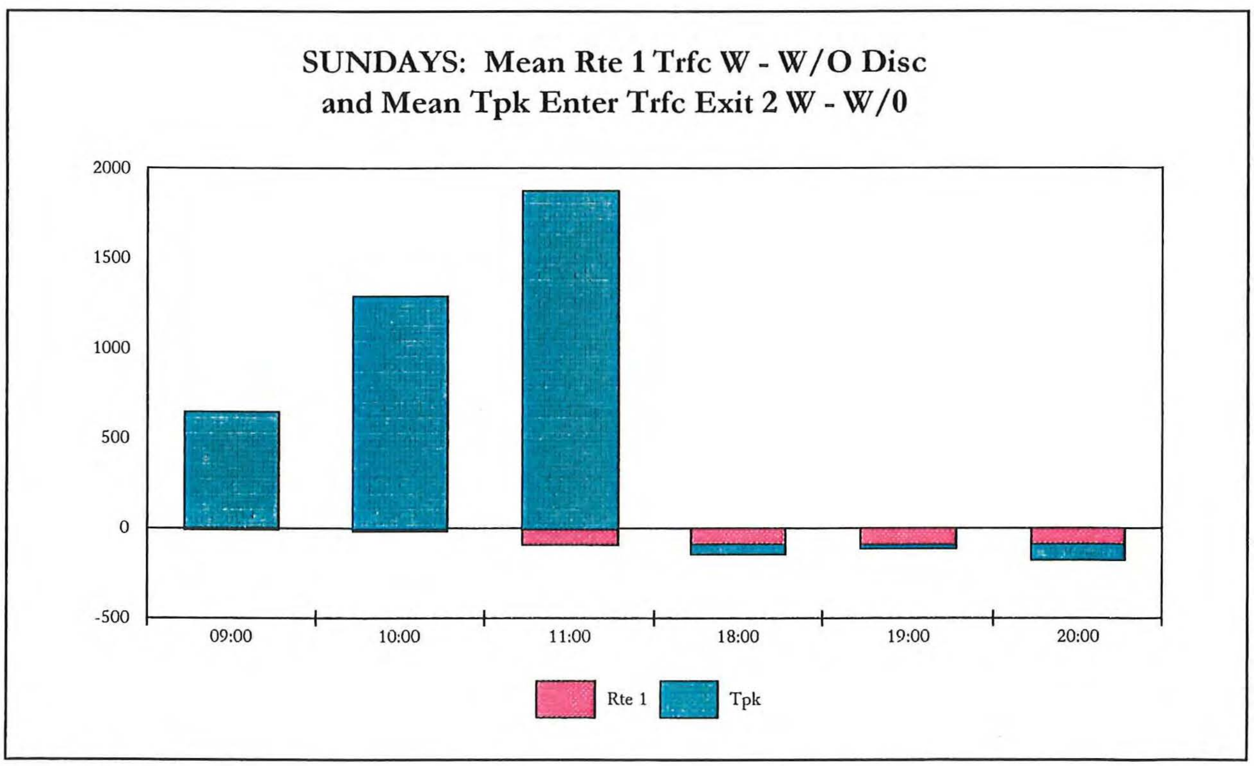

Figure 8

Moreover, as Figure 6 shows, there was not a significant difference between average coupon use on the weekends with advertising compared with those weekends without. This figure shows the average hourly use of coupons during the two weekends when advertising was in effect minus the average use on the three weekends when there was no advertising There was a definite increase in the 7:00 pm hour on August 4 which accounts for the large difference shown in the first evening hour for Fridays. Even when Labor Day is included with the other Sunday data[6], there is little change. With over one million coupons distributed through newspapers and on the Turnpike on weekends with advertising, the total of discount transactions is at most 200 more than on weekends without advertising The reasons for this are not clear, but suggest that the use of advertising in connection with a congestion pricing scheme needs to be carefully designed.

• Traffic Diversion from Route 1. The use of exiting traffic as the measure of change raises the question of whether a portion of traffic was diverted from Route 1 to the turnpike as a result of the free travel offered during the discount periods, accounting for the observed increases in the off-peak periods. Figures 7 and 8 compare the difference between average hourly traffic on Route 1 measured at the Department of Transportation's traffic counter located in Ogunquit with entering traffic on the turnpike for the same hours.

Figure 7 compares Friday traffic on Route 1 during the discount toll periods with entering traffic at Exit 1. Since the dominant direction of traffic on Fridays is northbound, Exit 1 was selected since traffic diverting from Route 1 to the turnpike to take advantage of the free travel would divert at that first exit south of the traffic counter. The figure shows the difference in average hourly traffic for the five weeks in 1995 when discounts were in effect and the weeks in which they were not. As indicated, there were very small decreases in Route 1 traffic in the discounted weeks compared with the undiscounted weeks, but Exit 1 entering traffic was many times higher. Even if all of the decreased traffic on Route 1 had diverted to the turnpike, this would not have accounted for the changes in turnpike traffic during these hours.

A similar analysis for Sundays is presented in Figure 8. This figure also includes Labor Day, and compares the change in Route 1 traffic between the discounted and undiscounted periods with entering traffic at Exit 2. Exit 2 is the first exit north of the Ogunquit counter so diversion of the predominantly southbound traffic on Sunday would be expected to move towards the turnpike here rather than continuing on Route 1. There is a noticeable decline in Route 1 traffic in the last hour of the morning discount period, as well as during each of the hours of the evening discount periods, but again this decline is not enough to account for the increase in traffic at Exit 2. It is likely that there was some diversion from Route 1 onto the turnpike, on Sundays, but again, increased traffic during the discounted hours on the turnpike was not accounted for by traffic diversions. Thus whatever the reasons for the inconsistent results, traffic diversion does not appear to be one of them.

• Too broad a peak. The inconsistent patterns of peak hour traffic shifts sug-

[6] More coupons were used on Labor Day than on any other day. 9,245 v. an average of 6,789 for the five Sundays of the discount weeks.

gest that a six hour time period may be too wide a peak period for effective management with tolls. On Fridays, there was a decrease in traffic in the first and last hour of the peak period, but little shift in the rest of the peak. Similarly there were both increases and decreases in peak period traffic on Sundays. Only on Labor Day is there a clear hourly pattern during the peak consistent with expectations.

• Other traffic determinants. The decline in traffic on Sunday mornings in the discounted weekends compared with the undiscounted weekends suggests that there may have been a consistent trend towards leaving later on Sundays in August compared with July, a trend reinforced by the discounts in the evening but which was not overcome in the morning. Weather during the summer of 1995 was remarkably and consistently dry and pleasant, in both July and Augusta, so this did not by itself explain shifts in traffic patterns occurring in August.

Regression Analysis

In this section, the traffic data is examined using multiple regression models to test for the statistical significance of relationships between traffic patterns and the use of the discount coupons. In the regression models, the dependent variable Y_{ijk}, representing the traffic passing through a given interchange (i), in a given hour (j), on a given day (k), may be represented in two different ways. The traffic count may be measured as a level, representing the actual number of cars passing through a given interchange in a given hour on a given day, or as a share, representing the ratio of the traffic passing through a given interchange in a given hour on a given day to the total traffic passing through that interchange on that day.

The advantages of representing the traffic count as a share rather than as a level may be illustrated using a simple example. Assume that it is rainy and cold every weekend in July prior to the introduction of the discount coupons, and warm and sunny each weekend in August when the coupons are in use. An increase in traffic during the discount hours in the month of August may thus be the result of (1) an increase in total traffic throughout the entire day, resulting from the better weather, or (2) the introduction of the coupons. If traffic is measured as a level it becomes necessary to include other variables such as the weather, the price of gasoline, the state of the economy, etc., that may affect the overall level of traffic. These variables must be controlled for to isolate the effects of the coupon on traffic flows. If any of these other explanatory variables are omitted from the model the estimates of the effects of the coupons may be biased (that is, incorrectly estimated).

This problem may be avoided by measuring traffic as a share. Assume the better weather in August increases the overall level of traffic (T) during the weekends by ten percent. As long as the traffic in a given hour (H_i) also increases by ten percent, the share of traffic in that hour ($S_i = H_i/T$) will remain unchanged. If traffic is measured as a share there is no need to include variables such as the weather, price of gasoline, etc., to control for overall changes in the traffic flow. The use of the hourly share of daily traffic as the dependent variable thus minimizes the possible effects of an omitted variable bias. For this reason we measured the traffic flow as a share, rather than as a level.

Model Specification

The decision to specify the dependent variable as a share instead of a level greatly simplifies the specification of the model. Since Y_{ijk} represents the share of traffic passing through a given interchange (i) in a given hour (j) on a given day (k), it is only necessary to control for the different exits, hours of the days, and days of the week.

The discount coupons were valid on two days, Fridays and Sundays. Given the significant differences in the traffic patterns during these two days, the decision was made to estimate separate equations for Fridays and Sundays. As a result, it is unnecessary to include an explanatory variable to control for the day of the week.

Two different models with two different independent variables were used to represent the treatment effect, or the introduction of the discount coupons. In Model 1, the independent variable is a simple binary (dummy) variable defined to be DUM, and is specified as follows: DUM = 0 in the first five weeks of the summer during which no coupons were used, and DUM = 1 in the last five weeks of the summer during which the coupons were used. Model 2 uses a variable, RATIO, which represents the fraction of traffic passing through a given interchange at a given hour that presented a coupon to the toll attendant.

The treatment variable DUM implicitly assumes that the discount coupon program was equally effective throughout the entire five week period in which it was in use. In reality, the percentage of motorists employing the coupons varied across hours, days, weeks of the month, and by exit. As a result, the DUM variable may fail to provide an accurate measure of the responsiveness of traffic shares to price changes resulting from the use of the coupons.

The different exits and hours of the day were represented with binary (dummy) variables. The data were collected from exits 1-7 and 6a, implying a total of 8 exits. A binary variable was defined for each exit, with $E_1 = 1$ if the observation was collected from exit 1 (for example), and 0 otherwise. An additional twenty-four binary variables were defined for each hour of the day, with $H_1 = 1$ if the observation occurred during the first hour (for example), and 0 otherwise. (The data were measured in the period following a given hour; for example, H_8 represents the period of time between 8:00am and 8:59 am.)

Using these definitions the basic model is defined in equation 1:

$$Y_{ij}=\alpha+\sum \beta_i E_i+\sum \beta_i H_i+\sum \beta[D_j DUM*H_j]$$

There E_i represents a binary variable for each exit (2-7 and 6a), H_j represents a binary variable for each hour (j = 2 - 24), and DUM*H_j is an interaction term constructed as the product of DUM and H_j. In some models the interaction term was constructed as the product of RATIO (the percentage of traffic using the discount coupons) and H_{j1}.

The primary coefficients of interest are the β_{Dj}, as they represent the impact of the discount coupons on the share of traffic in a given hour. Prior to the pricing experiment the value of DUM = 0, implying that the share of traffic passing through a given interchange at a given hour is B_j. During the experiment the value of DUM = 1, implying that the share of traffic is now $\beta_j + \beta_{Dj}$. The coefficient β_{Dj} thus represents the change in the traffic share following the introduction of the coupons. If the estimated value of $\beta_{Dj} > 0$, the use of the discount coupons increases the share of traffic during the off-peak hours. If the estimated value of $\beta_{Dj} < 0$ (= 0), the discount coupons reduced (or had no impact on) the share of traffic during the off-peak hours.

In some equations RATIO was used in place of DUM to determine the impact of the discount coupons on traffic shares. Prior to the experiment RATIO = 0, implying that the share of traffic passing through a given exit at a given hour is B_j. Following the introduction of the coupons RATIO > 0, implying that the traffic share is now $\beta_j + \beta_{Dj}$RATIO. If the estimated value of $\beta_{Dj} > 0$, the off-peak traffic shares increase, with the increase positively related to the use of the coupons.

In the models discussed above, the coefficient β_{Dj} is constant, implying that the effects of the discount coupons do not increase (or decrease) over time. It is possible that in the weeks following the introduction of the coupons more travelers learned about them, increasing the impact of the discount pricing. To test this hypothesis the interaction term DUM*H_j was replaced with DUM*H_j*$WEEK_m$, where $WEEK_m$ is a binary variable defined as $WEEK_1 = 1$ in the first week (for example) following the introduction of the coupons, and 0 otherwise. Five such variables were added to the equation, one for each week of the experiment. The coefficient β_{Dj} was replaced with β_{Djm}, thus allowing the impact of the experiment to vary over time. The results from this expanded model were not particularly encouraging, as the additional variables added little to the overall explanatory power of the model (the R^2). In addition, the effects of the experiment were random over the 5 week period, neither increasing or decreasing systematically over time. For this reason the simpler model that restricts the impact of the discount coupons to be constant over time was employed.

Estimation

Two additional issues are (I) the use of weighted as opposed to unweighted data, and (ii) the treatment of the Labor Day data.

Each of the observations on the dependent variable represents the share of total daily traffic passing through a given exit in a given hour. Some exits may have a traffic flow with hundreds of vehicles, while others may have thousands. Treating the data as unweighted gives each of these observations equal weight in determining the final value of the estimated coefficients.

As an alternative, it is possible to assign a greater weight to the observations representing a greater number of cars by estimating the model as a weighted regression. We employ the weighted regression approach, and use the raw traffic counts as the weights. This approach gives the observations representing a greater number of vehicles a greater weight in determining the value of the estimated coefficients.

The second issue deals with the treatment of the Labor Day data. Usually Sunday represents the end of the weekend, implying an increase in traffic as families head home prior to the start of the work week. Since Labor Day always occurs on a Monday, the Sunday prior to Labor Day no longer represents the end of the weekend, implying that traffic patterns on this day may differ from other Sundays. During the Labor Day weekend the traffic patterns on Monday may be more representative of the normal end of the weekend pattern than the traffic counts on Sunday.

We estimate the model for Sundays treating the Labor Day data as follows: (I) do not include Labor Day in the Sunday data, (ii) add Labor Day to the Sunday data, and (iii) use the Labor Day data in place of the data for the Sunday prior to Labor Day. The third alternative would appear to be the preferred approach, with the first alternative the least preferred.

Regression Results

The estimated values of the t-statistics, are presented in Table A-2. Estimates are presented for both the DUM and RATIO treatment variables, and for the three different treatments of the Labor Day data. All six models provide roughly the same explanatory power, with the adjusted R^2's averaging approximately 75%. Two conclusions may be drawn from a review of the regression results for Sundays. First, the manner in which the data from Labor Day are treated has a significant impact on the estimated results. Including the Labor day data together with the Sunday data, or replacing the data for the last Sunday with the data from Labor Day leads to an increase in the number of estimated coefficients with statistically significant values. We believe that the regression results based on the data that includes Labor Day should be given the most weight.

Weighted Regression Results for **Sundays**				
Hour	T-Statistic DUM Equation	T-Statistic RATIO Equation	T-Statistic DUM Equation	T-Statistic RATIO Equation
	Excluding Labor Day		**Including Labor Day**	
9am	0.3685	1.0507	1.0351	**2.4269**
10am	0.5395	0.9610	1.5515	**3.2333**
11am	0.3752	0.9214	1.0504	0.1706
12pm	**1.9000**	1.1269	**2.2884**	*1.8474*
6pm	0.3040	0.6892	0.5294	0.8787
7pm	0.6415	0.6274	1.3162	0.5290
8pm	0.0609	**2.2059**	0.1391	2.3708
9pm	0.8132	0.2342	0.7651	0.6672
R^2	.7543	.7750	.7485	.7503

Shaded = Negative Coefficient Bold = Statistically Significant at .05 level Italics= Significant at .10 level

Table 3

Second, the different independent variables, DUM and RATIO, often produce different results. This can be seen most clearly by examining the third set of estimates, in which the data for Labor Day replace the data for the last Sunday. When DUM is used as the treatment variable, the introduction of the discount coupons results in positive changes in traffic shares in the morning hours (although only the estimate for 12pm is statistically significant at the 5% level or better), and negative but statistically insignificant changes in the evening hours. When RATIO is employed as the treatment variable, use of the discount coupons leads to a positive and statistically significant increases in traffic shares during 9 a.m., 10 a.m. and 8 p.m., and has no statistically significant impact during the other hours. For the reasons discussed in Section B we place greater reliance on the results obtained using RATIO variable.

The estimated values of the β_{D_j} parameters for the Friday data, together with the t-statistics, are presented in Table Estimates are presented for both the DUM (Model 1) and RATIO (Model 2) treatment variables.[7] Recall that a positive estimate implies an increase in the share of traffic during the off-peak hours following the introduction of the discount coupons. Of the sixteen estimated parameters, twelve (75%) are positive, although only one, the estimate for 10 a.m. using the ratio variable, is statistically significant at the 10% level or better. The estimated parameter for 12 p.m. is statistically significant at the 11% level in the DUM equation, and at approximately the 15% level in the RATIO equation. Taken together, the results fail to

Weighted Regression Results for **FRIDAYS**		
Hour	T-Statistic DUM Equation	T-Statistic RATIO Equation
10am	1.2288	**2.6689**
11am	0.2401	0.9086
12am	1.6103	1.4389
1pm	0.1260	0.5765
7pm	0.5763	0.6149
8pm	0.1288	0.2377
9pm	0.3218	0.7544
10pm	0.3398	0.2242
R^2	.7243	.7253

Shaded cells = negative coefficients. **Bold** = Statistically Significant

Table 4

[7] Model 3 results using the effects on traffic exiting at each southern toll plaza as the dependent variable are preliminary and are not presented here.

indicate a consistent increase in traffic shares during the off-peak hours following the introduction of the discount coupons.

Results 2: Composition of Traffic

A key question concerning the applicability of congestion pricing to the Maine Turnpike is whether the high proportion of vacationers making up weekend turnpike traffic means that there is not enough repeat usage to allow learning about price incentives and responding to them. The only way to gauge these characteristics of Maine Turnpike users was to conduct a survey, and this was done over the weekend of the August 25-27, the fourth weekend of the experiment.

The survey technique chosen was a hand-out, mail-back survey of the type typically employed in highway user studies. The survey form was handed to all entering vehicles at selected exits and selected times (see box). On Fridays and Saturdays of the fourth weekend, the survey was distributed during the peak hours as were the coupon-brochures distributed on all other weeks. The surveys distributed on these days were printed with two coupons attached so that coupon distribution would continue as on other weekends. On Sunday, the survey was distributed without coupons attached, and was thus distributed in both peak and offpeak hours. The York toll plaza was used as a distribution point on Friday and Saturday to reflect the primarily northbound traffic; on Sundays, Wells and Kennebunk were substituted to reflect the predominantly southbound traffic.

Day	Plazas	Times
Fridays	1, 6A, 7, 9, 11A	1:00p-6:00p
Saturdays	1, 6A, 7, 9, 11A	11:00a-1:00p
Sundays	2, 3, 6A, 7, 9, 11A	12:00p-6:00p

Times of Survey Distribution

Returns of the survey varied substantially from day to day and exit to exit, as shown in Table 5. Overall, 16.1% of the traffic entering the turnpike during distribution hours returned their surveys. More than 60% of the survey returns were on Sunday, followed by Friday (27%) and Saturday (13%). Sunday was also the highest day for percentage of returns, with over 36% of surveys returned. The lowest percentage of returns was on Fridays (8.4%). Only 5% of entering traffic at Exit 1 on Fridays returned surveys, but this represented about 14% of all the surveys returned.

Table 6 shows the responses to the question: "how often do you make this trip compared with responses to a question about

Percent of Traffic Entering at Designated Hours that Returned Survey								
	ENTERING PLAZA							
Survey Date	1	2	3	6A	7	9	11A	Total
Friday Aug 25	4.9%			12.7%	2.6%	4.7%	5.8%	8.4%
Saturday Aug 26	2.9%			13.5%	10.2%	13.5%	5.0%	9.5%
Sunday Aug 27		29.3%	0.9%	19.9%	10.8%	13.6%	10.9%	36.3%
Total	4.3%	29.3%	0.9%	16.6%	5.8%	10.0%	8.6%	16.1%

Table 5

	TRIP FREQUENCY						
	Year Round	Weekends Summer	All Summer	Once/Year	Other	NA	TOTAL
PURPOSE							
Work	4.1%	0.0%	0.2%	0.0%	0.3%	0.0%	4.7%
Company Business	4.2%	0.0%	0.1%	0.2%	0.6%	0.0%	5.2%
Personal Business	8.7%	0.3%	0.6%	0.6%	1.9%	0.0%	12.1%
Shopping	4.8%	0.3%	0.4%	0.9%	0.9%	0.0%	7.2%
Social	10.6%	0.5%	0.9%	2.2%	2.7%	0.0%	16.9%
Recreation	16.9%	4.9%	9.0%	11.0%	9.3%	0.2%	51.2%
School	0.8%	NA	0.0%	0.2%	0.4%	0.0%	1.4%
N/A	0.4%	0.0%	0.1%	0.0%	0.1%	0.6%	1.2%
TOTAL	50.4%	6.0%	11.3%	15.1%	16.2%	0.9%	100.0%

Table 6

the purpose of the trip". Over 50% of respondents indicated that they travel the turnpike year round, while 6% indicated they travel on weekends only during the summer and 11% all summer. This means that two-thirds of the survey respondents indicated they travel the turnpike with enough regularity to learn about the incentive program.

Over half of the respondents indicate that they were traveling for recreational purposes. As might be expected, the highest proportion of once-per-year travelers were traveling for recreation. It is interesting to note, however, that nearly 33% of recreational travelers indicated they did so year round.

Table 7 shows the frequency of trip by the day of respondent's travel on the survey weekend. Friday shows the highest proportion of year round travelers, as would be expected since this also contained the highest proportion of work-related and commuter

	Year Round	Weekends Summer	All Summer	Once/Year	Other	Total
SUN	47.5%	6.9%	12.2%	16.4%	17.0%	100.0%
FRI	59.4%	4.5%	10.3%	10.1%	15.7%	100.0%
SAT	48.8%	5.3%	9.9%	21.1%	14.9%	100.0%

Table 7

travelers. However, more than 60% of travelers were repeat users on all three days, with the lowest proportion on Saturdays. Saturdays are the day when week-long vacations normally begin and end.

tolls and offpeak discounts are likely to persuade more travelers to shift the time of their travel, it was decided to examine the public's reaction to peak hour pricing using the survey. The survey asked the following question:

	Year Round	Wkends Summer	All Summer	Once/Year	Other	TOTAL
Maine	75.5%	2.5%	4.1%	5.5%	12.4%	100.0%
Massachusetts	44.7%	10.9%	16.2%	13.6%	14.5%	100.0%
Other New Eng	40.0%	7.9%	15.7%	18.9%	17.5%	100.0%
Middle Atlantic	16.4%	2.2%	11.7%	44.7%	24.9%	100.0%
Other	22.6%	2.9%	16.2%	25.2%	33.1%	100.0%
TOTAL	50.9%	6.1%	11.4%	15.3%	16.4%	100.0%

Table 8

Table 8 shows the frequency of travel by the home state of the respondent. As would be expected, Maine residents showed the highest proportion of year round travel, but there is also a high proportion of year round travelers from Massachusetts (44.7%) and the rest of New England (40%). Combining year round, summer weekends, and all summer responses, nearly 72% of Massachusetts travelers are frequent users of the turnpike.

Thus, despite the very high proportion of out-of-state and recreational users of the turnpike on weekends, it is likely that a significant enough proportion of out-of-state users of the turnpike can learn about the availability of any congestion pricing system.

Perceptions of Congestion Pricing

The controversy sparked by the proposal to impose a peak hour surcharge led the Legislature to prohibit peak hour tolls. Since the price differentials created by peak hour

"In the future, the Maine Turnpike Authority may decide to continue providing discounted tolls for travel during offpeak hours. If this occurred, the Authority would have to make a decision regarding the revenues that would be lost. Which of the following would you recommend to the Authority:

1. Raise tolls all year
2. Raise tolls during the summer only
3. Raise tolls during peak hours
4. Permanently reduce revenues and cut maintenance
5. Other."

Overall preferences were as follows:

Option	Percent Choosing
Raise tolls all year	12.3%
Raise tolls in summer	11.0%
Raise tolls in peak hours	34.4%
Reduce Revenue/Cut Maintenance	17.2%
Other	19.7%

Of the options, three clearly involve raising revenues, and these options were chosen by more than half (57.7%) of respondents.

	Increase Tolls					
	All Year	Summer Only	Peak Hours	Revenue Reduced	Other	Total
ME	7.1%	13.1%	33.2%	21.4%	25.2%	100.0%
MA	15.7%	9.4%	40.0%	17.8%	17.1%	100.0%
Other NE	17.6%	12.1%	35.8%	15.8%	18.7%	100.0%
Mid Atlantic	16.7%	13.2%	37.7%	14.3%	18.1%	100.0%
Other	15.6%	11.8%	33.6%	14.2%	24.9%	100.0%

Table 9

Table 9 shows the home state of the respondent compared with the answer to question about revenue options. Raising tolls during peak hours was clearly the preferred choice among respondents from all regions. Respondents from out-of-state were somewhat more likely to prefer this option than were Maine residents, with Massachusetts residents most supportive. Raising tolls all year was the least preferred by Maine residents, while raising tolls in the summer only was least preferred by Massachusetts residents. Maine residents were also the most likely to suggest permanently reducing revenues and maintenance.

The general direction of these findings are confirmed in Table 10, which compares responses about revenues with the purpose of trip. Again, peak hour tolls were preferred in most cases. Recreational travelers preferred peak hour tolls nearly two to one over any other option. Peak hour tolls received least support from those traveling for work and for company business. Travelers for work were the most likely to select reducing revenues and maintenance as the pre-

	Increase Tolls						
	All Year	Summer Only	Peak Hours	Revenue Reduced	Other	N/A	TOTAL
Work	5.5%	10.7%	23.3%	23.7%	31.6%	5.1%	100%
Company	7.9%	10.0%	26.8%	23.9%	27.1%	4.3%	100%
Personal	9.4%	11.3%	35.2%	19.0%	20.7%	4.3%	100%
Shopping	9.8%	13.4%	32.2%	21.6%	18.6%	4.1%	100%
Social	10.0%	13.0%	35.9%	17.1%	19.5%	4.4%	100%
Recreation	15.5%	10.2%	35.6%	14.9%	18.1%	5.8%	100%
School	5.4%	16.2%	41.9%	14.9%	10.8%	10.8%	100%
N/A	4.8%	3.2%	12.9%	19.4%	14.5%	45.2%	100%
TOTAL	12.3%	11.0%	34.1%	17.2%	19.6%	5.7%	100%

Table 10

ferred option, while company business travelers selected this option just behind peak hour pricing.. This is a somewhat curious finding since these are the most frequent of the travelers on the turnpike; 87% of those traveling to work and 81% of those traveling on company business report using the turnpike year round. At the same time, these frequent users may be the most resistant to toll increases, though as a whole respondents in these categories were still more likely to select a toll increase than not.

The survey data indicate that, when presented with a direct benefit to them in the form of an opportunity for discounted tolls during off peaks, turnpike users believe that peak hour pricing is the best alternative to make up revenue losses. This suggests that so long as there is a perceived balance between peak surcharges and off-peak discounts, there will be wider acceptance of peak tolls than might have been anticipated given the controversy surrounding this subject.

It should be noted that the "other" category is quite large, accounting for nearly one fifth of all responses. The questionnaire provided room for respondents to briefly indicate what option they would prefer, many took advantage of this.

The question of peak hour tolls was also examined using a survey question designed to elicit the reaction to varying levels of peak hour surcharges on existing tolls. Survey respondents were given four options in the event of a surcharge varying from $0.25 to $3.00 (in 25 cent increments from $0.25 to $1.00 and 50 cent increments from there to $3.00):

- Continue travel on the turnpike
- Shift the time of travel to avoid the surcharge
- Shift the route of travel to avoid the surcharge
- Not make the trip.

The question presented these options in the form of a grid in which the respondent could indicate preferences by simply checking the appropriate box. The hypothetical toll surcharges were presented in random order to encourage careful examination of the options:

Figure 9 shows the total number of times a box in a grid was checked by a respondent. Because respondents were not always consistent in their check marks (for example, some respondents checked only one or two boxes in the questionnaire), the count of responses underlying Figure 9 used only those responses that showed consistency (transitivity) of preferences.

Figure 9 shows that at relatively low hypothetical surcharges such as $0.25, most survey respondents would continue their trip, but as the surcharge increases, there is a greater tendency to alter travel behavior. For surcharges from $0.25 to $1.50, there is relative indifference between altering travel time and route. At a surcharge above $2.00, there is an increasing preference to alter route rather than time, which is very difficult to do on the Maine Turnpike. It is also noteworthy that a surcharge of $2.00 appears to be the level at which the stated preferences for continuing travel crosses the preference for altering travel; beyond this point stated preferences indicate a greater willingness to alter behavior.

ing travel; beyond this point stated preferences indicate a greater willingness to alter behavior.

not make a trip at surcharges below $3.00, and only 1.7% of respondents who were traveling for recreation say they would not make

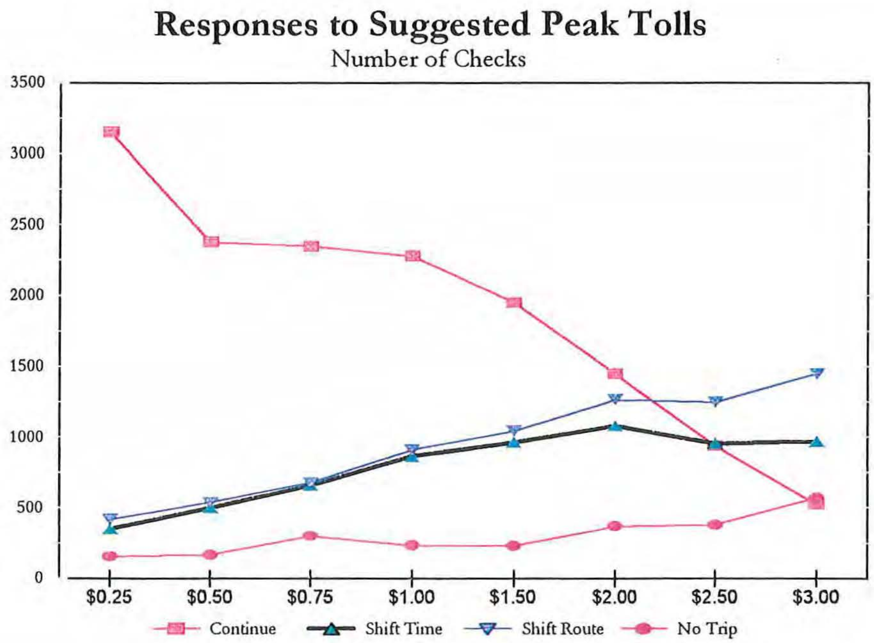

Figure 9

There was particular concern about the potential of a surcharge for discouraging travelers from even making a trip. This was one of the options presented, but it was not selected by many survey respondents at levels below $3.00. Table 11 shows additional detail on those respondents who indicated they would not make a trip at a given surcharge level. In this table, the amount shown is the lowest amount that a respondent checked. Table 11 compares the lowest rate at which respondents indicated they would not make a trip with the purpose of the trip. A total of 14.8% of respondents indicated that they would not make the trip if a surcharge were imposed, but the vast majority of these would not make the trip at a level of $3.00. Only 3.5% of respondents indicated they would

the trip at surcharges below $3.00. Below $2.00, the proportion of respondents who say they would not make the trip is even lower: 1.6% of total respondents, and 0.8% of recreational travelers.

Great care needs to be exercised in interpreting any of the survey responses about the reaction to specific peak hour surcharges. The problem of eliciting valid responses to hypothetical prices is an issue that plagues much economic research using surveys.[7]

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[6] The problems are commonly encountered in the use of surveys to value environmental resources whose values are not set in markets. A good discussion of the issues may be found in: Mitchell,

	Lowest Toll Surcharge at Which Respondent Indicated They Would Not Make The Trip (Percent of Total Responses)									
PURPOSE	**$0.25**	**$0.50**	**$0.75**	**$1.00**	**$1.50**	**$2.00**	**$2.50**	**$3.00**	**Total**	**<$3.00**
Work	0.04%	0.02%	0.00%	0.02%	0.00%	0.11%	0.00%	0.32%	0.50%	0.19%
Company	0.02%	0.00%	0.04%	0.00%	0.02%	0.06%	0.02%	0.37%	0.52%	0.15%
Personal	0.02%	0.02%	0.02%	0.09%	0.02%	0.19%	0.11%	1.34%	1.81%	0.47%
Shopping	0.04%	0.07%	0.06%	0.02%	0.02%	0.09%	0.07%	1.12%	1.49%	0.37%
Social	0.04%	0.07%	0.04%	0.07%	0.04%	0.24%	0.04%	2.17%	2.71%	0.54%
Recreation	0.32%	0.13%	0.04%	0.15%	0.19%	0.54%	0.34%	5.85%	7.54%	1.70%
School	0.02%	0.00%	0.00%	0.02%	0.00%	0.04%	0.00%	0.07%	0.15%	0.07%
N/A	0.00%	0.00%	0.00%	0.00%	0.00%	0.04%	0.00%	0.06%	0.09%	0.04%
TOTAL	0.49%	0.32%	0.19%	0.37%	0.28%	1.31%	0.58%	11.30%	14.83%	3.53%

Table 11

There are two possible problems that arise: strategic bias and "unreal" responses. The first problem arises when someone is asked their response to raising a price and they believe that by indicating a willingness to accept a higher price they may be signaling approval for raising the price. Thus they bias their answers downward. The second problem arises when people are confronted with a pricing situation with which they are unfamiliar; their answers may reflect their willingness to answer a hypothetical question but not necessarily what they would do when confronted with an actual increase in prices (in this case, tolls).

For these reasons, this survey data can only be used as a general guide to reactions to toll surcharges. There is no survey-based substitute for actually implementing toll changes to measure possible changes in traffic. The survey does reveal that there is clear resistance to toll surcharges at a $3.00 level, but relatively little resistance below that level. The survey suggests that surcharges ranging from $1.00 to $2.00 would meet little resistance and may be effective in altering traffic behavior.

Conclusions

The field trials of congestion pricing on the Maine Turnpike and the accompanying survey substantially met the objectives set forth for the 1995 study, but important issues remained unresolved.

- Offering free passage did increase use of off-peak hours when flexibility to change time of travel was likely greatest, but was not effective at other times.

- Peak hour traffic was not significantly affected, due in large part to the extended peak period and to the limitations of the discount coupon system.

- The discount coupon system was effective in informing people about the benefits of traveling in the off-peak, but limiting the availability of discounts by using coupons (that cannot be available to everyone) may have limited the total number of vehicles which might alter their travel.
- An aggressive public information campaign targeted directly at Turnpike users resulted in relatively high awareness of the program. A limited advertising campaign in commercial media may have been helpful, but it did not increase the number of coupons used except on one or two days.

- While as much information as possible was provided to patrons the limited period of the experiment was probably too short to fully inform all those who might potentially have shifted their travel time.

The survey revealed that repeat users of the turnpike, even from out-of-state, constitute a significant majority of weekend traffic. This means that congestion pricing can become known to a significant portion of users. The survey also showed a broad support for the idea of peak hour pricing when placed in the context of off-peak discounts.

THE 1996 STUDY

STUDY APPROACH

In designing the 1996 study, three critical elements shaped the study design:

1. The legislation prohibiting raising tolls during peak hours remained in effect. Once again, only discounts would be offered.

2. The electronic toll collection system would not be implemented in time for the 1996 trials.

3. The 1996 study would focus on those who traveled on the Turnpike frequently enough during the summer to respond to price incentives.

As noted above, the original study design took into account the intention of the Turnpike Authority to convert to electronic toll collection by the summer of 1996. Because of delays in implementing the new system, it became clear that the second year of trials would have to be conducted using the existing ticket system. This meant that the advantages of shifting from a tolling system based on time of exit (the ticket system) to one based on time of entry (which the electronic toll system would be) were lost. In addition, it was clear that the discount coupon system used in 1995 would be ill-suited to an approach that targeted frequent travelers. The discount coupons were widely distributed on the Turnpike and through the media, and could be used for casual as well as regular trips.

The decision was made, therefore, to use a variation on the frequent travelers program offered by airlines. Discounted tolls during the off-peak would be offered using the Turnpike's magnetic card pass system. This system, which has been in effect since 1991 allows commuters to present a credit-type card issued by the Turnpike Authority at the time the toll is due. The card is swiped through a magnetic card reader at the toll booth, which records the transaction. Commercial users who frequently use the Turnpike may also pay through a similar arrangement.[1]

The new approach was called the SmartPass program. SmartPass holders would be able to present their pass at the toll booth for travel involving the southern portion of the Turnpike (exits 1-7) during off-peak hours and receive discounts of up to \$1.60 per trip, or a free trip if the toll were less than that amount. This was the same arrangement that was in effect for the discount coupons in 1995. The pass could be used for unlimited trips (on eligible days and times) over the summer. Three changes were made from the discount coupon program:

1. The program would run 10 weeks rather than 5, from June 28 to September 2 (Labor Day)

2. Saturdays were added to the program. Discounts were offered from 8:00 am to 10:00 am and from 3:00 to 5:00 pm on Saturdays.

3. The discount hours on Friday and Sunday were reduced from three hours (in 1995) before and after the peak to two hours. This change was made in consideration of revenue losses for the Authority. The hours farthest away from the peak were the least used in the

[1] The commuter pass system is based on flat payment for a three month period which allows unlimited travel between the exits paid for by the commuter. The toll booth transaction simply records the presence of a commuter on the highway. Commercial customers establish a credit account; individual transactions are recorded and a monthly statement is presented to the account holder for payment.

discount coupon program, and with the addition of Saturdays, this was considered a reasonable accommodation to the Authority's revenue concern.[2]

The distribution of SmartPasses was arranged through several means. A brochure was developed explaining the program, and was distributed at Turnpike toll booths beginning on Memorial Day weekend, and continuing through the first weekend in August. The brochure contained an application form which could be filled out and either mailed to the Authority or handed in at the exiting toll booth. In addition, a toll-free number was established through which Turnpike patrons could request a SmartPass. The toll-free number was publicized using media in Maine, New Hampshire, and Massachusetts in a manner similar to the publicity campaign undertaken in 1995. The Turnpike Authority prepared the SmartPass and mailed it to the customer, usually within one week of receiving the request. The passes were available at no charge.

The SmartPass thus combined the essential elements of the 1995 discount coupon program with respect to the terms and conditions of the discount, extended the offer to additional weeks and days, and provided a convenient method of both obtaining the pass and receiving the discounts. Moreover, the program was specifically designed to be most useful to those who would frequently travel the Turnpike over the course of the summer without the necessity for repeated use of coupons.

[2] July 4 fell on a Thursday in 1996, meaning this weekend would not follow normal patterns. The SmartPass was made eligible for use from Wednesday, July 3 through Sunday, July 7 in order to minimize the chances for confusion but still make the pass usable for frequent travellers.

1996 RESULTS

Results from the 1996 trials are discussed in the sections below. An overview of SmartPass use is presented first including results of a survey of SmartPass holders, followed by analysis of changes in traffic. Changes in traffic are examined using analysis of the exiting toll plaza data in a manner similar to that undertaken for the 1995 trials. In addition, the Turnpike Authority installed traffic counters to examine main-line traffic volumes. Data from this analysis are also presented.

1. SmartPass Use

There were 26,314 SmartPasses distributed over the course of the summer. SmartPass holders used their passes a total of 46,615 times over the 10 weekends when they could be used. Table 12 shows a summary of SmartPass use by day and by eligible hours. Three quarters of passes were used on Friday and Sunday, with Sunday accounting for more than 40% of users. Use tended to be heavier in the evenings of Friday and Sunday than in the mornings, though morning use was heavier on Saturdays. The 46,615 transactions represent an average of 1.8 transactions per holder.

Even with 26,000 passes distributed, the total number of SmartPass transactions was substantially smaller than the total number of discount coupon transactions in 1995. Over the five weeks (11 days) that the discount coupon program was in effect, a total

TOTAL SMARTPASS TRANSACTIONS BY DAY AND HOUR						
Time⇨	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM
Friday	N/A	N/A	145	2,864	2,927	455
Saturday	1,715	2,885	398	N/A	N/A	N/A
Sunday	N/A	149	3,091	3,609	567	N/A
	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM
Friday	N/A	N/A	N/A	262	4,730	4,336
Saturday	2,446	2,572	537	N/A	N/A	N/A
Sunday	N/A	N/A	N/A	280	5,526	5,097
	OTHER	TOTAL	Percent			
Friday	922	16,641	35.7%			
Saturday	288	10,841	23.3%			
Sunday	814	19,133	41.0%			
TOTAL		46,615				

Table 12

of 61,000 transactions were recorded compared with only 46,615 over the ten weeks (36 days)[3] of the 1996 program. This lower level of use means fewer trips were affected, but it also means that there were fewer travelers who received the discount for traveling at a time when they would have gone anyway.

There are a number of possible reasons for this. First, the distribution of SmartPasses might have been skewed towards the latter part of the summer through distribution problems or because people applied late. Figure 10 shows, however, that, in fact, the majority of SmartPasses were distributed in the early part of the summer (75% had been mailed by July 14). Moreover, after some initial fluctuations, the last seven weeks of the trial period showed the number of SmartPass transactions per weekend remained relatively constant, while the proportion of SmartPasses distributed each weekend that were actually used also remained constant. These patterns are consistent with expectations that the bulk of passes would be distributed early in the summer and would then be used throughout the 10 week period.

[3] Including Wednesday July 3, Thursday July 4, and Monday, September 2.

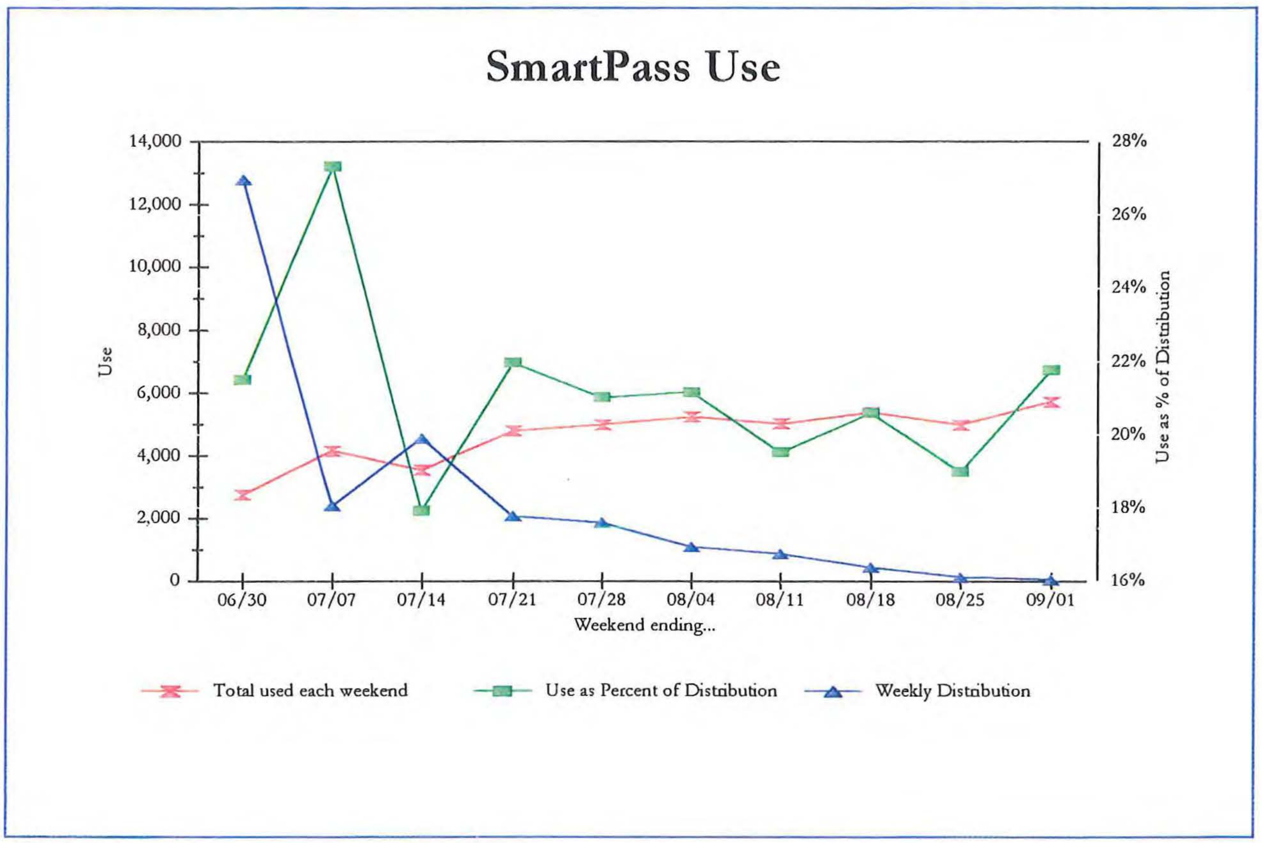
SmartPass Use
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Use
28%
26%
24%
22%
20%
18%
16%
Use as % of Distribution
06/30
07/07
07/14
07/21
07/28
08/04
08/11
08/18
08/25
09/01
Weekend ending...
Total used each weekend
Use as Percent of Distribution
Weekly Distribution

Figure 10

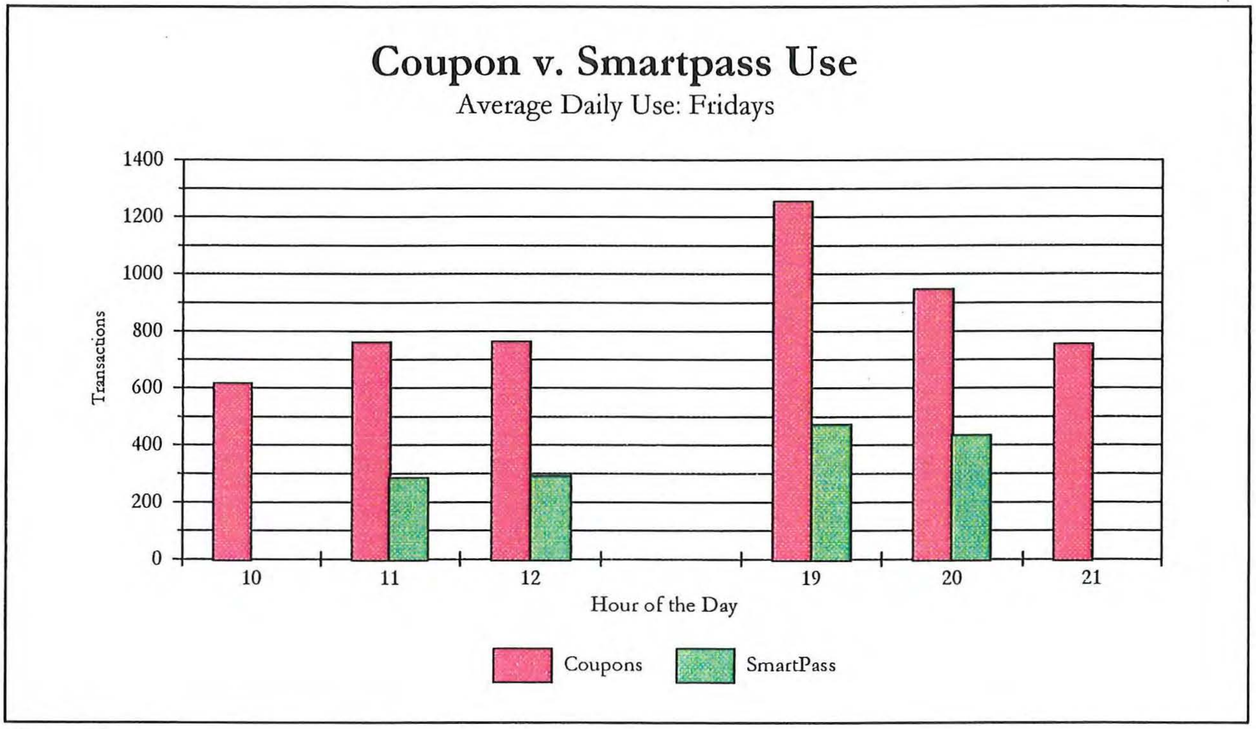

Figure 11

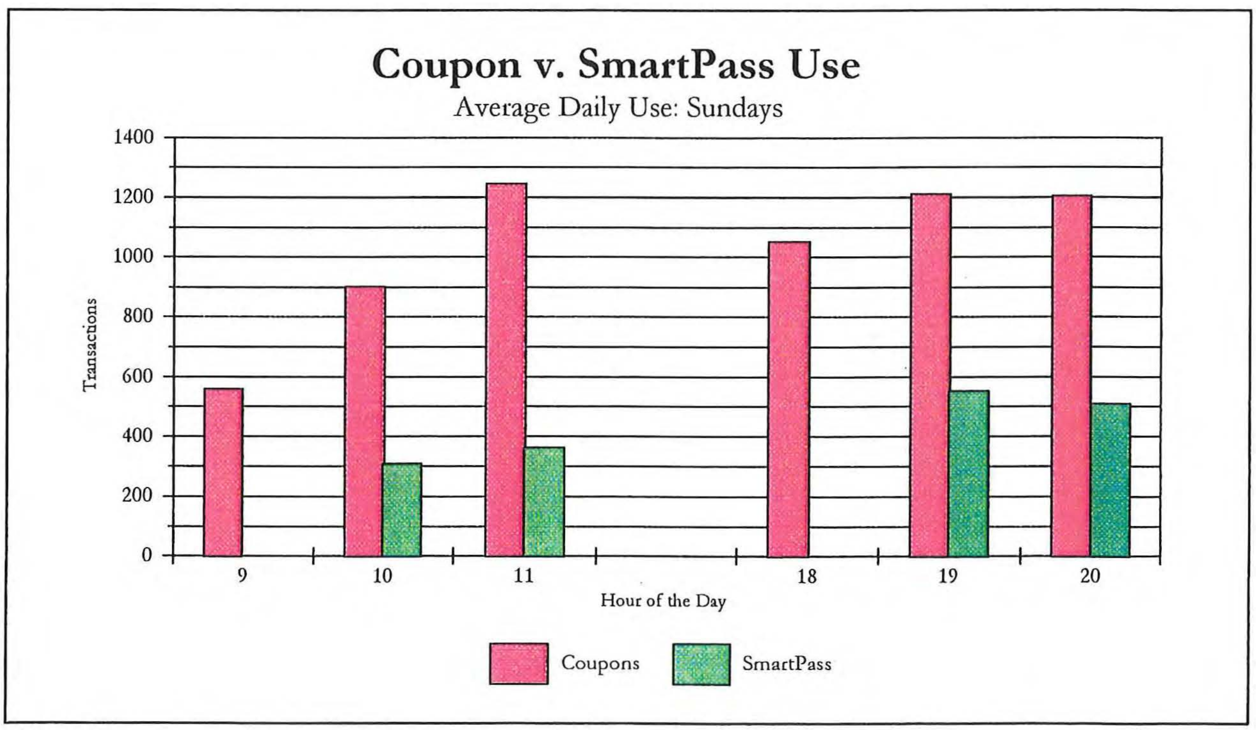

Figure 12

The SmartPass program involved fewer eligible hours per day, but this alone could not have accounted for the fewer transactions. Figures 11 and 12 compare the pattern of average daily SmartPass use with average daily discount coupon use. Somewhat similar patterns in hourly use can be observed for both 1995 and 1996 programs, although Sunday use of SmartPass tended to be somewhat equal among each of the morning and evening hours. Nevertheless, it is apparent, again, that SmartPasses were simply used less at each point than were discount coupons.

SmartPass holders may also have disproportionately resided in states other than Maine or nearby states, and thus had relatively little opportunity to take advantage of the program. As Table 13 shows, however, the vast majority of SmartPass holders were from Maine and Massachusetts (these two states accounted for 86% of users and 83% of non-users). The distribution is similar to the distribution of travelers found in the 1995 survey. Moreover, it may be noted that among the neighboring states, pass holders from both Massachusetts and New Hampshire were somewhat more likely to use their passes than were Maine residents.

State	USERS	% of Users	NONUSERS	% of Nonusers	% of State that were SmartPass Users
CA	0	0.00%	2	0.02%	0.00%
Canada	0	0.00%	2	0.02%	0.00%
CO	1	0.01%	1	0.01%	50.00%
CT	377	2.82%	415	4.09%	47.60%
DC	1	0.01%	5	0.05%	16.67%
DE	4	0.03%	2	0.02%	66.67%
FL	6	0.04%	10	0.10%	37.50%
IL	0	0.00%	1	0.01%	0.00%
MA	4,757	35.62%	2,791	27.49%	63.02%
MD	3	0.02%	13	0.13%	18.75%
ME	6,784	50.79%	5,624	55.39%	54.67%
MI	0	0.00%	2	0.02%	0.00%
MW	0	0.00%	1	0.01%	0.00%
NA	0	0.00%	1	0.01%	0.00%
NB	0	0.00%	5	0.05%	0.00%
NE	0	0.00%	2	0.02%	0.00%
NH	1,131	8.47%	792	7.80%	58.81%
NJ	39	0.29%	68	0.67%	36.45%
NM	0	0.00%	1	0.01%	0.00%
NS	0	0.00%	1	0.01%	0.00%
NT	0	0.00%	1	0.01%	0.00%
NY	74	0.55%	150	1.48%	33.04%
OH	2	0.01%	8	0.08%	20.00%
PA	8	0.06%	46	0.45%	14.81%
QC	0	0.00%	3	0.03%	0.00%
RI	141	1.06%	129	1.27%	52.22%
SC	1	0.01%	2	0.02%	33.33%
TN	0	0.00%	1	0.01%	0.00%
VA	4	0.03%	15	0.15%	21.05%
VT	21	0.16%	52	0.51%	28.77%
WI	0	0.00%	1	0.01%	0.00%
WV	1	0.01%	3	0.03%	25.00%
Grand Total	13,356	100.00%	10,154	100.00%	56.81%

Table 13

The data on SmartPass use raises two major questions:

1. Did SmartPass offer an adequate incentive to change the time of travel?

2. Why were SmartPasses not used more frequently?

To answer these questions a telephone survey was conducted of a randomly selected sample of 1,139 SmartPass holders between September 15 and October 10, 1996. The sample was stratified to reflect both users and nonusers, but users were somewhat over-represented in the final sample because of a higher rate of refusal to participate in the survey by nonusers

The survey data shows, however that frequency of SmartPass use tended to increase with frequency of travel. Table 14 compares the responses to a question about the number of times a SmartPass user traveled on the Turnpike during the 10 weeks of the program with how often they used their pass. As the number of weekends increased, the number of times a respondent reported using their pass more than five times, also increased.

Tables 15 through 17 examine the responses to the question about whether the respondent changed the time of their travel in order to use their SmartPass. Because users could have changed time on more than one trip, the survey first asked them to recall the last time they took a trip during which they used their SmartPass, and whether they changed their time on that trip. Table 15 compares the answer to this question with the day of the week on which the reported last trip took place. Approximately one-third of respondents indicated they changed their time in order to use their SmartPass. Users reported they were more likely to change if

	Number of Times Smartpass Used (SmartPass Users Only) N= 794					
# Weekends traveled Turnpike	Once	Twice	Three Times	Four Times	>Five Times	TOTAL
1	2.0%	0.1%	0.0%	0.0%	0.0%	2.1%
2	1.0%	2.6%	0.3%	0.6%	0.5%	5.0%
3	2.5%	3.0%	1.4%	0.8%	1.1%	8.8%
4	2.3%	2.3%	2.5%	2.3%	2.6%	12.0%
5	2.3%	4.2%	2.3%	1.5%	3.5%	13.7%
6	2.6%	3.0%	2.9%	1.6%	3.4%	13.6%
7	0.9%	0.8%	1.4%	1.0%	2.4%	6.4%
8	1.3%	1.1%	1.5%	1.4%	4.2%	9.4%
9	0.3%	0.9%	0.5%	0.9%	2.1%	4.7%
10	2.1%	3.9%	3.0%	2.1%	12.6%	23.9%
TOTAL	17.3%	22.0%	15.7%	12.2%	32.6%	100.0%

Table 14

Did you change the time of your travel to use your SmartPass on your last trip? (% of column)				
	FRI	SAT	SUN	TOTAL
Went Earlier	20.0%	14.1%	20.9%	18.8%
Went Later	14.3%	10.9%	16.2%	14.1%
Did not Change	65.2%	75.0%	62.6%	66.2%
TOTAL	100.0%	100.0%	100.0%	100.0%

Table 15

their trip took place on Sunday rather than on Friday or Saturday (the day least likely to report a change in time). On all three days those respondents who did report shifting their time, said they were more likely to shift their travel earlier rather than later.

Respondents were also asked whether they had changed travel times on any other trips. Thirty-three percent reported that they had changed the time of travel on other trips, but half of the respondents to this question indicated they did not recall whether they had changed the time of their travel. Of those who did report that they changed times of travel during other trips, most (63%) reported that they had changed time on only one trip or a "few" trips.

Table 16 compares the willingness to change time of travel with the amount of time change. Respondents who did change their time reported having changed their time of travel by less than 30 minutes and by more than 2 hours at about the same rate. However, those who changed their time to go

Amount of Time Change (Last Trip using SmartPass) % of Column				
	Went Earlier	Went Later	Per cent of time changers	Percent of SmartPass Users
Change <30min	32.9%	22.3%	28.9%	9.3%
Change 30-60min	14.8%	12.5%	14.1%	4.5%
Change 1-2Hrs	23.5%	26.8%	25.4%	8.2%
Change > 2Hrs	26.2%	36.6%	31.6%	10.2%

Table 16

Origin of Last Trip	Destination of Last Trip		
	IN MAINE	OUT OF MAINE	% of Users
IN MAINE	15.9%	20.6%	Went Earlier
	13.9%	15.0%	Went Later
	70.2%	64.1%	Did not Change
OUT OF MAINE	20.0%	0.0%	Went Earlier
	13.3%	0.0%	Went Later
	66.2%	16.7%	Did not Change

Table 17

earlier were more likely to change their time less than half an hour, while the majority of those who changed their time to go later reported they changed time at least 1 one hour.

Tables 17 and 18 present another way of looking at time change, based on the distance traveled. Table 17 compares time change patterns with the origins and destinations of the last trip. For simplicity of analysis, the data were recoded to origins and destinations within Maine or outside of Maine. Those who were traveling into or out of Maine were slightly more likely to report a change in their time of travel than those who were traveling only within Maine. This is consistent with both the finding that residents of Massachusetts and New Hampshire were more likely to be users of SmartPass than Maine residents were. This is a little surprising since the usual assumption is that time change is easier for short trips than for longer ones. The pattern of shifting travel earlier rather than later is also apparent among those who reported shifting their time.

Table 18 continues the analysis of time change with trip distance by comparing the time change on the last trip using SmartPass with the length of that trip (in hours). Most trips were less than three hours in duration (again consistent with the geographic pattern of users). Of these trips, there was a slightly greater willingness to change the longer the trip. Trips shorter than 2 hours (less than 1 hour and 1-2 hours) showed a slightly greater tendency to travel later; those longer showed a tendency to travel earlier.

	Change Time on Last Trip?			
Last Trip Time (Hours)	Went Earlier	Went Later	Did not Change	TOTAL
<1	3.0%	2.9%	17.4%	23.3%
1	3.9%	4.4%	14.2%	22.5%
2	5.7%	3.0%	13.7%	22.4%
3	3.1%	1.8%	11.7%	16.8%
4	1.8%	1.0%	4.4%	7.3%
5	0.8%	0.5%	2.0%	3.3%
6	0.3%	0.3%	0.9%	1.4%
7	0.0%	0.1%	0.4%	0.5%
8	0.0%	0.0%	0.3%	0.3%
9	0.0%	0.0%	0.3%	0.3%
10	0.0%	0.1%	0.0%	0.1%
TOTAL	18.8%	14.1%	66.2%	100.0%

Table 18

Table 19 completes the analysis of patterns of change by comparing the amount of change with the time of departure for the last trip with SmartPass. Departures in the afternoon and evening were somewhat more likely to be accompanied by a time shift than departures in the morning. The length of the time change does not vary significantly with

	Amount of Change in Last Trip					
When did last trip begin?	Did not change	Change <30min	Change 30-60min	Change 1-2Hrs	Change > 2 Hrs	TOTAL
MORNING	32.1%	4.4%	2.6%	4.4%	4.2%	47.9%
AFTERNOON	16.2%	1.6%	0.6%	2.1%	1.5%	22.5%
EVENING	16.8%	3.1%	1.3%	3.7%	2.5%	27.6%
TOTAL	66.4%	9.3%	4.5%	10.2%	8.2%	100.0%

Table 20

the time of departure.

The final issue examined with respect to willingness to change time concerned motivation for the time change. The SmartPass monetary incentive was one possible motivating factor examined, and the desire to avoid congestion the other. Table 20 shows the stated importance that was attached to the monetary incentive in the decision to change the time of travel. 80% of those who reported changing the time of their travel indicated that the monetary incentive provided by the SmartPass was a "somewhat" or "very important" factor in their decision. However, over 90% of the time changers stated that the desire to avoid congestion was "somewhat" or "very important". Moreover, only 30% of the time changers indicated that the monetary incentive was "very important", while more than twice as many (68%) indicated that the desire to avoid congestion was "very important". Clearly the monetary incentive was a factor, but it was not the principal factor involved in the decision to change the time of their travel. The strong desire to avoid congestion was also an important factor. It is the combination of these factors that is important in motivating changes in travel behavior (at least with only a reduction in tolls as an incentive).

The survey showed that only a relatively small proportion of SmartPass users actually changed their time in order to use the program. This is not, by itself, a sign that the program was unsuccessful. Depending upon traffic volumes and capacity, only a small pro-

		Did you change the time of your travel ? (Changers only)		
		Went Earlier	Went Later	TOTAL
How important was monetary incentive?	Very Important	30.2%	22.8%	30.3%
	Somewhat Important	49.0%	37.6%	49.4%
	Somewhat Unimportant	18.8%	10.1%	16.5%
	Very Unimportant	1.3%	4.7%	3.4%
How important was desire to avoid congestion?	Very Important	65.8%	71.4%	68.2%
	Somewhat Important	24.2%	17.0%	21.1%
	Somewhat Unimportant	6.0%	7.1%	6.5%
	Very Unimportant	3.4%	4.5%	3.8%

Table 19

portion of travelers shifting time could have an effect on congestion. To investigate why the use level was not higher, both users and nonusers were asked about their reasons for not using the SmartPass program more. As Table 20 shows, the overwhelming reason given for not using the SmartPass more often was that they did not travel at times when it indicated that more flexibility in their travel schedule would have encouraged greater use. These people were, for these trips, beyond the influence of the toll incentives.

Another perspective on SmartPass users can be gained from looking at some of the demographic characteristics of users and

It was easy to apply for...			
	Users	Nonusers	All
Strongly agree	93.2%	92.6%	93.0%
Somewhat agree	5.6%	5.3%	5.5%
Somewhat disagree	0.8%	1.8%	1.1%
Strongly disagree	0.5%	0.3%	0.4%
It was easy to use to pay tolls... (Users only)			
Strongly agree			93.5%
Somewhat agree			5.4%
Somewhat disagree			0.6%
Strongly disagree			0.5%
It could be used at times that were convenient...			
	Users	Nonusers	All
Strongly agree	20.9%	15.0%	19.2%
Somewhat agree	43.2%	19.6%	36.3%
Somewhat disagree	22.9%	32.5%	25.7%
Strongly disagree	12.9%	32.8%	18.7%

Table 21

was valid. This was true of both user and nonusers, although nonusers were somewhat more likely to have lost their pass or to not state a reason.

The final question is what would have motivated people to use SmartPass more often than they did. Eighteen percent of respondents who had used their SmartPass indicated that a larger monetary incentive would have encouraged them to use their SmartPass more often, while 79% of the respondents

nonusers. Table 22 examines SmartPass users and nonusers in terms of their education and income levels. Most (>75%) had some post-secondary education, and users were slightly more likely to have a higher education level than nonusers. This is particularly true of college graduates. Since income is highly correlated with education level, these tables should show consistent patterns, and this is indeed the case.

	Education Level			Income			
	Smart Pass User?				**SmartPass User?**		
	Yes	No	Total		Yes	No	Total
8th Grade	0.1%	0.3%	0.2%	<$10k	0.6%	2.0%	1.1%
9th-11th grade	1.1%	1.7%	1.3%	$10k-15k	1.3%	1.7%	1.4%
High School	17.0%	15.7%	16.6%	$15-20k	2.3%	3.5%	2.6%
Voc School or Non college	2.0%	2.3%	2.1%	$20-25k	4.7%	5.8%	5.0%
Some college	18.8%	21.4%	19.6%	$25-35k	12.0%	15.9%	13.2%
College graduate	60.3%	56.5%	59.2%	$35-50k	20.4%	17.4%	19.5%
				>$50k	45.7%	41.7%	44.5%

Table 22

This analysis of education and income levels raises the question of whether SmartPass users were more likely to change times of travel related to these factors. Education seems to make no difference in willingness to change time, but as Table 24 shows, lower income users reveal a slightly greater tendency to change time of travel.

A last question concerning SmartPass was whether there were administrative barriers to effective use of the program. Table 26 shows the responses to questions concerning the SmartPass holders perceptions of the ease of interacting with the program. There was very strong agreement, among both users and nonusers, that the program was easy to apply for, was easy to use when paying the toll (as expressed by users). However, there was much less agreement that the times at which SmartPass could be used were convenient.

Conclusions: SmartPass Use

The SmartPass program was successfully implemented according to the design parameters set out for it. It was used by frequent weekend travelers, including many people from outside of Maine whose weekend travel constitutes the most significant portion of weekend congestion. However, the frequency of utilization was low, particularly when compared with utilization of discount coupons in 1995. The SmartPass program did induce a small number of travelers to change their time of travel, but the monetary incentive offered by the program was not a significant factor by itself; the combination of monetary incentive plus the desire and the opportunity to avoid the congestion of peak periods were the keys to what effect the SmartPass did have. The extent of that effect is the subject to which we now turn.

2. SmartPass Effects on Traffic Patterns

The basic unit of analysis in this section, as for the 1995 data, is the hourly share of daily traffic. This variable permits a straightforward examination of the key behavior that the congestion pricing experiments seek to influence, the time of travel, while avoiding problems in interpretation that would be caused by using raw traffic data. (Raw traffic data varies as a result of numerous factors from week to week, while hourly traffic shares are somewhat more stable). Three different approaches are taken to examining this data:

1. The hourly share data measured as exiting traffic at each toll plaza for 1996 is compared with the hourly share data for exiting traffic in 1995 and 1994 for comparable hours without discounts.

2. In 1996, as part of the construction of the new electronic toll system, the Turnpike Authority installed traffic counters on the roadway at a point between the Saco and Scarborough interchanges. Counter data permits an examination of the effects on the traffic volumes that are the principal concern about congestion. However, traffic counters were not available in 1993-1995, so traffic counter data from 1990-1992, the last period in which traffic counters were installed, is used for reference.

3. A regression analysis of the exiting traffic data is used to more systematically examine the relationship between SmartPass use and changes in traffic as measured at the exiting toll plaza.

[NOTE: In the graphics that follow, the X-Axis shows the hour of the day shown in 24 hour time. All hourly data points are for the hour beginning, that is a data point for the hour 19:00 shows all traffic measured from 19:00 to 20:00 (7:00 pm to 8:00 pm)]

1. Comparison of Hourly Exiting Traffic Data

The first element in this analysis looks at the mean hourly share of traffic data for Fridays[1], Saturdays, and Sundays.[2] Mean hourly shares were calculated for each day across the 10 weeks of the summer, and compared with mean hourly shares for 1994 and for July, 1995. July, 1995 was chosen since it was unaffected by the discount coupon program (for Saturdays, all summer weekends in 1995 was used as a reference since the discount coupon program did not apply to Saturdays).

Figure 13 shows the mean hourly share data for Fridays. If SmartPass were effective in shifting the time of travel, the peak period should show a reduction, while the off-peak hours (in the boxes) should show an increase in 1996 over 1994 and 1995. The 1996 data shows a slight increase in the morning over July 1995 levels, but is significantly below the 1994 levels. In the

[1] Data for Fridays in 1996 included Wednesday July 3 and Thursday, July 4 since these were heavy inbound days. Data problems prevented analysis of Friday, July 5, but because of the configuration of the July 4 weekend in 1996, the loss of this day should not matter.

[2] Labor Day 1996 is not examined separately. Labor Day was quite rainy, and large number of people exited Maine on either Sunday or early in the day on Monday. Any influence of SmartPass was greatly diminished by the weather, which was the dominant factor in determining traffic patterns on that day,

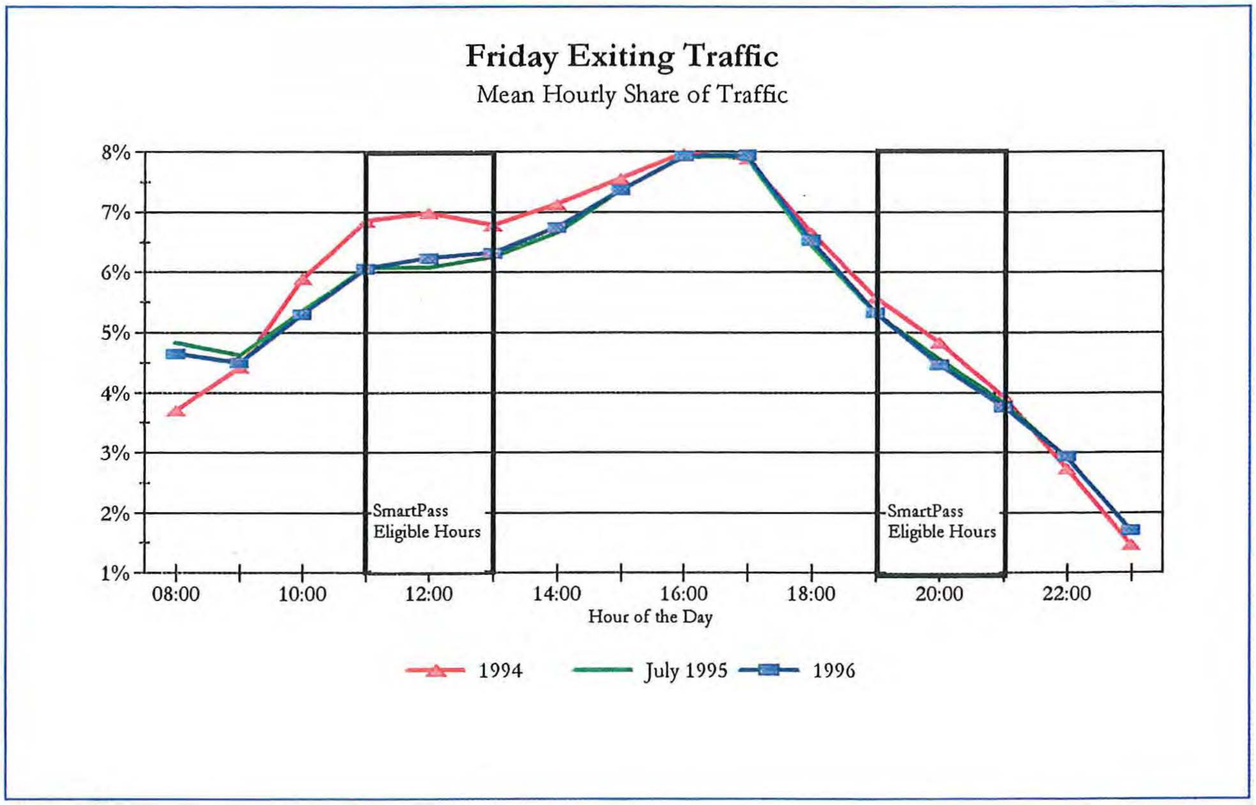

Figure 13

evening off-peak, 1996 shares are below both reference year levels.

Figure 14 shows the data for Saturdays. The 1996 traffic was noticeably higher in the morning off-peak hours. In the evening off-peak, the 1996 data is slightly above that of 1995, but well below the average for 1994. Peak hour patterns are similar; 1996 lies between the 1994 and 1995 patterns. SmartPass may have influenced traffic patterns in the morning, but less so in the afternoon.

Figure 15 shows the data for Sundays. The 1996 data lies above 1994, noticeably so in both the morning and evening off-peak hours, but shows little change from 1995 in either periods. The peak period data again shows no consistent improvement over the reference periods.

Recalling that the survey data showed that those who did switch the time of their travel tended to shift to earlier rather than later travel, and that half of all travelers reported their last trip as beginning in the morning, these figures suggest that SmartPass may have had some success in shifting traffic patterns towards the morning. Effects on evening off-peak traffic were very limited, as were apparent effects on peak period traffic.

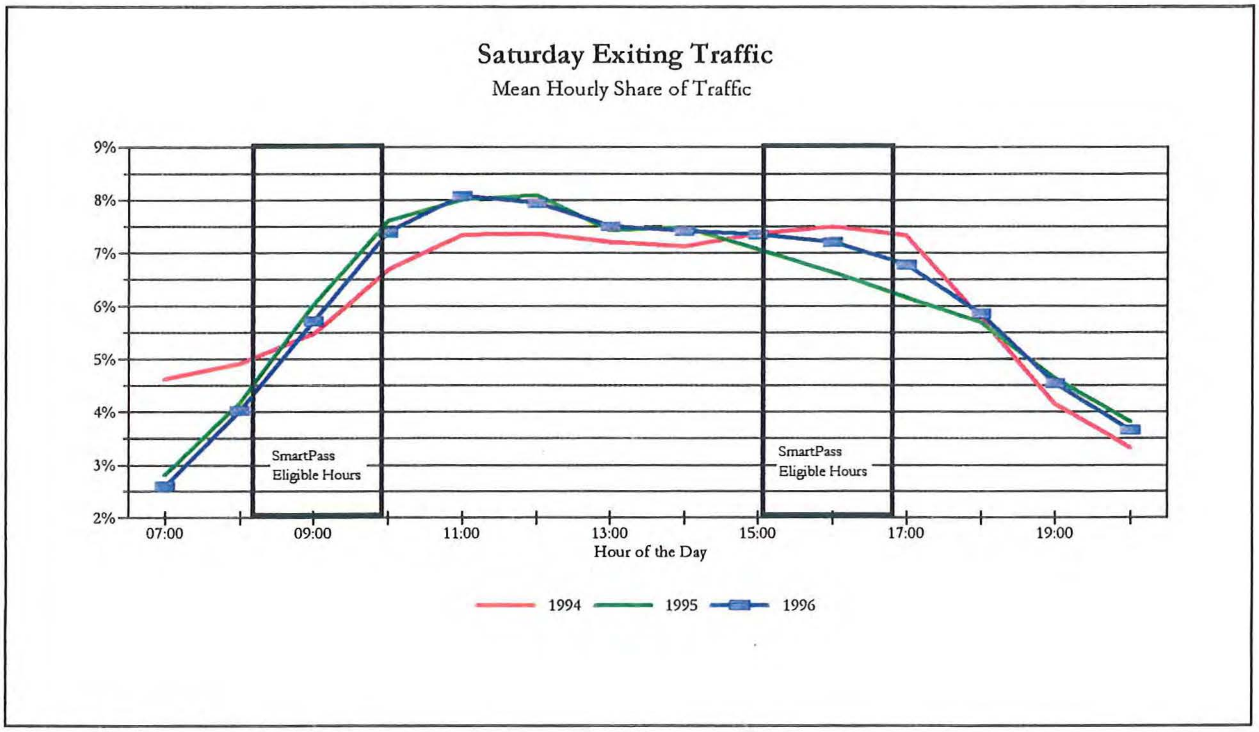

Figure 14

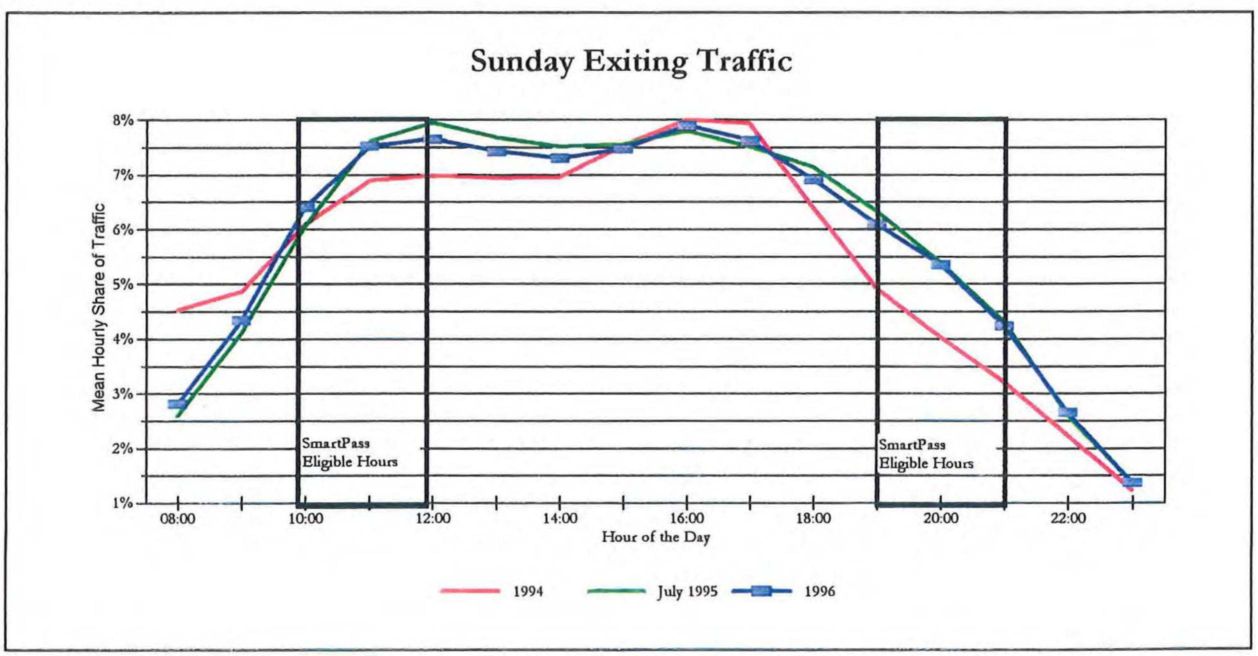

Figure 15

The next set of figures combines an analysis of the *change* in the hourly share of traffic between 1996 and either 1994 or July 1995 with the proportion of traffic exiting the Turnpike at Exits 1-7 at a given period that presented a SmartPass. In these graphics, the change data (presented as lines) should be positive (>0) in the hours when the SmartPass was eligible for use.[3] The change data should also be negative (<0) during the peak hours. In order to refine the analysis, each of the weekend days is examined for all of summer 1996 and separately analyzed to compare July and August 1996 with the same months for 1995 and 1994. These figures permit a clearer view of the differences in traffic patterns, and provide a view of any relationship with SmartPass use. [In reviewing these graphics, pay special note to the vertical axis, which shows larger changes at some times than at others.]

Figures 16 through 18 show the data for Fridays. For all of 1996 (Figure 16), the mean hourly share of traffic in the morning SmartPass hours showed a slight increase in traffic relative to 1995 in the 12:00 hour, but overall traffic in 1996 showed no real differences with 1995 (the 1996 line stays very close to the 0 line). A slight negative relationship was found in the 20:00 hour (8:00 pm), despite the fact that this is the hour that shows the highest proportion of traffic using SmartPass on Fridays. A similar pattern is seen on Fridays in July (Figure 17) , although the traffic in 1996 was below July 1995 and July 1994 levels in both of the evening hours. In August (Figure 18), the morning hours show an increase in 1996 over both reference periods, and there is a slight increase in the 19:00 (7:00 pm) hour over 1995. A decrease in peak hours through most of the middle of the day also occurs.

Figures 19 through 21 show the data for Saturdays. Traffic in 1996 showed no change in the peak period relative to 1995, but was slightly above 1994 levels. However, there was a shift towards travel in the afternoon off-peak compared with 1995 (though the opposite occurred with compared with 1994). The shift towards the off-peak in the afternoon was accompanied by the *lower* level of SmartPass usage on Saturdays; the higher level of SmartPass use was accompanied by a lower level of traffic in the morning hours compared with 1995. A similar pattern is shown for July 1996 (figure 20). In August, a distinct reduction in the peak is evident, but this appears to be part of an general increase in traffic in the late afternoon and evening, later than the SmartPass discount period.

The trends for Sundays are shown in Figures 22 through 24. Sunday traffic shows a distinct increase in the evening period compared with 1994 traffic which coincided with maximum SmartPass use.. There is also an increase in morning hours. The same patterns are clear when July 1996 is compared with the previous years' July. The August patterns show clear increases in off-peak traffic compared with August, 1994, particularly in the evening hours, but the same is not the case with respect to July, 1995. The peak period in 1996 also showed a decline in use compared with 1994, but only compared with some hours in July 1995.

The exiting traffic data suggests that, despite the relatively low level of SmartPass use, some association can be seen between

[3] SmartPass use appears at hours other than those designated as eligible because of the Turnpike Authority policy of accepting SmartPasses if presented outside eligible hours.

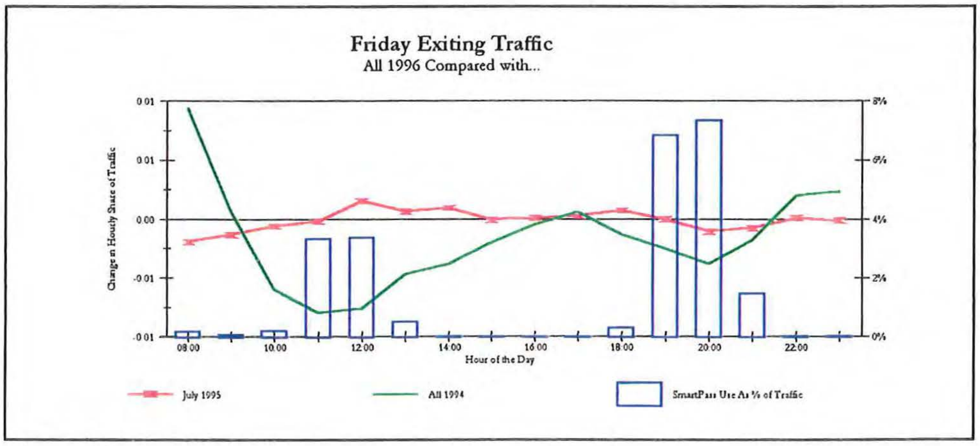

Figure 16

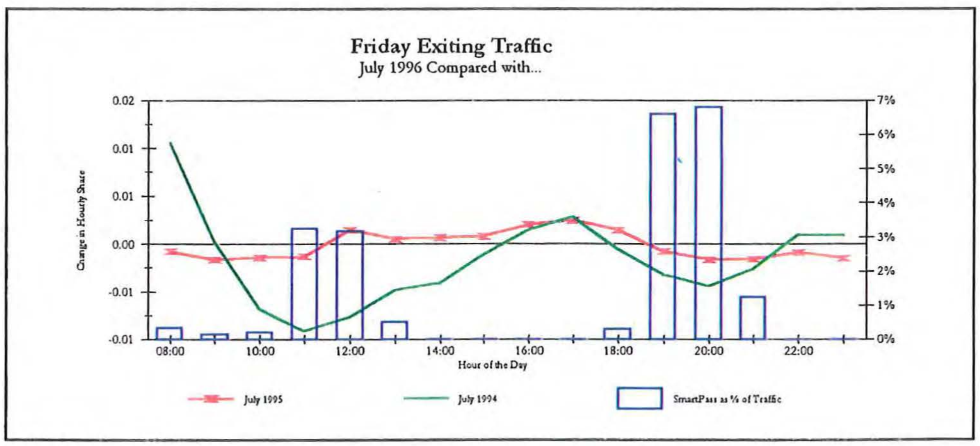

Figure 17

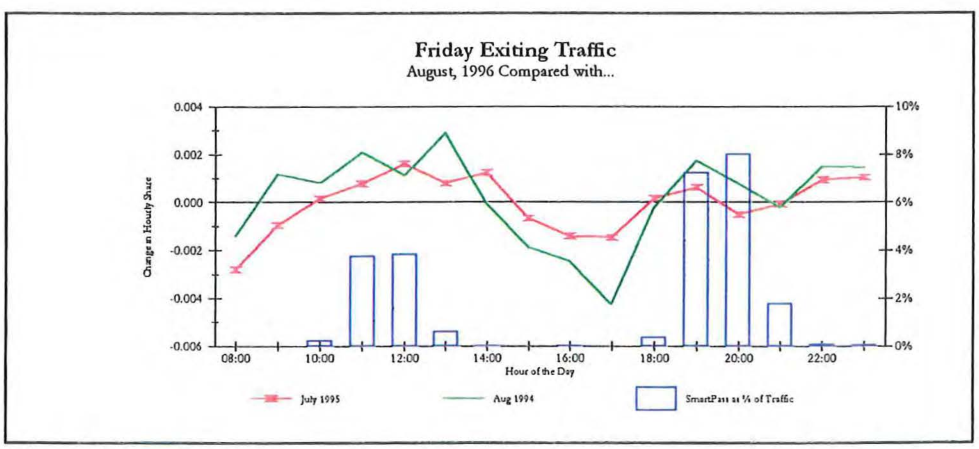

Figure 18

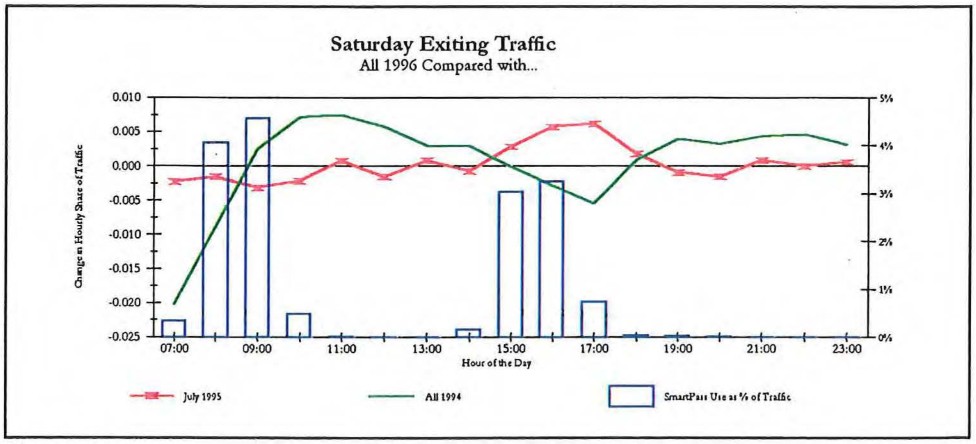

Figure 19

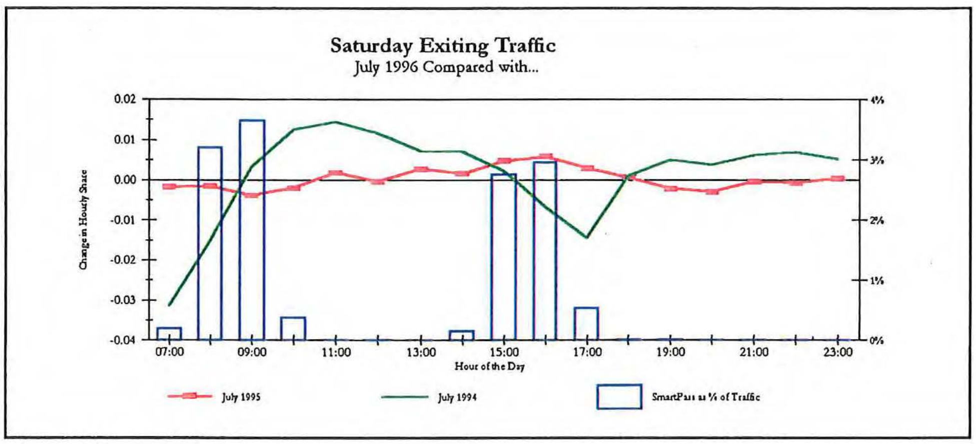

Figure 20

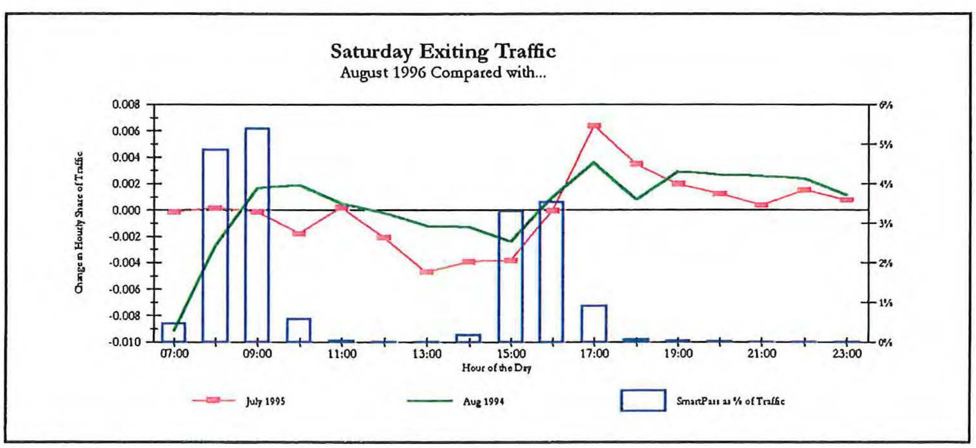

Figure 21

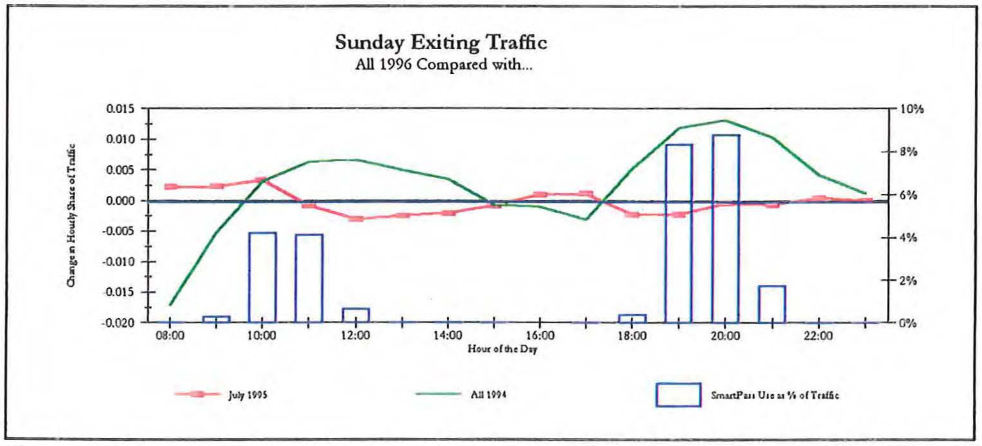

Figure 22

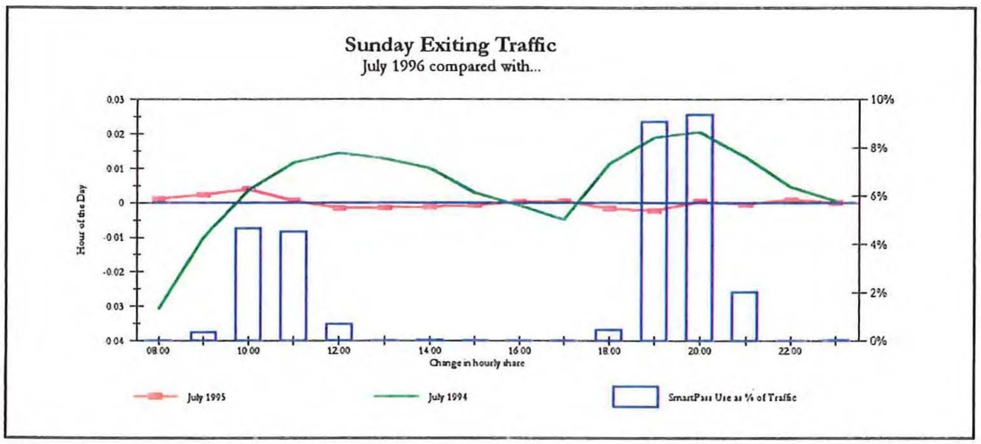

Figure 23

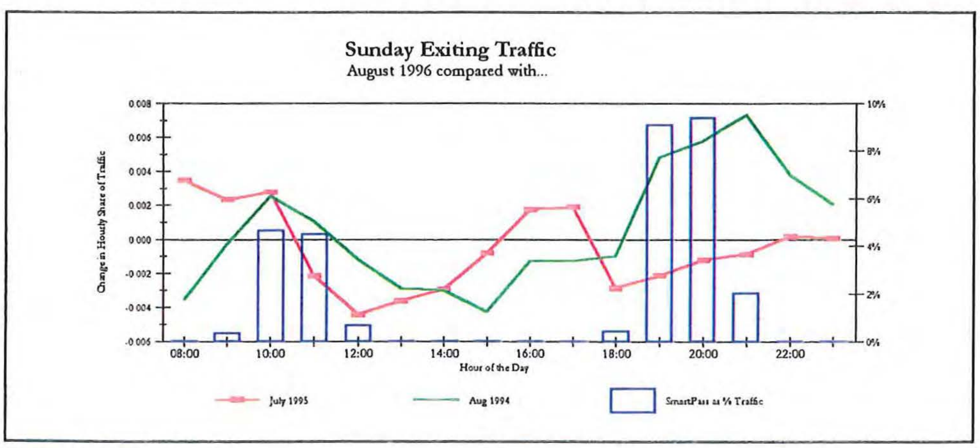

Figure 24

increased use of the off-peak hours on some days and at some times. This appears to be the strongest on Sundays and weakest on Fridays. Peak traffic was largely unaffected when compared with July 1995 levels, but some evidence suggests that peak traffic was lower when compared with 1994 on some days. However, since these measurements are taken at the exiting toll plaza, they provide only indirect measures of the actual effects on the road itself. To examine this question, we now turn to the traffic counter data.

2. Traffic Counter Analysis

For traffic counter analysis (Figures 25 through 30), there are two graphics for each day, one measuring the south bound lanes and the other the north bound lanes. Again, the share of each hour's traffic is the unit of analysis. The traffic counter was placed between the Saco (Exit 5) and Scarborough (Exit 6) interchanges, and data is available for the five weekends in August. The reference data is August in 1990-1992, the last years prior to 1996 when the Authority had traffic counters installed.

On Fridays (Figure 25), slight increase occurs in the morning, but 1996 evening off-peak traffic is lower than that in the previous years. The major issue on Friday is northbound traffic (Figure 26). In that direction, 1996 traffic levels were slightly higher in the morning when compared with two of the three reference years, but the traffic in the evening hours was below the reference years. Peak hour traffic was fairly variable, with some hours in 1996 below the reference years, but the trends do not show any distinct changes from the trends in traffic in the surrounding hours. A distinct peak from 16:00 to 19:00 (4:00 to 7:00 pm) remains in all the years.

Saturdays (Figures 27 and 28) show a very broad peak both north and south bound. Saturday traffic is a combination of both inbound and outbound tourists and commuting/commercial traffic. Peak traffic is in the late morning, reflecting the south bound tourists leaving at the end of vacations. Southbound traffic was slightly heavier in 1996 during the morning discount hours, but lower in the afternoon. In this direction, peak hour traffic was generally lower than the reference years, but by only a small amount and not consistently.

Northbound traffic (incoming vacationers) did show some increase in the morning off-peak as well, and this was apparent in both hours. An increase in afternoon traffic also occurred during the SmartPass hours. Together, these are accompanied by a reduction in peak traffic in 1996 compared with the base years. This would appear to be consistent with the large number of SmartPass holders from Massachusetts and New Hampshire who may delay their travel on Saturday.

Sunday traffic northbound (Figure 29) shows no patterns consistent with SmartPass effectiveness; the off-peak hours in 1996 are below the reference year levels in both the morning and evening, while peak hours are above the traffic levels of previous years. However, southbound traffic (Figure 30), the direction where the greater levels of traffic occur, do show some patterns consistent with SmartPass effectiveness. Both morning and evening off-peak hours in which SmartPass could be used show higher levels of traffic, while the peak is somewhat lower.

The traffic counter data is thus largely consistent with the exiting traffic data. Sundays show the greatest changes in traffic

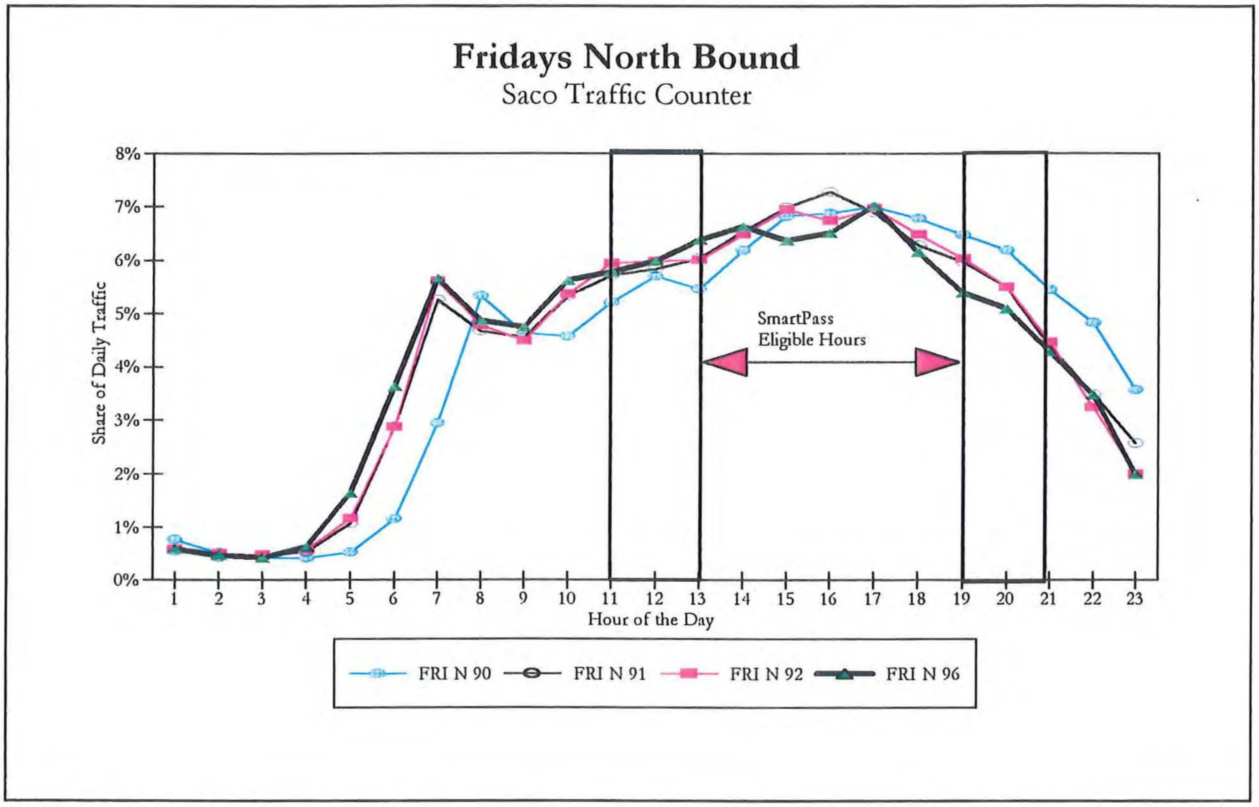

Figure 25

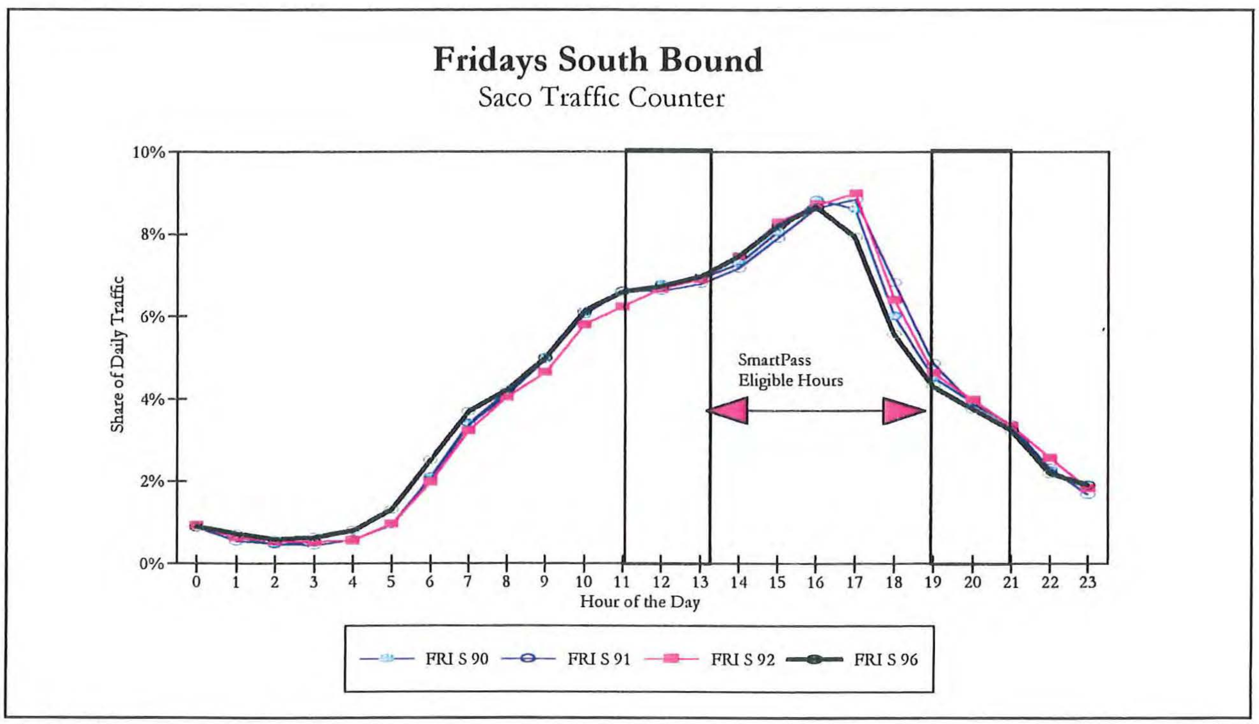

Figure 26

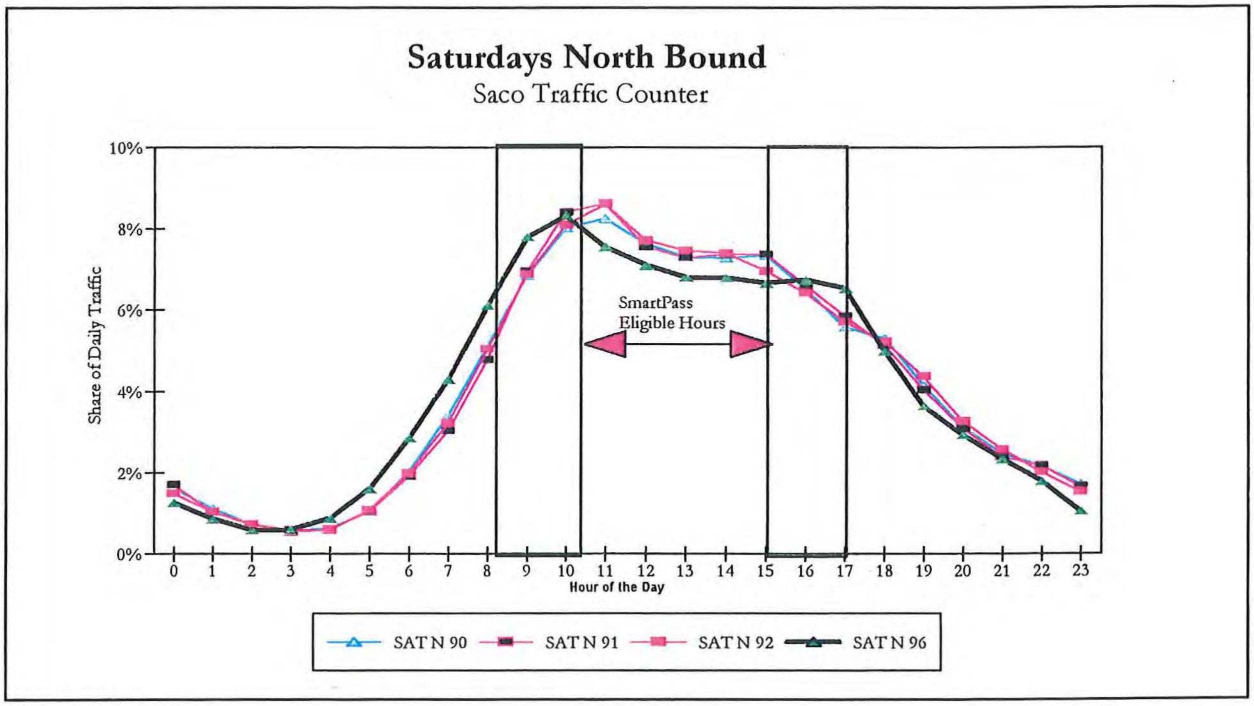

Figure 27

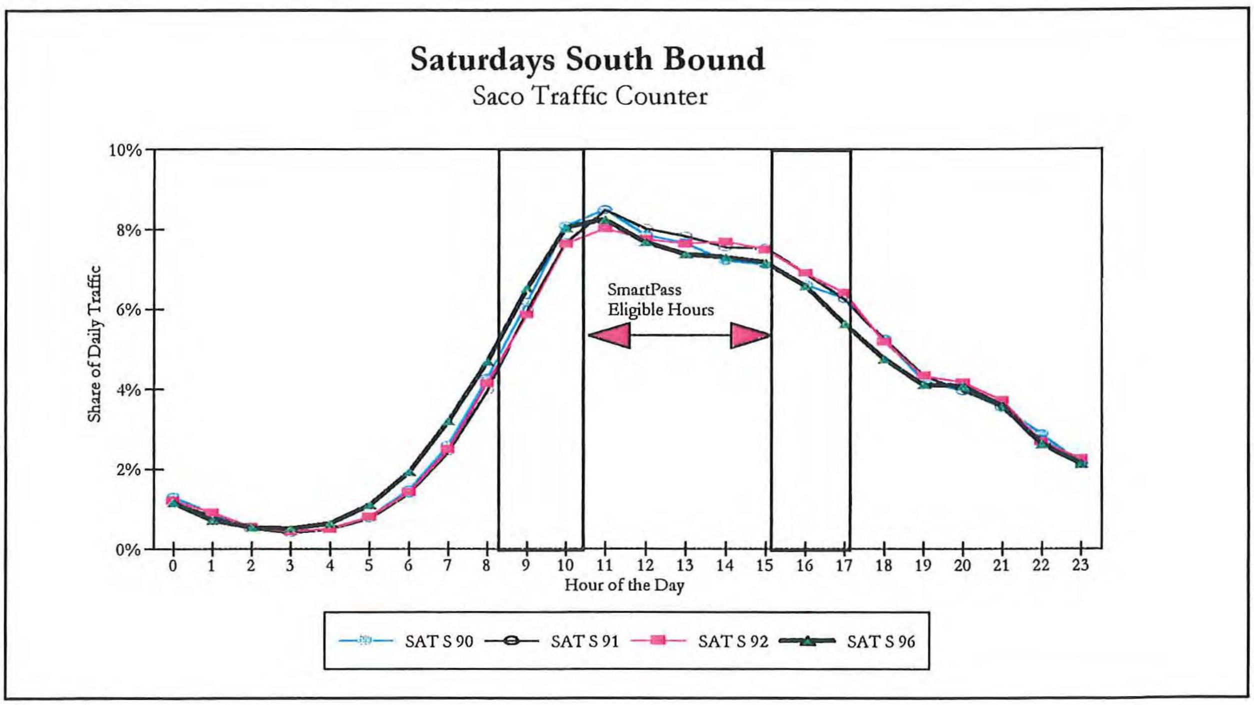

Figure 28

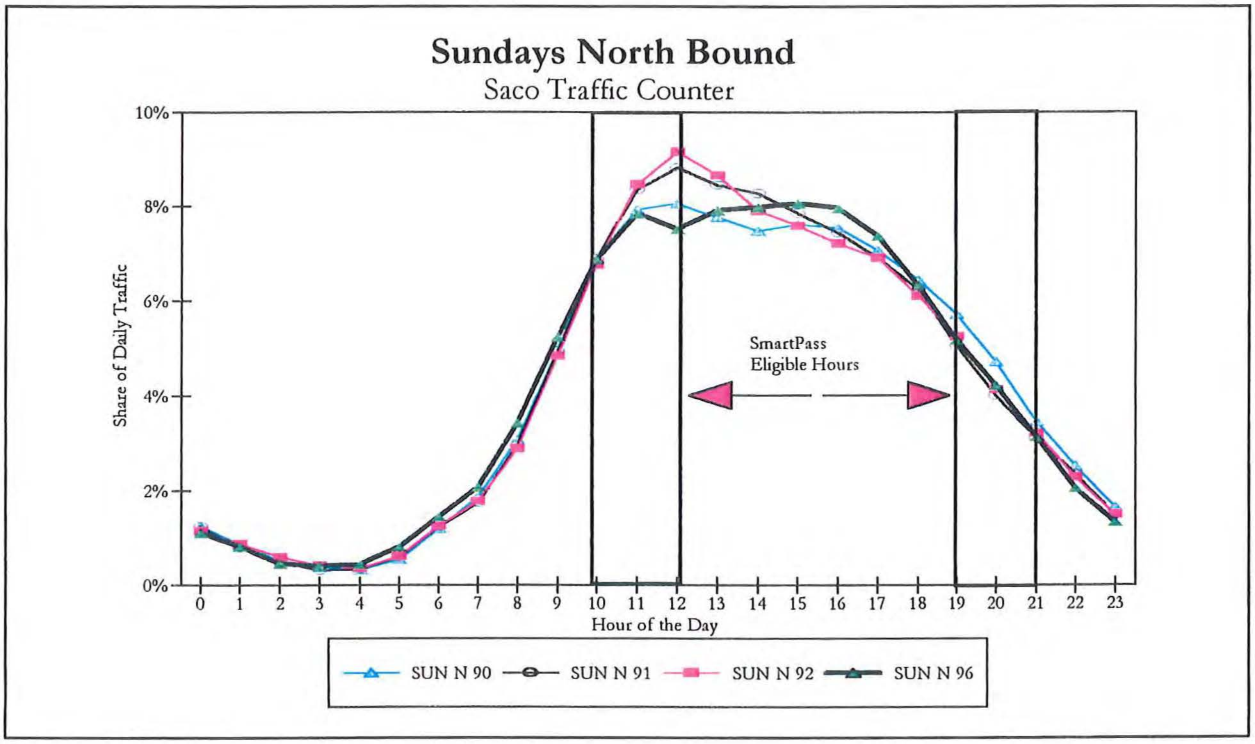

Figure 30

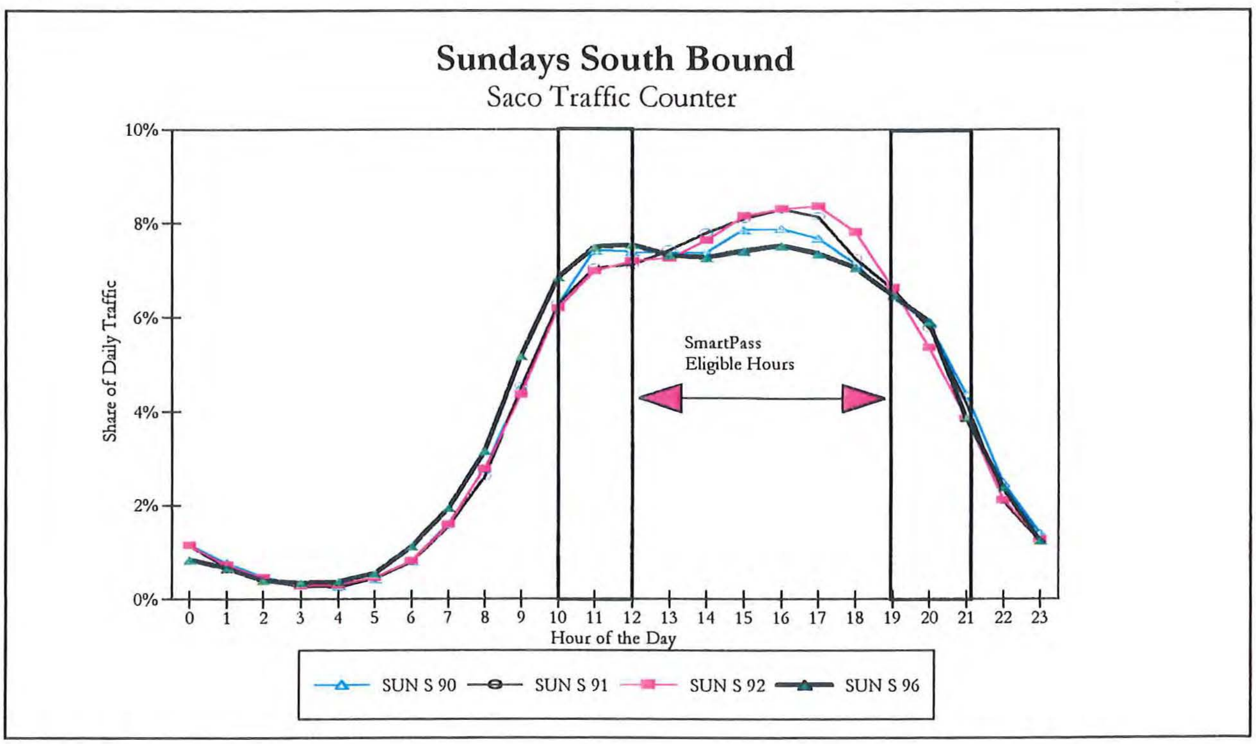

Figure 29

consistent with the effectiveness of the SmartPass program, but the effects on the other days are weak or nonexistent, particularly on Friday. The results on Saturdays are mixed. The final element of the traffic analysis examines the statistical relationship between SmartPass use and changes in traffic as measured by hourly shares.

3. Regression Analysis

The regression model used for the analysis of time change is shown in equation 2:

$$HS_i^t = \alpha + \beta_1 H_1 + \beta_2 H_2 \ldots + \beta_{25} E_{25} + \beta_{26} E_{26} \ldots + \beta_{33} H_1 D + \beta_{34} H_2 \ldots$$

Where:

HS_i^t = the share of daily traffic passing exiting at toll plaza i at hour t.

$H_{1\ldots}$ = A dummy variable for hour 1, etc. (1-24) (=1 for a given hour, 0 otherwise)

$E_{25\ldots}$ = A dummy variable for a given exiting toll plaza (1-7).

$H_{33\ldots}$ = an interaction term equal to the product of the dummy variable for hour 1 and the % of traffic passing through a given hour that used SmartPass. A statistically significant relationship for this variable in a positive direction during the eligible hours would show SmartPass effects.

β_n = the parameters estimated from the data. The regression was performed using weighted least squares, where the weights represent the traffic at Exit i and hour t.

Table 26 shows the T-statistics for the variables measuring the relationship between SmartPass use and traffic. A statistic >1.9 indicates a 95% chance that the traffic at that time was associated with the level of SmartPass use. The relationship for the off-peak hour should be positive, meaning the coefficient $\beta > 0$; these results are shown in the unshaded cells the table. The relationships that are negative (showing a relationship that is in the opposite direction from what was expected) are shaded gray in the table. In this analysis, 1996 are data is analyzed with two different equations, one which includes data from 1994 and 1996 (Eq94-96) and the other which includes data from all three years (Eq94-95-96).

The results show statistically significant relationships in the right direction only on Sundays, with the clearest success in the Sunday 8 pm hour, which is significant in both equations. The equation using data from all three years shows significant relationships at the .05 level (95% probability of a relationship that did not occur by chance) for three of the four SmartPass hours and a significant relationship at the .10 level (90% probability the relationship did not occur by chance.)

Neither the Friday nor the Saturday data show significant relationships in the right direction. The Friday data shows coefficients that are both negative and statistically significant in the morning. The coefficients are negative in the evening hours as well, but are not significant. The negative results were most likely determined by the 1994 morning data, which shows a distinct growth in hourly share data in the late morning. This pattern is not matched by either the 1995 data or confirmed by the traffic counter data, so it may be an anomaly of that year's data. A similar problem may exist for the 8 am hour on Saturday; the 1994 data for this hour's

Regression Results for 1996								
FRIDAYS			SATURDAYS			SUNDAYS		
	Eq94-96	Eq94-95-96		Eq94-96	Eq94-95-96		Eq94-96	Eq94-95-96
11 am	**5.81927**	**4.16869**	8 am	7.20594	**5.52287**	10 am	1.46824	*1.75399*
12 pm	**5.49805**	**3.78095**	9 am	0.27868	1.45453	11 am	1.02974	**2.86038**
7 pm	0.25292	0.25302	3 pm	0.26448	0.29574	7 pm	1.15058	**2.3880**
8 pm	0.62336	0.13605	4 pm	*1.80903*	0.31469	8 pm	**2.75111**	**3.3986**
R^2	.717	.711		.760	.787		.666	.683

Shading = negative coefficient **Bold** = significant at .05 *Italics* = significant at .10

Table 26

share of traffic is substantially below either 1995 or 1996 levels, resulting in a statistically significant result in the wrong direction.

4. Traffic Analysis: Conclusions

The analysis of traffic used three different approaches: analysis of exiting traffic data from the interchanges, of mainline traffic counters, and a regression analysis. On all three bases, it is clear that the SmartPass program was not successful in significantly reducing peak hour travel on weekends on the Maine Turnpike. The closest the program came to success was on Sundays. Traffic counter data showed growth in the off-peak and a small decline in the peak relative to 1990-1992 data. On Sundays, exiting traffic data shows clear and statistically significant relationships that increased off-peak traffic during several hours in a manner directly associated with SmartPass use. These findings are also consistent with the survey data which showed the most willingness to change time on Sundays (38% of SmartPass users indicated that they changed the time of their travel on their last trip). Sunday is also the day when the greatest amount of schedule flexibility exists for travelers, which the survey indicated was the most important factor in decisions to travel when the SmartPass was valid. It is also consistent with the fact that more SmartPasses were used on Sunday than on either of the other days.

On the other hand, the SmartPass program had no discernible effects on Friday. None of the measures showed changes consistent with success. Again, this result is generally consistent with the survey data. Fridays are most likely the days of the least flexibility, although the reported willingness to change is not greatly different from that for Sunday. It should be noted that the lack of success in the morning is most clearly related to the 1994 data which may be somewhat anomalous. While comparison with 1995 also revealed no major changes in the morning, the fact that the 1995 discount coupon program had some success in the morning suggests that some positive effects may be observed. In any event, it is clear that no effects on Friday evening could be discerned. All of the data are clear on this point.

Saturday shows the most mixed results. The comparison of the 1996 exiting traffic data with the previous years revealed some success in the afternoon when compared with 1995, although it was not statistically significant since the increased traffic in the afternoon off-peak was associated with a smaller proportion of traffic using SmartPasses than in the morning.

It is important to note that the variability in the "baseline" data from 1994 and 1995 is enough to limit the confidence that can be placed in any of the traffic analysis data. Additional years of baseline data might have revealed somewhat stronger, or somewhat weaker, relationships.

CONCLUSIONS: CONGESTION PRICING AND THE MAINE TURNPIKE

Under the restrictions placed on the Turnpike Authority by the Legislature, prohibiting raising tolls during peak hours, it is clear that discount only congestion pricing will not play a significant role in alleviating traffic congestion on the Turnpike. The two years of trials, using two different approaches to offering free off-peak travel as an incentive, showed relatively weak results. At some hours, on some days, and at some exits, a noticeable (and in some hours, statistically significant) shift towards the off-peak hours (particularly on Sundays) was observed, but the sum of these effects were insufficient to result in shifts in peak hour traffic sufficient to relieve congestion. We believe this lack of effect on peak volumes was due to:

- The very wide peak periods (6-7 hours) that occur on summer weekends;
- The relatively small monetary incentive (although it was the maximum allowed by law); and
- The travel patterns of Turnpike users which allow for more flexibility to shift the time of travel on some days but not others.

Nevertheless, the fact that congestion pricing under these restrictions was still able to result in some measurable changes in travel patterns raises questions about what the future of congestion pricing may be for the Turnpike. Two questions are critical:

1. If the current congestion pricing approach using only off-peak discounts was capable of inducing some change in traffic behavior, could congestion pricing using the more usual peak hour pricing approach make a larger contribution to peak congestion management?

2. If congestion pricing cannot manage peak traffic by itself, does it still have a role to play in the future?

A firm answer to the first question cannot be provided at this time. This is the question that we most wanted to investigate and this is the question that we were prohibited from investigating. What, then, can be said about congestion pricing using a peak hour surcharge based on the evidence to date?

Certainly peak hour surcharges could encourage more travelers to avoid peaks than off-peak discounts (depending on the amount of the surcharge). The theory of congestion pricing remains valid. The mail survey conducted in 1995 indicated that some travelers would, in fact, make this choice. But we still lack information about what toll increase would be necessary to effect peak reductions. Critically, we do not know what peak tolls to set to reflect the different sensitivities to tolls at various hours and days that were uncovered by the research to date. This information can only be gathered with additional experimentation; surveys conducted to date are helpful, but cannot be considered conclusive.[1]

Moreover, the very broad peak periods that already characterize the Turnpike, are likely to become a larger problem in the future, even under conservative traffic growth assumptions. This means that even if peak pricing was sufficient to reduce traffic on the Turnpike, it is not clear where the diverted

[1] "Market research is of limited value as people do not always act in ways that they suggest they will. To understand the consumer acceptance of congestion pricing, experimental research is on behavior is essential." Hubert H. Humphrey Institute of Public Affairs, *Buying Time: Final Report* University of Minnesota, 1996.

traffic would go, either in terms of additional hours of the day or other routes.

The question about where diverted traffic would go is an important one. If the *only* objective of the Authority were to reduce congestion using tolls, then it would be relatively easy to use congestion pricing(absent Legislative prohibitions). Peak tolls could simply be set at very high rates, and travelers could easily be discouraged from traveling on the Turnpike except in cases where they were willing to pay a high price to do so. However, this ignores a fundamental principle: the issue that has to be addressed by transportation policy is not congestion, *per se*, but the economic value to travelers lost when congestion occurs. This value is usually measured for commercial travelers by the increased costs of operating vehicles and for noncommercial travelers by the value they place on their time while traveling. If congestion pricing is implemented to simply exchange one lost value (from discouraged trips or trips at times with other costs to the traveler or shifting congestion onto other roads) for another, no net improvement in economic welfare results.

This is why learning about travelers precise responses to incentive tolls is so important. Set the tolls too high, and it is possible to be worse off than with congestion; set them too low and the congestion problem is not adequately addressed. And the right toll cannot be guessed at, nor measured from surveys. The only way to find out is to do precisely what was done over the past two years: implement toll changes and measure the results.[2]

This would seem to be a call for more study of the subject of congestion pricing, but that would probably not be possible. While it might be desirable to have the Legislature lift its prohibition so that the issue of the effects of peak hour pricing could be settled with a much higher degree of confidence than is possible at present, the Legislature is unlikely to do so. This is not a political judgment about the Maine Legislature, but is a reflection of the underlying political economy of congestion pricing proposals as evidenced by actions in Maine and elsewhere.

In prohibiting the use of peak surcharges, the Maine Legislature was merely following the pattern set in a number of other state and local governments and in other countries. Although it is used to some degree in other countries and is being used in association with some privately-financed roads in the United States, congestion pricing on highways is in danger of remaining largely, in Anthony Downs words,, "what it has historically been: a theoretically interesting device invented by academics and implemented only in their imagination".[3] As simple and elegant as congestion pricing appears in theory and as attractive as it is from an economic efficiency point of view, governments have been loath to adopt it. Despite the strong incentives offered by the federal ISTEA legislation, very few state and local governments have taken advantage of the federal funds to try congestion pricing. The funds have been so little

[2] Anthony Downs notes that "[Road charges] should be set just high enough to divert the minimum number of vehicles in order to achieve desired average speeds, but the should not be so high that surrounding roadways become clogged.... Choosing the right tolls will, therefore, be a matter of trial and error experimenting on each road." See Downs, Anthony, *Stuck in Traffic: Coping with Peak Hour Traffic Congestion* (Washington: The Brookings Institution) 1992, p. 56.

[3] Downs, *Stuck in Traffic*, p. 60.

used, that Congress rescinded most of the funds for the program in November, 1995.

A number of projects have been proposed in California, where traffic congestion is a major state issue, but the only one to actually be implemented is the privately-financed project on State Route 91 in Orange County. The California Legislature has blocked implementation of projects in San Diego and San Francisco-Oakland.[4] Nor are these recent actions the only examples. New York has tried to implement congestion pricing in the 1970s and 1990s; both times political leaders in the city and state blocked any attempts by independent transportation authorities to implement peak surcharges.[5]

A number of reasons have been advanced to explain this strong opposition to peak period pricing, but the most important is that people object to higher prices when they are either being asked to pay for something that was formerly free and that they believed had been paid for through their gasoline taxes, or when they perceived no additional benefits to themselves that would result from the higher prices. This has led a number of writers on congestion pricing to suggest that it may only be appropriate in those cases where new or expanded capacity is to be paid for with a portion of the proceeds of the congestion toll.[6]

This conclusion was also supported by a Citizens Jury® on congestion pricing options in the Minneapolis area conducted by the Jefferson Center for the Hubert H. Humphrey Institute of Public Affairs at the University of Minnesota[7]. When the options for managing congestion in the Minneapolis-St. Paul area were reviewed in detail with a group of 22 residents of the region, they argued against the use of congestion pricing at first on the grounds that it is not likely to be effective because people had few alternatives. However, they recognized that congestion pricing could have some role to play if it were tied to other transportation improvements. They were most supportive of congestion pricing when tied to improvement projects on existing roads.[8]

In sum, there is as little reason to believe that the Legislature would reverse itself

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[4] Congestion Pricing Home Page, Hubert Humphry Institute of Public Affairs (http://www.hhh.umn.edu/centers/slp/conric/ See also, "Institutional and Political Challenges in Implementing Congestion Pricing: Case Study of the San Francisco Bay Area" in National Research Council, *Curbing Gridlock: Peak Period Fees to Reduce Congestion* (Washington: National Academy Press, 1994), pp. 300-17. An experiment involving the opportunity for single-occupancy-vehicles to pay a toll in order to use a high-occupancy-vehicle lanes has been approved for the San Diego area.

[5] Zupan, Jeffrey. "The New York Region: First in Tolls, Last in Road Pricing?" in *Curbing Gridlock*, pp. 200-15.

[6] See, for example, Martin Wachs of UCLA, quoted in Prendergast, John "What Price Congestion Management?" *Civil Engineering* April, 1995, pp. 37-39.

[7] Citizens Jury® is a registered trademark of the Jefferson Center, 346 Century Plaza, Minneapolis, Minnesota 55404-1007

[8] Proceedings of Congestion Pricing Workshop held May 17, 1996 in Chicago. Proceedings on the Congestion Pricing Home Page at http://www.hhh.umn.edu/Centers/SLP/Conpric/chicago.htm#update. The Citizens' Jury also suggested that "congestion pricing" was not a name which resonated well with the public and urged that another term be used. They suggested "congestion relief tolls". See also *Buying Time*, pp. 89-96. The SR91 project in California uses the term "value tolls".

and authorize an experiment in peak hour pricing as there is good reason to believe that such experiments are essential. There are also barriers to effective use created by the large peak periods and the shrinking of alternative times into which travelers could realistically go with projected traffic growth. The answer to the first question of whether true congestion tolls would alleviate congestion must therefore be that it is possible, but unlikely, that it will require extensive additional analysis and experimentation, and that it is unlikely that permission to conduct such studies will be granted.

Does congestion pricing involving a combination of peak hour surcharges and offpeak discounts have any future on the Maine Turnpike? It should, because it is clear that no single strategy will alleviate congestion on the Turnpike. The analysis of a variety of traffic management and substitute strategies by the Authority shows limited success for any of them.[9] The most commonly-mentioned response to congestion, adding two additional lanes from mile 12 to Portland, will reduce congestion for some period of time, but "... in the long run, building new roads or expanding existing ones does not reduce the extent of peak-hour congestion to any extent..."[10] Long history suggests that simply adding capacity to relieve congestion results in a reduction of travel costs (congestion costs) that attracts travelers who had previously avoided the congested period by shifting their time of travel or their route[11]

This study did not evaluate whether additional lanes are necessary to reduce congestion, and *we draw no conclusions with respect to that issue*. However, if a decision were made to widen, congestion pricing, including peak hour tolls, should continue to be considered by the Authority. Congestion tolls, whether peak hour tolls alone or combined with offpeak discounts will have several advantages for the Authority if the decision is made to widen:

1. They will provide a revenue source to help defray the costs of the widening. Using some of the revenue of congestion tolls would assign a proportion of the costs of widening to peak users who will receive the most benefit from the expansion of the roadway. Basic fairness suggests that those who create the demand for the wider road also pay their share of the costs.[12]

2. They will provide a traffic management device which could be used well into the future as traffic growth and congestion build once again as they inevitably will. Peak hour pricing would extend the effective life of a less-congested Turnpike beyond what would otherwise be the case. Even the modest incentives of the discount

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[9] VHB, *Maine Turnpike Alternatives Study* (Portland: Maine Turnpike Authority, December 1996)

[10] Downs, *Stuck in Traffic* p. 37.

[11] Or by using public transit, an option not significant here.

[12] The Legislature explicitly recognized that users of the Turnpike should bear the costs of maintenance and improvement when, in 1980, they voted to keep tolls on the road rather than let them expire. This was a difficult decision since the Turnpike had originally been sold to Maine people on the grounds that Turnpike would become a free road when the bonds were paid off. The Legislature recognized, however, that such costs should not be borne by the gas tax, but could more fairly be borne by Turnpike travellers.

coupon and SmartPass programs had some effect, and through a combination of selecting the right levels of peak and off-peak tolls and the use of the new electronic toll system, congestion pricing could be an important part of the Authority's future efforts to manage traffic.[13]

The Legislative barrier remains to be overcome. However, the results of recent examinations of congestion pricing, such as that in Minnesota, suggest that congestion pricing accompanied by improved transportation facilities may effectively meet the concerns of citizens and their elected representatives.

The 1995-96 congestion pricing trials on the Maine Turnpike did not result in effective traffic management, but a great deal has been learned that suggests that the unique conditions of the Maine Turnpike, including the high proportion of tourist traffic and the weekend traffic peaks, are not an insurmountable barrier to using congestion pricing. If the Turnpike Authority and Maine State Government can build on this foundation in the future, there is every prospect of a better transportation system for Maine that will serve the state well for many years to come.

[13] The telephone poll asked SmartPass holders whether they would be interested in using the new TransPass electronic toll system. 72% of SmartPass holders indicated they were "somewhat" or "very" interested in using TransPass. 33% of holders indicated that toll incentives offered through SmartPass would make it "very likely" that they would consider changing the time of their travel.

APPENDIX

Maine Turnpike
Congestion Pricing Study Advisory Committee

Jonathan Carter
Town of Wells

Joseph Kott
Regional Transportation Advisory Committee 7

Bruce Hammond
Natural Resources Council of Maine

Maria Fuentes
Maine Better Transportation Association

Vernon Cook
The Senator, Augusta
Maine Publicity Bureau

Bob Thompson,
Androscoggin Valley Council of Governments

Jim Uphan
City of Bath (formerly Southern Maine Regional Planning Commission

John Bubier
Greater Portland Council of Governments

Jerry Casey
Maine Department of Transportation

John Duncan
Portland Area Comprehensive Transportation Study

Aline Cote
Wood Structures Inc.
Biddeford

Wayne Davis
TrainRiders Northeast

Sen. Albert Stevens
Sabattus

Rep. William O'Gara
Westbrook

John Burke
Lewiston Area Comprehensive Transportation Study

Lloyd Irland
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