Appendix B

Literature Review and Case Studies

Chicago Regional Congestion Pricing Study

Congestion Pricing White Paper

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Table of Contents

Figures

Tables

CHAPTER 1

OVERVIEW

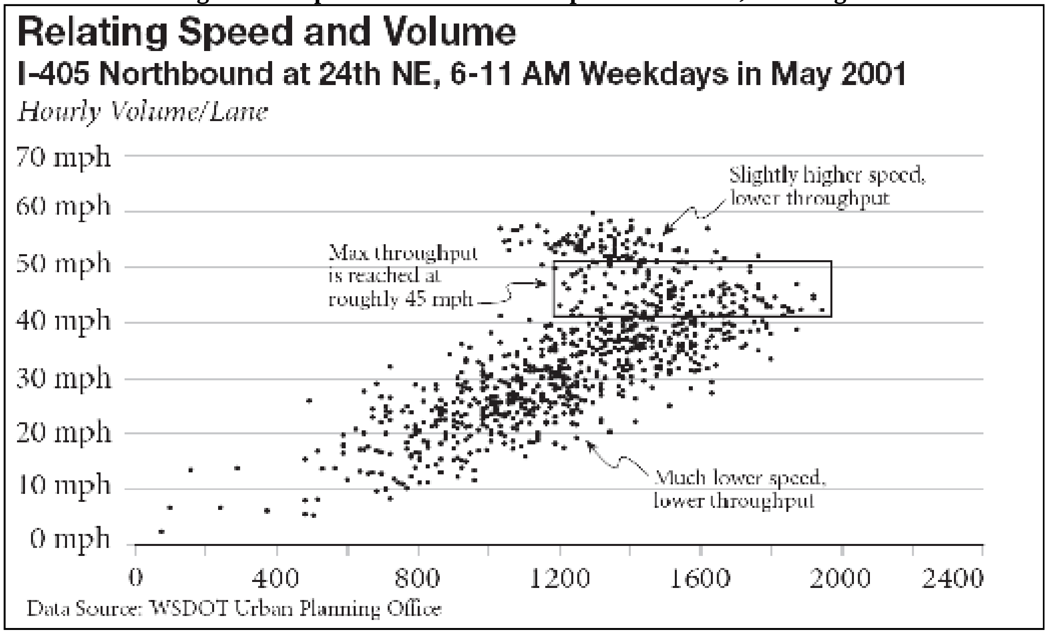
The focus of this report is on the impacts of congestion pricing policies and projects that have been implemented in the United States. Chapter 1 provides a definition of congestion pricing, an overview of the locations where congestion pricing has been implemented in the United States, and a general summary of the impacts of congestion pricing that have been observed. Special attention was given to impacts on travel behavior, public perception, equity, and the environment. The impacts of specific projects are discussed in more detail in later chapters.

DEFINITION

A basic definition of congestion pricing is a policy to harness the power of the market to partially reduce the waste of traffic congestion. These policies aim to reduce congestion by giving incentive to travelers to shift peak-period trips to off-peak, shift low-capacity trips to other more capacity-efficient modes, combine trips, or decide to no longer make certain trips. Wastes of traffic congestion include lost time, increased vehicle operating cost, and increased pollution.

The waste of traffic congestion is especially significant in over-capacity roadway conditions. Based on traffic flow theory, when traffic reaches over-capacity conditions, the addition of only a few vehicles to the traffic stream can severely impact all users on the roadway. For example, Figure 1-1 shows a speed and hourly volume per lane relationship on I-405 in Seattle, Washington for mornings in May 2001. According to the Highway Capacity Manual, the theoretical maximum hourly capacity of a highway lane is well over 2,000 vehicles. This capacity is not achieved in this example which likely suggests an upstream bottleneck is occurring. For this severely congested highway it can be observed that maximum throughput is achieved at roughly 45 mph. As speeds drop below 45 mph however (over-capacity conditions), vehicle throughput quickly diminishes. Maintaining speeds at 45 mph would be the most efficient use of capacity in this example. A congestion pricing policy to achieve this end would be to charge a variable toll on I-405 during this time period so that only enough drivers are willing to pay to maintain the 45 mph speed. This would limit the number of vehicles attempting to enter the bottlenecked condition in order to maintain maximum throughput.

Figure 1-1: Speed and Volume Example from Seattle, Washingon



The congestion pricing concept is commonplace in other industries such as airlines, theatres, hotels, and utility companies. Recently, technological advances in electronic toll collection (ETC) technology have made congestion pricing on roadways more feasible. With ETC, tolls can be collected at highway speeds, eliminating the slowdowns associated with traditional toll collection booths. Increased awareness of energy and environmental effects of automobile travel have recently heightened interest in congestion pricing. Also many congested urban areas have latent demand for automobile travel too high to be feasibly met by capacity increases alone. Congestion pricing can be a tool to manage this demand.

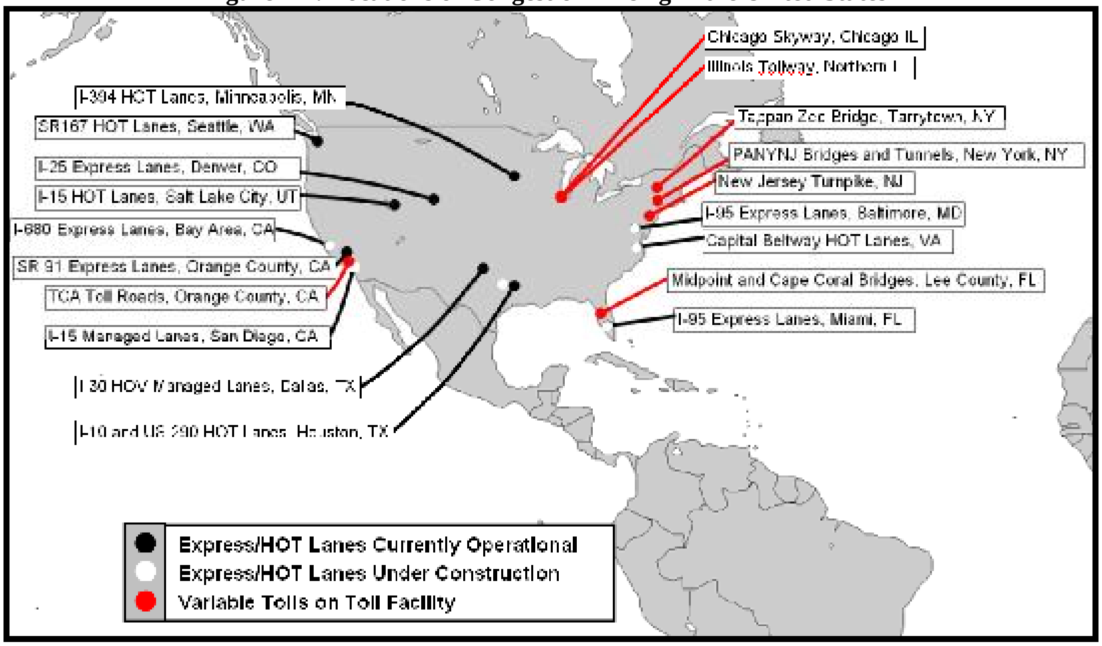
CATEGORIES AND LOCATIONS

Categories of congestion pricing include:

- Variable Tolls on Toll Facilities
- Express or High Occupancy Toll (HOT) Lane Facilities
- Cordon Tolling
- Distance-based Tolling

Figure 1-2 shows the locations of roadway systems with congestion pricing policies in the United States. Several other projects and policies are under consideration throughout the country.

Figure 1-2: Locations of Congestion Pricing in the United States



VARIABLE TOLLS ON TOLL FACILITIES

Variable tolls on toll facilities systems charge higher tolls during peak periods than during off-peak hours. These types of policies have been implemented on bridges in Lee County Florida, on the bridges and tunnels managed by the Port Authority of New York and New Jersey, on the Tappan Zee Bridge near New York City, on the Illinois Tollway, and on the New Jersey Turnpike.

EXPRESS AND HOT LANE FACILITIES

Express and HOT lane facilities are the most widespread use of congestion pricing in the United States. They can either be new-build toll lanes or toll lanes converted from existing underutilized or overutilized high occupancy vehicle (HOV) lanes. Currently no facilities have been converted from existing general purpose lanes. According to Federal Highway Administration (FHWA) definitions, HOT lanes refer to systems that allow specific groups of users to travel on the system for free during all operational periods while charging other users. On the other hand, express lanes refer to systems that charge (at least during certain time periods) all users on the system. Reduced tolls are given to specific vehicle groups in express lane systems (and free access in HOT systems). These vehicles usually include carpools, buses, and motorcycles. Note that the FHWA HOT and express lane definitions are often used interchangeably in standard practice.

According to the FHWA definitions, the HOT lane systems currently in operation include the I-394 HOT Lanes (MnPass) in Minneapolis, SR 167 HOT Lanes in Seattle, I-25 Express Lanes in Denver, I-15 HOT Lanes in Salt Lake City, I-15 Managed Lanes in San Diego, I-30 HOV Managed Lanes in Dallas, US 290 HOT Lanes in Houston, and the I-95 Express Lanes in Miami. The I-15 Managed Lanes in San Diego and the I-95 Express Lanes in Miami are also currently being expanded. The I-10 HOT lanes in Houston are currently under operation as HOV only during the current observational phase. The Capital Beltway HOT Lanes in northern Virginia and the I-680 Express Lanes in the bay area of California are currently being constructed as HOT lanes. The express lane system currently in operation is the SR 91 Express Lanes in Orange County. The I-95 Express Lanes in Baltimore are also under construction as express lanes.

CORDON TOLLING

Cordon tolling refers to when a toll is charged to drivers who enter a congested area, often a city’s central business district. No cordon tolls have been implemented in the United States but several have been implement in other part of the world. The most publicized cordon toll systems are in Singapore, London, and Stockholm. Cordon tolls have been proposed in the United States, the most well-known example being in part of Manhattan in New York City. After passing in the city, this proposal did not gain approval in the state legislature in April 2008.

DISTANCE BASED TOLLING

While not congestion pricing by itself, distance based tolling or vehicle miles traveled (VMT) based tolling can also incorporate congestion pricing concepts if a higher toll rate per mile is charged by time or location. Distance based or VMT based tolling systems have gained interest lately as an alternative to fuel taxes. Currently no distance or VMT based tolling systems (with or without congestion pricing) have been implemented in the United States. Privacy issues and the cost of the tolling infrastructure are among the problems with implementation.

SUMMARY OF IMPACTS

The potential impacts of the implementation of congestion pricing policies that are the focus of this report are travel, public perception, equity, and environmental.

TRAVEL IMPACTS

Congestion pricing can have a number of travel impacts depending upon price schedule and levels, the price elasticity of demand for the tolled facility, the level of availability of travel alternatives, and schedule flexibility of travelers. Congestion pricing has been found to be most effective when people have alternate routes, alternate departure times, transit, and ridesharing.

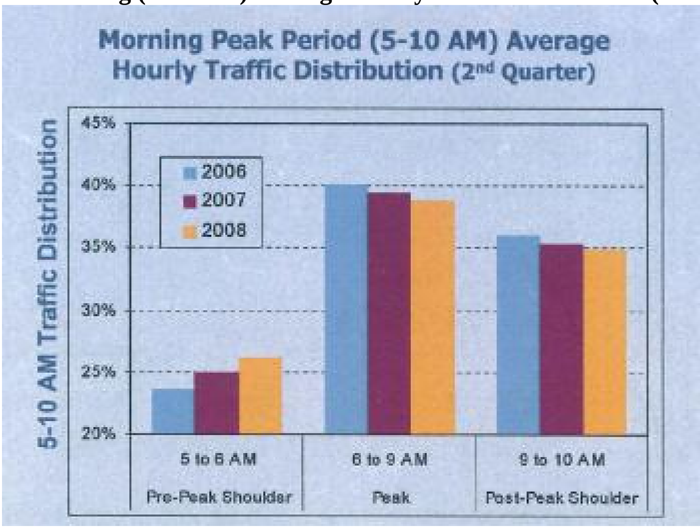
Examples of potential travel impacts of congestion pricing include:

- A change in the time of travel. Peak traffic may shift to off-peak with a consequent reduction of peak period traffic. Afterward, some off-peak traffic may also shift to the peak period to take advantage of the improved conditions (if they are willing to pay the increased toll).
- A shift in mode from single occupant automobile to alternative travel modes such as carpooling, transit, or bicycling that now have new incentives.
- A shift in routes to untolled or lower-tolled roads (or lanes).
- Combining more activities into a single trip or eliminating trips now deemed unnecessary.
- Change in destinations. For example, over the short term stores that are closer could become more favorable to shop at. If congestion pricing were to be implemented on a regional level, over the long term land use patterns may also be affected. There are opposing theories in this area; some argue that it would discourage sprawl while others believe it would increase decentralization.

One measure of travel impacts is price elasticity which varies with different system characteristics. This measure can apply to all types of congestion pricing systems. For example, cities with quality public transportation systems would likely have higher price elasticities to tolling because alternatives to automobile travel would be easily accessible. Many studies have arrived at price elasticity estimates of between -0.1 to -0.4 for urban highways (a ten percent increase in tolls would reduce traffic volumes by one to four percent). A 2002 survey of automobile long-distance commuters indicates that financial incentives are the most effective strategy for reducing car trips (*Assessing the Potential for Road and Parking Charges to Reduce Demand for Single Occupancy Vehicle Commuting in the Greater Vancouver Region*). A $3 round-trip toll was expected to reduce automobile commuting by 25 percent. A 2000 study involving time and mileage-based pricing (*Distance and Time Based Road pricing Trial in Dublin*) found that motorists reduced peak-period trips by 22 percent, total trips by 6 percent, peak mileage by 25 percent, and total mileage by 12 percent.

One specific example of shifting traffic to off-peak on a variable tolls on a tolled facility was reported by The Port Authority of New York and New Jersey (PANYNJ) in January 2009. In 2008, the toll for crossing the bridges and tunnels managed by PANYNJ during peak hours was increased from $6 to $8 for passenger car drivers paying electronically. Tolls during off-peak times were set at $6 for these drivers. This change doubled the off-peak price differential to $2. Significant reductions in AM peak period traffic were observed in 2008 with corresponding increases in traffic the hour before peak. This continued the trend from 2006 to 2007 when there was a $1 off-peak price differential. These changes were largely attributed to the off peak price incentive that exists for the approximately 75% of passenger car drivers that pay electronically. Figure 1-3 below illustrates these changes.

Figure 1-3: Morning (5-10 AM) Average Hourly Traffic Distribution (2nd Quarter)



Data Source: "Port Authority of NYNJ Congestion Pricing – The Results", Poster Presentation at TRB 2009

Shifts in mode to carpooling and transit are often one of the main objectives of HOT and express lane facilities to maximize person throughput. These facilities often offer price incentives to carpool or take a bus service. Also, considering HOV to HOT conversions, existing HOV lanes often suffer from high violation rates. These violation rates can deteriorate service so much that the HOV lane fills with single occupant vehicles and offers little travel time benefit for carpoolers and buses. This was the case on the I-95 HOV lanes near Miami, Florida which are now being converted and expanded into hot lanes. Implementing congestion pricing policies in these situations has been found to reduce violation rates significantly and ensure benefits to carpoolers and buses. For example, the ***I-394 MnPASS Technical Evaluation Final Report*** stated that violation rates on the MnPass HOT system in Minnesota went from 20% to 9% on the non-barrier section after conversion from HOV to HOT. At the same time speeds improved in the general purpose lanes as single occupant vehicles were able to legally buy into the HOT lane. (A note was made that part of the speed improvement was likely due to a Minneapolis area wide reduction in traffic). However, HOT and express lane systems may encourage more drivers to travel during the peak period in some cases. For example, the MnPASS technical evaluation stated that overall peak period volume increases suggest drivers who previously were squeezed out of the peak periods due to congestion may have incentive to return to the peak period with the reliable HOT lane alternative.

Policy changes with respect to vehicle occupancy can have large impacts on HOT and express lane systems as discussed in the *Continuation Study to Evaluate the Impacts of the SR 91 Value-Priced Lanes Final Report*. Within three months of the December 1995 implementation of the SR 91 Express Lanes in Orange County, California a 40% increase in vehicles with at least three people in them (HOV3+) was observed on all lanes of the highway. These vehicles where allowed to travel on the express lanes at no charge while single occupant vehicles and vehicles with two people paid the full toll. In January 1998, when a 50% toll was implemented on HOV3+ vehicles their numbers dropped by about one third (approximately 2000 vehicles per day).

The ***Value Pricing Pilot Program Lessons Learned Final Report*** listed several impacts that were found in the Value Pricing Pilot Program (VPPP) program. This program was part of the last two federal transportation bills and funded the implementation of a certain number of selected congestion pricing projects. One finding from the VPPP program was that variable tolls on existing toll facilities have lead to more efficient facility use, generally preserving or increasing revenues. Another finding was that HOT lane conversions had gained better use of underutilized HOV lanes while not slowing or dissuading HOV users. There was some non-conclusive evidence that these conversions had brought relief to adjoining general purpose lanes by attracting some of the traffic from these lanes. New construction express and HOT lane systems were found to have a much higher throughput at significantly higher speeds than adjoining general purpose lanes and to reduce congestion on the overall facility.

PUBLIC PERCEPTION

The impact of a congestion pricing project on public perception is especially important during the planning and implementation process. In the end, the public will determine the success or failure of a proposed system. It has been shown that public perception of a proposed congestion pricing system generally improves after implementation, making pilot projects important.

In the report, *The Public Supports Pricing If…A Synthesis of Public Opinion Studies on Tolling and Road Pricing*, 110 studies on public perception of road tolling were examined. Of these, 19 of the 26 studies (73%) relating to HOT lanes and eight out of the 13 studies (62%) relating to express lanes showed a majority support from the general public. However, of the 19 studies on cordon or area type pricing only six (32%) showed majority support. These studies show that public support does exist for congestion pricing (especially HOT and express lane type systems), but there are still many cases when majority support is not achieved (especially for cordon style systems). Although variable tolling on toll facilities studies were not specifically examined, 25 of the 35 studies (71%) on traditional tolling showed majority support.

Several factors were identified in the report as being important to positively impact public perception of road pricing. These include:

- The level of support from the public is higher if road pricing can be "perceived of as a choice" rather than "a punishment". "In many European examples, support was higher when road pricing was put forth as part of a comprehensive policy package of road and public transit investments".

- The public tends to support the projects where revenues are dedicated to highway infrastructure or public transit rather than special interest groups.
- "The public learns from experience" and shows even higher support after experiencing the benefits of the projects.
- Get the public fully informed of the pros and cons of the project tends to gain more supports. "In surveys in both Denver and Alameda County, support for HOT lane projects increased after information and clarification on how the HOT lanes worked. In San Diego, equity concerns dissolved and support for a pricing project strengthened when participants received clarifying information on the features of the project."
- People "do not want to pay for roads that they have gotten for free in the past". This "relates to why having an "alternative cost-free route" is so important for public support, and why support for tolling new roads and bridges is higher than for tolling existing facilities".
- "In terms of equity, there is general agreement that decisions to use or not use a priced facility revolve around people's needs and preferences. Everyone, regardless of who they are or where they live, benefits from having a choice."
- The public wants the mechanics of tolling to be simple and clear.
- "The public favors tolls if the alternative is taxes."

Another report, ***Marketing the Managed Lanes Concept***, focused on the importance of education in the public outreach process. The report lists several common messages that have been well received by the pubic. These include focusing on congestion pricing projects as a choice for commuters, one tool as part of a comprehensive congestion management plan, a way to maximize available road capacity, and something that has been successfully implemented elsewhere. Additionally, the public is generally unaware of how transportation projects are funded so education in this area as well as clear definitions of how revenues will be used after implementation has been found to be important.

One example of increased support after implementation of a HOT lane system is in the Minneapolis-St. Paul region. Congestion pricing as a tool to manage congestion in the region had been discussed since 1994. Proponents worked through several unsuccessful attempts to implement a congestion pricing pilot project in the 1990s before gaining legislative approval for the MnPASS system in 2003. There was still wide uncertainty about the I-394 MnPASS system before its implementation in 2005 but it has since been generally regarded as successful. Building on this success, a current proposal to implement congestion pricing (by variable pricing the inside shoulder) on I-35W south of Minneapolis has thus far been much less controversial than the I-394 HOT lanes as reported in the Congestion Pricing Committee meeting at the 2009 Transportation Research Board conference.

San Francisco had congestion pricing as one portion of a recent Urban Partnership Agreement (UPA) proposal. The UPA program was a 2007 funding incentive by the federal government for proposals that aggressively used tolling, transit, telecommuting, and technology to relieve congestion. Part of the proposal was to implement variable charges to fund reconstruction of Doyle Drive, a main thoroughfare that connects the Golden Gate Bridge and downtown San Francisco. Alternatives of implementing a downtown cordon toll, implementing variable tolls on the Golden Gate Bridge, and implementing variable tolls on Doyle Drive were considered. However, this part of the proposal was eventually withdrawn. One main reason for this was identified that people were generally not able to understand the congestion pricing concept.

EQUITY

Equity refers to the fair distribution of benefits and costs resulting from a congestion pricing policy decision. One common equity-based objection to congestion pricing is that low-income people may be priced off the road during the peak period. Another is that congestion pricing is actually a double tax because motorists are being asked to pay to use a facility that was initially financed through gasoline and other taxes.

However, the *Value Pricing Pilot Program Lessons Learned Final Report* has found in project experience that the perception of unfairness may be overdone. Equity evaluations have found higher income travelers often use facilities somewhat more than lower income groups, but general use exists across a wide range of incomes. Concerns have been raised during planning phases of HOT and express lane systems about catering to the rich. However the concerns are usually not sufficient to halt projects and normally diminish as projects get underway. One study associated with a planned expansion project found strong support with few differences about fairness based on ethnicity or income.

In general, congestion pricing will be inequitable if low income drivers are not adequately compensated for the higher tolls or if there are insufficient reasonable transportation alternatives. Addressing how revenues will be spent has been found to be important to compensate low income groups. Investing the money in expanded transit service on the system has been one successful strategy.

If the value to the traveler of the saved time using a system plus a portion of the redistributed revenues accessed is larger than the cost of the toll, then the traveler is better off. While value of travel time savings normally increases with income, lower income travelers still have certain trips that have a high value of travel time. This relates to the findings on several HOT lane systems that most users access the systems relatively infrequently (such as one or two days a week) when their value of travel time savings is higher. Also, if redistributed revenues are directed to transit, benefits can accrue to lower income travelers that never (or very infrequently) pay the toll.

ENVIRONMENTAL

In theory, measurable environmental improvements could be achieved by the implementation of a congestion pricing system. This is especially true with larger cordon or area type pricing systems.

Few environmental impacts studies have been undertaken on HOT and express lane systems after implementation. One study as part of the ***I-394 MnPASS Technical Evaluation Final Report*** found no substantial impacts on air quality and noise after implementation.

In the cordon-style charging system in London, England measurable reductions in carbon dioxide, nitrogen oxide, and particulate matter emissions were attributed to the congestion charge. These environmental improvements are documented in *Central London Congestion Scheme: ex post Evaluation of the Quantified Impacts of the Original Scheme* and include the original toll and the July 2004 toll increase. However, the London congestion charging implementation is of a much larger scale than any current congestion pricing implementation in the US.

CHAPTER 2

CASE STUDY: NEW JERSEY TURNPIKE

BACKGROUND

The New Jersey Turnpike Authority (NJTA) operates New Jersey Turnpike (NJTPK), a 148-mile facility with 28 exit locations. With average daily trips exceeding 700,000 vehicles, it is one of the most heavily traveled roads in the United States. (Data are from 2005.)

Since September 2000, NJTA has implemented a time-of-day pricing program for vehicles with E-ZPass, an electronic toll collection (ETC) system, to shift some peak-period traffic to off-peak hours. The price differential increased in several phases.

For the first stage of the program, time-variant toll levels were introduced in September 2000 concurrently with the introduction of E-ZPass technology. On average, 12 percent higher tolls during peak hours were charged on weekday peak periods from 7 to 9 AM and from 4:30 to 6:30 PM. The second stage started on January 1, 2003. Compared to the first stage, the toll rate was increased by 5 percent for E-ZPass off-peak, 10 percent for E-ZPass peak, and 17 percent for all cash passenger cars. For passenger cars with E-ZPass, the tolls during peak hours became 15 percent higher than off-peak hours, equivalent to 10-60 cents depending on the distance traveled. Users paying with cash were charged a higher rate as an incentive to change to E-ZPass. The peak period E-ZPass discount (compared to cash) was eliminated in 2004. With the most recent toll increase a 25 percent peak period discount is in effect for E-ZPass users.

Table 2-1 lists the passenger car toll rate increases from 2001 to the present. Toll rates listed are for driving the entire length of the facility so most trips would be much lower.

Table 2-1: New Jersey Turnpike Passenger Car Toll Rate Increases 2001 to Present

Passenger Car Toll	1991	September 2000	January 20003	2004	December 2008
Cash All Day	70%	20%($5.50)	17%($6.45)	-	40%($9.05)
E-ZPass Peak	-	8%($4.95)	10%($5.45)	18%($6.45)	40%($9.05)
E-ZPass Off Peak	-	0%($4.60)	5%($4.85)	-	40%($6.80)
E-ZPass Weekend	-	8%($4.95)	10%($5.45)	-	66%($9.05)

EVALUATION

An evaluation titled *Evaluation Study of New Jersey Turnpike Authority's Time of Day Pricing Initiative* was completed in 2005 using data collected during 1998-2003. A paper titled *The New Jersey Turnpike Road Pricing Initiative: Analysis Traffic Impacts* was published based on the evaluation. The main finding of the evaluation was that the stage one introductions of E-ZPass technology and time of day pricing reduced average trip delay by about 3 – 18 percent and reduced toll plaza delays by 44 – 74 percent. For the stage two time of day pricing no statistically significant impact of traffic patterns on the Turnpike was observed.

Throughout the 2000 to 2003 time period there was a statistically significant increase in demand for the Turnpike and no evidence of a shift in demand to other modes or routes with time of day pricing. In the first stage of time of day pricing, some peak traffic shifted to off-peak periods as found in analysis of aggregate volume analysis. Absolute traffic volumes were observed to "increase at a lower rate (6 percent for the AM peak and 4 percent for the PM peak) compared to the absolute traffic volumes at off-peak periods (10 percent). In addition, the decrease in the percent share of peak periods was statistically significant (1.7 percent for the AM peak and 3.7 percent for the PM peak)" compared to off-peak (1.1 percent increase). However in the second stage of peak period pricing this trend was found to be reversed as peak period volumes increased at a higher rate than off-peak. Based on this analysis the paper stated that "these changes among two stages of time of day pricing implementation can be due to the first stage of the time of day pricing program which might have encouraged commuters to shift to peak shoulder and, in turn, increased travel times in these periods. However, due to lack of detailed traffic and travel time data at the aggregate level, it is not possible to pinpoint the exact reason of this change in traffic."

Analysis of disaggregate data from three months before and after the phase two implementation found few traffic impacts from the relative increase in the peak period discount (raised to 15 percent from 12 percent). It was found that most of the users prefer peak periods with a lower travel time and higher tolls than peak shoulders with a higher travel time but lower tolls even if traffic is higher at the peak periods. The analysis indicated that users were trying to avoid congestion rather than avoid higher tolls. The evaluation summarized this finding by stating that the "second stage of the time-of-day pricing program did not have a quantifiable impact on traffic patterns". The paper also compared the analysis to studies on the SR 91 Express Lanes, the I-15 HOT Lanes in San Diego, and the London Congestion Charging scheme. The paper commented that "unlike these studies, traffic on the New Jersey Turnpike is more uniformly distributed between mid-peak and peak shoulders. Thus, highest traffic is not always observed at mid-peak periods." This likely would reduce the impact of peak period pricing.

NJ Turnpike users were observed to have relatively high VOT values ($15/hr-$20/hr) and low elasticity values (between -0.06 and -0.18), indicating that they give higher values to travel time savings compared to other toll road users in the US. These findings would suggest that much higher peak toll differentials than 12 or 15 percent would need to be implemented to achieve a significant change in driver behavior.

To obtain descriptive information on the impacts of time of day pricing on passenger travel behavior a survey was conducted during June and July 2004. The survey found that 7 percent of individuals (36 out of 513 respondents) changed their travel behavior after the first phase of time of day pricing. The main reactions to time of day pricing included increased car trips along alternate routes and decreased frequency of trips on the Turnpike. Only 10.5 percent of the 303 E-ZPass users were aware of the discounts associated with time of travel. Users traveled at the time they did mainly to avoid congestion rather than to take advantage of cheaper tolls.

CHAPTER 3

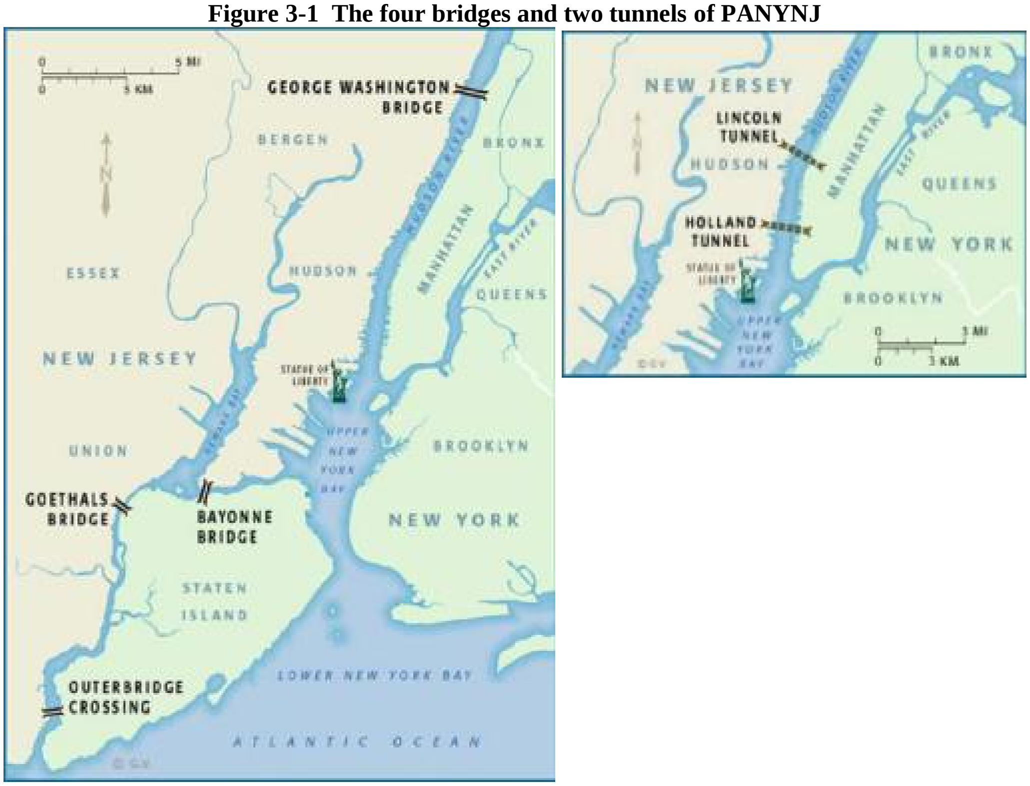
CASE STUDY: PORT AUTHORITY OF NEW YORK AND NEW JERSEY

BACKGROUND

The New York/New Jersey Port Authority (PANYNJ) operates an extensive bi-state transportation system of tunnels, bridges, and terminals between New York and New Jersey. It is one of the most heavily used systems in the country. There are four bridges and two tunnels, of which one bridge (George Washington Bridge) and two tunnels (Lincoln Tunnel and Holland Tunnel) connect New Jersey with Manhattan of New York City, and the other three bridges (Bayonne Bridge, Geothals Bridge and Outerbridge Crossing) link New Jersey and Staten Island of New York City. Tolls are charged on vehicles crossing from New Jersey to New York only.

According to the PANYNJ website, more than 254 million vehicles use the agency's tunnels and bridges every year, and the George Washington Bridge is the world's busiest crossing. Figure 3-1 shows the bridges and tunnels of the PANYNJ system.

Figure 3-1 The four bridges and two tunnels of PANYNJ



Source: panynj.gov

In March 25, 2001, PANYNJ changed from fixed rate to variable pricing. It set up a high cash toll at all times of day, and a discount rate for E-ZPass users to encourage enrollment in the electronic tolling system. Additionally, for E-ZPass users a further discount was offered for vehicles traveling during off-peak hours. Peak hours are defined as weekdays from 6 to 9 AM and 4 to 7 PM, as well as on weekends from 12 noon to 8 PM. Also, discount overnight hours were established effective from 12 to 6AM for trucks using E-ZPass only. Another toll rate change occurred on March 2, 2008 that increased tolls and also increased the off-peak discount for passenger car E-ZPass users. Discounts are also currently offered to certain low-emission vehicles and carpool vehicles. Table 3-1 gives the toll rates before and after the 2001 toll changes and the current toll rates are given in Table 3-2.

Table 3-1: Toll Rates Before and After the March 5, 2001 Changes

Payment Type	Before 3-5-2001	After 3-5-2001
Cars		
Cash Peak	$4.00	$6.00
Cash Off-Peak	$4.00	$6.00
E-ZPass Peak	$3.60	$5.00
E-ZPass Off-Peak	$3.60	$4.00
Trucks (per axle)		
Cash Peak	$4.00	$6.00
Cash Off-Peak	$4.00	$6.00
E-ZPass Peak	$3.60	$6.00
E-ZPass Off-Peak	$3.60	$5.00
E-ZPass Overnight	$3.60	$3.50

Table 3-2: The Current Toll Rates on the PANYNJ Bridges and Tunnels

	E-ZPass Off-Peak Hours	E-ZPass Peak Hours	E-ZPass Overnight Hours	Cash All Hours
Autos	$6.00	$8.00	$6.00	$8.00
Motorcylcles	$5.00	$7.00	$5.00	$7.00
Trucks (per axle)	$7.00	$8.00	$5.50	$8.00
Buses	$4.00	$4.00	$4.00	$6.00

EVALUATION

An evaluation titled *The Impacts of Time-of-day Pricing Initiative at NY/NJ Port Authority Facilities Car and Truck Movements* was completed in 2006 based on the variable pricing rates before the March, 2008 changes. It concluded that variable pricing was successful to "spread weekday peak period traffic to the hours just before or after the peak toll rates are in effect, for both cars and trucks." The following are excerpted from the evaluation:

- There is statistically significant shift towards pre-peaks both in the mornings (5 to 6 AM) and afternoons (3 to 4 PM) in car traffic percent share after the variable pricing.

- However, weekday and weekend peak-period car percent share experienced a statistically significant decrease only at the George Washington Bridge.

- Weekday truck traffic percent share showed statistically significant shift to morning pre-peak (5 to 6 AM) and afternoon post-peak hours (7 to 8 PM).

- Unlike car traffic, truck traffic decreased for all peak-periods on both weekdays and weekends at all crossings after the time-of-day pricing, though the decrease in peak traffic was statistically significant only on weekdays.

- Weekend car and truck traffic percent share did not have statistically significant change in peak-shoulder hours (11 AM to 12 PM and 8 to 9 PM).

- The data indicates that 35 out of 505 (representing 6.93 percent of individuals and 7.4 percent of car trips) individuals changed behavior after the initiative. The analyses indicate that users responded in a combination of ways to the new toll schedule. This includes decreased travel by car and increased use of transit (2.6 percent); increased use of transit and increased carpooling (1.8 percent); decreased number of trips during peak and increased during off peak (1.5 percent); decreased number of trips during both peak and off peak (1.3 percent); and increased use of public transportation and switched to E-ZPass (1.2 percent).

- The analyses conducted using a data set collected for another purpose for the PANYNJ indicate that among E-ZPass users who are aware of the off-peak discount program, 16 percent had changed their travel schedules to enjoy the off-peak discounts. This represents 7.68 percent of the E-ZPass users and 5.33 pecent of the total number of users. The data also suggest that carriers are responsive to receivers' desires in terms of delivery times. Of the carriers that indicated they cannot change delivery times, 93 percent cited receivers' opposition as the key factor.

- Although the off-peak price differences are modest ($1 per trip, a 20 percent discount for cars), the effects have been significant. Comparing one typical day in May 2001 (less than 2 months after the variable pricing program went into effect) with a typical day in May 2000, the Port Authority analysis found that 7 percent fewer drivers used the agency's bridges and tunnels during the morning peak hour period and that 4 percent fewer were traveling the crossings during the afternoon peak hours. These declines amount to 5,150 fewer vehicles in the morning's most congested hours and 2,500 fewer during the early evening rush.

- Significantly, the shift of traffic out of the peak hours was accompanied by an increase in off-peak travel, as well as by increased car-pooling and transit use. The same May-to-May analysis found that 7 percent more vehicles (an increase of

2,150) used Port Authority facilities between midnight and 6 AM in 2001, with roughly half of the total vehicle increase occurring from 5 to 6 AM. The agency also said there were significant gains in traffic from 3 to 4 PM and that 3,350 more trips were made during the off-peak hours, 9 AM to 3 PM.

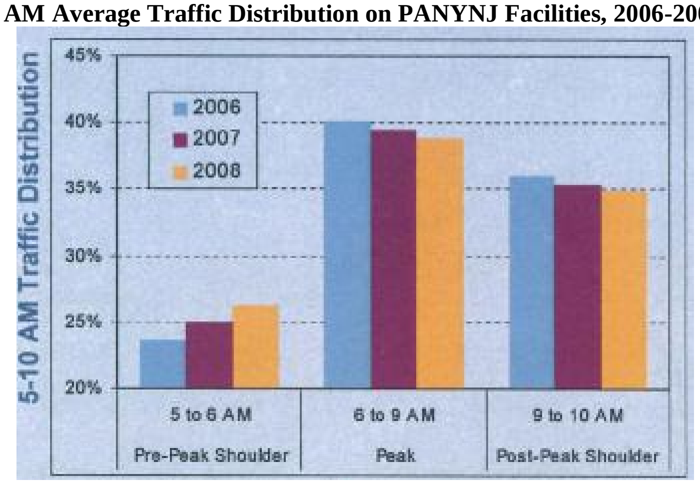
- Also, 7 percent fewer trucks (a reduction of 450) are traveling Port Authority crossings during the morning peak, while 4 percent more (an increase of 270) are traveling during the overnight hours of midnight to 6 AM. The shift out of the afternoon peak hours is less significant (a reduction of 50).

An updated evaluation was presented at a January 2009 Transportation Research Board poster presentation that updated the findings to include the March 2008 toll rate increases. The objectives of these increases were to:

- Encourage shifts to off-peak travel to address peak-period congestion
- Encourage mass transit in corridors with mass transit alternatives
- Promote environmental stewardship
- Preserve capital investment capacity derived from toll revenues by advancing more predictable incremental toll rate changes
- Maintain pricing incentives for commercial traffic management.

To address the first objective, the peak period E-ZPass discount was eliminated which doubled the off-peak price differential to $2. Table 3-3 shows that a shift away from the peak to the pre-peak shoulder continuing in the second quarter of 2008 with the increase. This occurred despite traffic volumes being down because of increasing fuel costs in the second quarter of 2008.

Table 3-3: The AM Average Traffic Distribution on PANYNJ Facilities, 2006-2008 (2nd Quarter)



Source: "Port Authority of NYNJ Congestion Pricing – The Results", Poster Presentation at TRB 2009

The toll structure supports improved PATH bus service and capacity, bus terminal enhancements, and exclusive bus lane operation to encourage mass transit. Since January 2006 PATH bus and New Jersey Transit ridership has grown by 20 percent. This was attributed to the incentives provided by the new toll rates as well as the gas price spike in 2008. In addition to improving and encouraging mass transit, environmental stewardship is promoted through the GreenPass discount program (also started March 2, 2008) that offers a $2 discount (from the normal $6 E-ZPass rate) to eligible vehicles during off-peak hours. Vehicles in this program must get at least 45 miles per gallon and meet "Super Ultra Low Emission Vehicle" standards. The program included over 1,300 accounts at the end of 2008.

CHAPTER 4

CASE STUDY: TAPPAN ZEE BRIDGE

BACKGROUND

The Tappan Zee Bridge is a 3.03 mile bridge in New York located over the Hudson River and managed by the New York State Thruway Authority. It is part of the I-87 and I-287 on the New York State Thruway mainline, located about 25 miles north of Midtown Manhattan. The bridge carries nearly 140,000 vehicles daily on seven lanes of traffic. The centermost lane is reversible by time of day but conditions are still very congested especially during peak commuting hours.

A round-trip toll on the TZB is collected from eastbound traffic, while no toll is collected from westbound traffic. Current toll rates for passenger cars are $4.75 for E-ZPass paying users and $5 for cash paying users. Commercial vehicles paying with E-ZPass pay half price when they avoid the 6-10 AM peak. The congestion pricing on commercial vehicles paying with E-ZPass has been in place since 1997 and was the first implementation of congestion pricing in the New York City metropolitan region. However, large discounts ($2 per trip compared to the cash toll rate) are available to commuters (those traveling at least 20 days per month) that effectively are the opposite of congestion pricing for a large percentage passenger cars traveling in the peak periods. Commuters who travel with three or more occupants in their vehicle can register to pay only $0.50 per trip at a $4.50 discount compared to the cash toll rate.

Currently, the focus for the bridge has moved to major rehabilitation or replacement. As discussed in *Alternatives Analysis for Rehabilitation or Replacement of the Tappan Zee Bridge* released in September 2008, the effects of age, truck volumes, and highway and marine salts are causing deterioration of the bridge. Several cost saving measures in the bridge design have amplified the scale and rate of deterioration compared to other bridges of similar size. Replacement alternatives include four general purpose lanes, two shoulders, and a bus rapid transit/HOT lane in each direction.

EVALUATION

Congestion pricing on commercial vehicles was implemented in response to large increases on truck traffic on the Tappan Zee Bridge, especially following the finishing of a segment of I-287 in New Jersey in 1993. One estimate in *Mobilizing the Region* Issue 113 stated that truck traffic had nearly doubled on the Thruway from 1993 to 1997. However, many sources expressed concern over other measures that were implemented simultaneously with the congestion pricing on trucks, especially increased discounts to commuting passenger cars. It was stated that discounts to commuter cars went in opposite of congestion pricing policies and would make any future pricing policies on passenger cars much more difficult politically. Remarks from Jeffrey Zupan of the Regional Plan Association at a May, 1997 public hearing on the proposed changes were summarized in *Mobilizing the Region* Issue 127. They included:

- Even with the congestion pricing measures for truckers the peak tolls on I-287 in New Jersey, the Thruway, and the Tappan Zee bridge remain lower than the peak tolls on the best alternative – the New Jersey Turnpike and the George Washington Bridge.
- By proposing to raise the bridge toll (from $2.50 to $3) for non-commuters the Thruway is deepening the discount to commuters to 67 percent which is bar far the greatest in the region. (Commuters using the crossing at least 17 times per month paid $1 per crossing at this time.) This would make the concept of incentive tolls for peak users much more difficult to eventually implement.
- The Thruway should instead keep the non-commuter toll the same and raise the commuter toll.

A November 1998 issue of *Mobilizing the Region* Issue 196 discussed early survey results of the congestion pricing program for truckers to have positive effects. Half of the respondents using E-ZPass said they changed at least one aspect of their travel behavior, including time of day, payment method, route, or some combination of the three. Also results indicated that E-ZPass-equipped commercial vehicles are changing their travel times by shifting their travel outside the most congested periods.

While it was found that 76 percent of cash-paying drivers were not aware of the congestion pricing policy, 27 percent of them stated they would be willing to change their time of travel or route if they had know of the policy and were enrolled in E-ZPass. Many truckers stated that they had no choice on whether to use E-ZPass because the decision was made with company executives. These findings were taken to mean that the program might be more successful with increased outreach efforts.

A *Congestion Relief Pricing Study for the Tappan Zee Bridge* corridor was completed by the New York State Thruway Authority in 1999. The study, which began in 1996, showed "that even modest price differentials between peak and off-peak toll rates stand to significantly reduce congestion on the chronically clogged bridge." The study was discussed in a September 1999 *Mobilizing the Region* Issue 238.

The study estimated that 75% of rush hour drivers paid the $1 commuter vehicle rate. Especially with these users, the study found higher peak prices would shift a significant number of drivers to other travel times. It was also found that some travelers who now avoid the peak hours due to the congestion would return to them if the peak pricing eased traffic flow enough. The finding was found to reflect the willingness of many commuters to pay a higher toll if it meant less time spent in traffic. Additionally the study found that peak period pricing would give incentive to express bus transit. At the time of the study there was no financial or time-saving incentive to use transit with the significant congestion and the $1.80 round trip cost of taking the bus (compared to the $1 commuter toll for drivers). Table 4-1 lists the effects on peak hour traffic volumes of three toll scenarios as estimated in the study:

Table 4-1: Tappan Zee Bridge Congestion Relief Study Toll Scenarios and Estimated Effects

	Toll Scenario		
	One	**Two**	**Three**
Changes in Traffic	7 – 9 AM: **$1.50** Shoulder: **$1** Off-peak: **$0.50**	7 – 9 AM: **$2.50** Shoulder: **$2** Off-peak: **$1.50**	7 – 7:30: **$2** 7:30 – 8:30: **$2.50** 8:30 – 9 AM: **$2** Shoulder: **$1.50** Off-peak: **$1**
Shift out of 7-9 AM Peak	16%	17%	15%
Shift into 7 – 9 AM Peak	9%	6%	5%
Net Peak Volume Change	-7%	-11%	-10%

Source: *Mobilizing the Region* Issue 238

Surveys conducted as part of the study found that many travelers have some flexibility and will actively consider time-of-day shifts when peak period prices are increased. Interviews with employers in the I-287 corridor served by the bridge indicated that "congestion is a problem, contributing to employee tardiness and stress." Some claimed "it is difficult to attract and retain employees from west of the Hudson River." The paper, *Traveler Reactions to Congestion Pricing Concepts for New York's Tappan Zee Bridge*, discussed the survey results in more detail. Surprisingly, there were no pronounced differences in the receptiveness to congestion pricing concepts among major demographic segments. Overall, slight majority support across the full traveler population was shown for congestion pricing concepts. However, those who opposed where much more vehement in their position and those supporting pricing were found to change their stance much more easily.

The final conclusion of the *Congestion Relief Pricing Study for the Tappan Zee Bridge* stated that "The analyses conducted for this study indicate that pricing can be used to change the behavior of a reasonably large number of travelers. The overall peak period traffic reduction is clearly significant enough to warrant serious consideration on the congested Tappan Zee corridor." Despite the findings, congestion pricing on passenger cars has never been implemented on the bridge and steep commuter discounts still exist for passenger vehicles.

CHAPTER 5

CASE STUDY: LEE COUNTY

BACKGROUND

Variable pricing has been used on two of the four bridges over the Caloosahatchee River in Florida, the Cape Coral and Midpoint Bridges, since August 1998. The bridges connect the cities of Cape Coral and Fort Myers in Lee County, Florida. The majority of the area employment is near Fort Myers so the four bridges provide important commuter links, especially for residents in Cape Coral.

The Cape Coral and Midpoint bridges have reduced tolls in the times just prior and just following the peak hours as an incentive for motorists to adjust their travel times. The discount periods are 6:30 to 7 AM, 9 to 11 AM, 2 to 4 PM, and 6:30 to 7 PM. The variable pricing discount is only available to those motorists who are participating in the LeeWay electronic tolling system and have a prepaid toll account. The other two payment options that are not eligible for the off-peak discounts are cash and payment with transponder without a prepaid account. At the start of the program, eligible drivers who were initially paying $1 could pay $0.50 during the off-peak and drivers who were also enrolled in the frequent user discount program who were initially paying $0.50 could pay only $0.25. According to the paper ***Long-Run Changes in Driver Behavior Due to Variable Tolls***, it was estimated the majority (94%) of drivers eligible for the congestion pricing discount were in the frequent user discount program.

The project expanded in 2003 to include variable pricing for large trucks to encourage increased travel during off-peak periods.

In November 2007, eastbound tolls were removed on both the Cape Coral and Midpoint bridges to improve traffic flow. The normal westbound tolls were increased to $2 as part of this change and the frequent user discount program was continued at similar relative discounts. The off peak toll discount was changed to $1.50 for payment with an electronic transponder and $0.75 for payment with an electronic transponder and being enrolled in a commuter discount program. The off-peak toll for large trucks was set at 75 percent of the peak period toll. For example, for trucks with 5 axles the peak period toll was set at $8 and the off-peak toll for payment with an electronic transponder was set at $6. Cash-paying vehicles continued to be ineligible for off-peak discounts.

EVALUATION

Study results showed that a significant number of Lee County residents did change their driving behavior with even small reasons to change. (The difference in toll in peak versus non-peak travel was as low as 25 cents.) Congestion pricing offered residents a monetary reason to change their behavior.

Participants in the program were motivated by toll savings, rather than time savings. This shows some importance on knowing the population being served. In New York or Utah, many participants in similar programs were motivated more by time savings. One factor for this is that Lee County is primarily a retirement community, populated by older residents. Another factor, explained in the paper *Observed Traffic Pattern Changes Due to Variable Tolls*, is that Lee County does not suffer from severe congestion. In 1998, the peak hour levels of service during the peak season the four bridges crossing the Caloosahatchee River was at least C. "Therefore, any traffic changes resulting from variable pricing will likely be due to economic factors (toll savings) and not to congestion (reduced travel time outside the peak period)."

This paper discussed the traffic changes in depth using data collected from August 1998 to December 1998. As was expected in the value pricing project plan, during this early-implementation phase a steady increase was seen in both the number of drivers eligible for variable pricing discounts as well as in traffic during off-peak periods. The largest traffic shift occurred on the Midpoint Bridge which saw a 7 percent increase in traffic during the early morning discount period. Nearly all of this change was attributed to those drivers eligible for peak period discounts as little change in times of crossing the bridges was observed in ineligible drivers.

Elasticities have been observed to decrease over time. For example, as described in the paper *Long-Run Changes in Driver Behavior Due to Variable Tolls*, from 1998 to 2002 the estimated relative elasticity during the early morning discount period dropped from -0.43 to -0.11 on the Midpoint Bridge. This was opposed to general results in other literature which assumed that, since drivers have more opportunities to change their travel behavior in the long run, long-run elasticities would tend to be higher than short-run. However, the paper also noted since toll rates did not increase with inflation, the purchasing power of the toll rate amount went down over time. This may over-emphasize the observed dropping elasticities over time. Figure 5-1 shows the price elasticities of demand for all daily periods from 1998 to 2002 on both bridges.

Figure 5-1: Tables Showing Price Elasticities of Demand over Time on Lee County Bridges

TABLE 1 Price Elasticities of Demand at Cape Coral Bridge

Analysis	Year (*j*)	6:30–7:00 a.m.		9:00–11:00 a.m.		2:00–4:00 p.m.		6:30–7:00 p.m.	
		PED (a)	PED (r)	PED (a)	PED (r)	PED (a)	PED (r)	PED (a)	PED (r)
Method 1	1999	0.20	0.27	0.10	0.12	0.11	0.14	0.02	-0.01
	2000	0.10	0.09	0.10	0.14	0.09	0.10	0.02	-0.01
	2001	0.13	0.13	0.09	0.13	0.10	0.10	-0.01	-0.03
	2002	0.03	0.01	0.07	0.09	0.08	0.07	-0.06	-0.08
Method 2	1999	0.24	0.31	0.09	0.10	0.10	0.10	0.04	0.05
	2000	0.15	0.17	0.06	0.10	0.07	0.07	0.01	0.02
	2001	0.21	0.22	0.06	0.10	0.06	0.06	-0.02	0.01
	2002	0.08	0.06	0.04	0.06	0.05	0.06	-0.04	-0.03

PED (a) is price elasticities of demand estimated using absolute changes in eligible traffic.
PED (r) is price elasticities of demand estimated using relative changes in eligible traffic.
Price elasticities of demand are denoted by positive sign and negative price demand elasticities denote no effect of variable pricing.

TABLE 2 Price Elasticities of Demand at Midpoint Memorial Bridge

Analysis	Year (*j*)	6:30–7:00 a.m.		9:00–11:00 a.m.		2:00–4:00 p.m.		6:30–7:00 p.m.	
		PED (a)	PED (r)	PED (a)	PED (r)	PED (a)	PED (r)	PED (a)	PED (r)
Method 1	1999	0.36	0.34	0.10	0.12	0.11	0.11	0.06	0.07
	2000	0.30	0.22	0.06	0.05	0.14	0.12	0.05	0.06
	2001	0.14	0.13	0.11	0.05	0.15	0.10	-0.02	-0.02
	2002	0.12	0.03	0.17	0.04	0.18	0.08	-0.03	0.00
Method 2	1999	0.43	0.42	0.09	0.10	0.10	0.09	0.11	0.11
	2000	0.39	0.28	0.07	0.05	0.14	0.09	0.07	0.06
	2001	0.21	0.14	0.10	0.06	0.13	0.06	0.07	0.06
	2002	0.31	0.11	0.14	0.06	0.14	0.05	0.08	0.03

PED (a) is price elasticities of demand estimated using absolute changes in eligible traffic.
PED (r) is price elasticities of demand estimated using relative changes in eligible traffic.
Price elasticities of demand are denoted by positive sign and negative price demand elasticities denotes no effect of variable pricing.

Source: *Long-Run Changes in Driver Behavior Due to Variable Tolls*

Data were obtained in a bridge-user survey conducted in May 1999. It was found that 28 percent of all drivers eligible for the toll discount used it at least once during the first nine months of the project. Most of these variable pricing participants, 71 percent, used it at least once per week. The reason most often cited for not using variable pricing was that time of travel was inflexible. Very few respondents felt the toll savings were too small to cause them to change their time of travel.

A telephone survey was conducted in July 2001, approximately 3 years after the variable pricing was implemented. A total of 794 surveys were collected out of 4,000 drivers who were contacted as described in the paper ***Long-Run Changes in Driver Behavior Due to Variable Tolls.*** The paper stated that "it was found that certain driver characteristics, such as drivers who made more frequent trips on the Cape Coral Bridge, were on commute trips, were full-time employees, had more persons in their households, had a postgraduate degree, and were between 25 and 34 years old all were significantly more likely to have increased their variable pricing participation over time. Conversely, driver who were retired or had a household income less than $16,000 were less likely to increase their variable pricing participation over time." It was surprising to find that households with lower incomes were less likely to increase variable pricing participation. One possible explanation for this stated in the paper was that "these low-income drivers had less flexibility in arriving at their workplace and, hence, it was difficult for them to change their time of travel to discount periods."

CHAPTER 6

CASE STUDY: SR 91 EXPRESS LANES

BACKGROUND

Since their opening in December 1995, the SR 91 Express Lanes in Orange County, California have become perhaps the most well-known and studied congestion pricing system in the US. The system was the first practical implementation of congestion pricing in the US and was constructed by the California Private Transportation Company (CPTC) as a private-public partnership with the state of California. The system was purchased by the Orange County Transportation Authority in 2003 for $207.5 million. Local pressure against a non-compete clause in the contract that prevented additions to free lanes along the SR 91 corridor was a major rallying cry for the buyout.

The 10-mile SR 91 Express Lanes were built in the median of the original 8-lane SR 91. This state route connects the major employment centers of Orange County and Los Angeles County to the rapidly-growing residential developments of Riverside County and San Bernardino County. An electronic tolling system called FasTrak is used to collect variable tolls. The toll rates come from a preset schedule based on the time of day instead of being based on actual congestion.

Table 6-1 lists several characteristics of the SR 91 Express Lanes as of mid-2008.

Table 6-1: Characteristics of the SR 91 Express Lanes

SR 91 Express Lanes	
General	
Location	Orange County, CA on SR 91
Type of System	HOT Lanes
Year Implemented	December 1995
Length	10 miles
Number of Lanes	Four lanes (two in each direction).
Lane Separation	Buffer area with yellow plastic channelizers
Access Points	Only at beginning and end
Operating Strategy	
Objectives	Diverting Traffic to hours with available capacity, maintain a free-flow speed, maintain travel time savings, accommodate projected growth in travel demand, and ensure that sufficient revenue is generated
Times	24 hours a day, 7 days a week
Range of Tolls	$1.25 to $10.00, average $3.13
Toll Setting Policy	Adjust the toll based on whether the hourly traffic volumes by day of the week and direction fall above or below predetermined volume thresholds for six or more weeks in a 12 week period.
Free Vehicles	HOV3+, zero emission vehicles, motorcycles, disabled plates, disabled veterans (except EB weekdays 4pm to 6pm when all free groups pay 50% of the toll)
Enforcement	License plate photo technology for toll violations and California Highway Patrol enforcement for HOV violations
Violation Fines	$20 in addition to toll for first notice on failure to pay toll, $35 second notice (2008), $271 for occupancy violation (2002)
Financial	
Capital Cost	$134 million (in 1995) as a private for-profit investment
Operating Costs	$23,768,662*
Gross Revenue	$49,838,090*
System Usage	40,146 vehicles per day*

*FY 2007 from 7-2006 to 6-2007

EVALUATION

The SR 91 Express Lanes were built on one of the most congested corridors in California that saw delays during peak times normally around 20-25 minutes before opening. According to the Benefit-Cost Analysis of Variable Pricing Projects: Sr-91 Express Lanes, with the addition of the four lanes the project initially reduced delays to around 10 minutes on the three general purpose lanes in each direction, but by 2000 congestion had returned to its 1995 levels. In October 1998 the Eastern Toll Road (SR 241, SR 261, and SR 133) opened to traffic and became a competitive route for some SR 91 trips (especially trips on the express lanes). This caused traffic volumes on the express lanes to drop from fiscal year (FY) 1999 to 2002 before increasing above the FY 1998 high in FY 2003. However congestion on the general lanes continued to worsen during this time, especially at the interchange between SR 91 and the Eastern Toll road. Usage increased every year from FY 2000 to FY 2007. (OCTA, 2008)

A study, ***Evaluating the Impacts of the SR 91 Value-Priced Express Lane Facility***, was sponsored by the California Department of Transportation and the US Department of Transportation to study the impacts of the SR 91 Express Lanes in 1998. A continuation study report was also published in 2000. The study found several interesting findings based on the first few years of operation of the system. It was found that the volume of both single occupant vehicles (SOV) and high occupancy vehicles (HOV) increased dramatically after implementation because of the greatly improved corridor travel conditions. Total average daily traffic (ADT) on SR 91 increased 14% (an increase of about 28,000 vehicles per day) in the year following implementation. It was estimated that 21% of this growth was from drivers who previously diverted to parallel arterials returning to SR 91 because of the more favorable travel conditions, 20% of the growth was from underlying long-term traffic growth trends, and 60% of the growth was induced by improved travel conditions. Most of the new induced trips during peak periods were for non-work purposes and were previously not made, made elsewhere, or made during off peak times. HOV with three or more occupants (HOV3+) increased by 40% after implementation likely due to the management policy allowing these carpoolers to drive for free.

The three main reasons for using the toll lanes were found to be perceived time savings, easier driving, and perceived safety. However, it was found that perceived time savings was often less than actual, as travelers who chose to pay the toll consistently overestimated this value. Also it was found that only approximately half of travelers using the toll lanes used the system more than once a week. This was considered to be an indication that many travelers carefully choose when it is advantageous to use the toll lanes, even if they may overestimate the advantage.

The report also concluded:

- Increasing numbers of commuters are willing to pay tolls to enjoy the tangible benefits of reduced travel time, improved driving comfort, and perception of improved safety.

- Even though more than 80% of peak period travelers on SR 91 are engaged in home-to-work travel, most commuters do not use the toll lanes on a daily basis. Nearly half the commuters who have used the toll lanes report using the lanes once per week or less. But with time and increasing congestion the percentage of toll lane users has increased.
- While toll lane use has continued to vary significantly with income, gender, age, and other characteristics, people from all demographic backgrounds make use of the facility. Contrary to some predictions that these would become "lexus lanes", motorists from all income brackets regularly use the facility, and report high levels of satisfaction due to the time savings (up to 20 minutes each way) and predictability of the drive.
- Being female is the factor most strongly associated with toll lane use, while high income, age, education, and traveling to work all influence travelers' likelihood of obtaining transponders.
- By June 1997, most peak period travelers on SR 91 (about 90%) had obtained FasTrak transponders and most of these (about 80%) obtained their transponders during the first six months of operation.
- The influence of the toll lanes, while locally important, did not induce traveler route shifts at the regional scale. Instead, the toll lanes have attracted a substantial share of the traffic using the SR 91 corridor. Throughout the study period, traffic volumes remained generally stable in the paralleled SR 57/60 freeway corridor about 15 miles to the north. In addition, field observations showed no association between opening the SR 91 toll lanes and any changes in the HOV traffic using the SR 57/60 corridor. This indicates that Toll road traffic in the morning peak direction is consistently less than in the afternoon peak direction, when congestion in the free lanes is worse.
- In spring 1997, the percentage of SR 91 travelers who used the express lanes ranged from about 7% in the mid-day off-peak, when time savings were minimal, to a high of 35% during the peak hour when delay to freeway users was an estimated 12-13 minutes. These observations imply a value of time for SR 91 commuters of $13-14 per hour.
- The accident rate for the section of SR 91 containing the express lanes decreased significantly after the express lanes opened. This most likely reflects the reduced peak period congestion. Over the same 1995-96 period, no significant changes in accident characteristics were found.
- FHWA reports during the peak hour (Friday afternoon, 5-6pm, east bound direction), the throughput traffic per lane in the express lanes is almost twice as many than the free lanes. And based on the traffic volume data provided by OCTA between Jan 9 and Mar 25, 2004, the share of vehicles carried in the peak hour on the express lanes had increased to 49%, which means the two express lanes carried almost the same volume as the four free lanes.

The SR 91 project emphasized providing new travel options to users. A high level of project approval was found to exist based on initial system studies because of this fact as well as the immediate and visible travel benefits for those choosing to pay. The consistent efforts toward favorable public relations and marketing were also believed to increase approval. The SR 91 Express Lanes are an innovative system that shows paying premium price for a premium highway service can achieve public acceptance and produce significant benefits to users.

CHAPTER 7

CASE STUDY: I-15 HOT LANES

BACKGROUND

The I-15 HOV facility opened in 1988 but was underutilized while adjacent general lanes became increasingly congested in the years following its implementation. The corridor also initially provided very limited transit options for commuters. In 1991, it was recommended that the possibility of drive-alone commuters paying a fee to use the HOV lanes be studied. Toll revenues would be used to improve public transit in the corridor. The San Diego Association of Governments (SANDAG) adopted a resolution to support a demonstration project in May 1991 and soon later developed the I-15 Value Pricing Project. Project funding for the initial planning phases was received from the Federal Transit Administration in 1992. After submission to the Federal Highway Admistration's Congestion Pricing Pilot Program as part of the Intermodal Surface Transportation Efficiency Act in 1993 and 1994, the project was approved for funding in January 1995. A law authorizing SOV usage on the HOV facility for a fee was signed in October 1994 by the California state legislation.

The first stage of operations, the I-15 ExpressPass program, ran from December 1996 to March 1998. In this phase a predetermined number of monthly passes were sold to SOV users allowing unlimited use of the HOV lanes. The program began with the passes being sold as window stickers but was changed to payment by electronic transponder in June 1997. The second stage, the I-15 FasTrak program, began on March 30, 1998. This program, which has continued to the present, allows customers to pay a fee that varies by time of day and traffic levels for SOV usage of the HOV lane. Some revenues from the I-15 HOT lanes are used to partially fund the Inland Breeze Express Bus service which was started along with the HOT lanes. The express bus provides service between northern suburbs and downtown San Diego along the I-15 corridor.

Construction is currently underway on a project to extend the system to a total of 20 miles and to improve the existing I-15 HOT lanes which will significantly change the system characteristics. This $1.3 billion I-15 managed lanes project, which is being largely funded by a half cent sales tax increase program called TransNet, added an additional 4.5 miles of express lanes in summer 2008, will add 3.5 miles in winter 2008, and will add 4 miles by 2011. All additions will occur progressively north of the current HOT lanes on I-15. The current 8-mile stretch of HOT lanes will also be widened to four lanes. The final system will have four reversible lanes throughout, three in the peak direction and one in the off-peak, and will have five direct access ramps. More frequent and expanded Inland Breeze Bus service and improvements to park-and-ride lots will also be included. Table 7-1 lists the characteristics of the I-15 HOT Lanes systems. Characteristics of the managed lanes expansion project are not included.

Table 7-1: Characteristics of the I-15 HOT Lanes Prior to the Managed Lanes Expansion

I-15 HOT Lanes	
General	
Location	San Diego, California on I-15
Type of System	HOV to HOT Conversion
Year Implemented	Starting December 1996 Phase 1 charged a flat monthly fee payment and starting March 1998 Phase 2 charged electronic dynamically varying toll
Length	8 miles
Number of Lanes	Two reversible lanes (in the same direction)
Lane Separation	Concrete barrier
Access Points	Only at beginning and end
Operating Strategy	
Objectives	Maximize the use of the existing capacity in the HOV lanes, improve transit and HOV services along I-15, and relieve congestion along I-15
Times	Mon. – Thurs. SB 5:45am to 11am, NB 12 to 7pm; Fri. SB 5:45am to 11am; NB 5pm on Fri. to 5am the following Mon. (weekend included); NB only on holidays
Range of Tolls	Minimum of $0.50 up to $4 under normal operating conditions, $8 maximum
Toll Setting Policy	Fees adjust dynamically as much as every 6 minutes to maintain LOS C on the express lanes
Free Vehicles	Motorcycles, carpoolers, low emission vehicles
Enforcement	California Highway Patrol (CHP) contracted to enforce 12 four-hour shifts per month. The CHP manually observes occupancy for non-Fastrak users as well as an indicator light on the gantry that flashes when Fastrak users are tolled
Violation Fines	$341 for carpool violations
Financial	
Capital Cost	About $10 million (1995) with $7.96 million from the Intermodal Surface Transportation Efficiency Act and $1.99 million of local in-kind funding of transit service
Toll Revenue	$4,400 average weekday toll revenue (approximate)*
System Usage	4,067 average weekday tolled trips, 10,346 average weekday HOV trips*

*FY 2008 from 7-2007 to 6-2008

EVALUATION

Between 1990 and 2000 the I-15 corridor near the HOT lanes experienced an annual growth rate in traffic between 2.1 and 3.2 percent. Average daily traffic on the HOT lanes also increased steadily after implementation from 11,700 vehicles per day in March 1998, to 13,838 vehicles per day in February 1999, to 17,884 vehicles per day in October 2001. The average weekday usage for FY 2008 was 14,413. Considering the vehicle share by mode, the average weekday volume of HOV was 13,347 (for a share of 75.3%) and of tolled vehicles was 4,256 (for a share of 24.0%) in 2001. A summary of key findings from *San Diego's Interstate 15 Congestion Pricing Project: Traffic-Related Issues* include:

- Volume in the I-15 Express Lanes increased steadily and substantially over the entire study period between 1996 and 1999. The magnitude of change indicates that these changes were physically significant and noticeable to I-15 Express Lane users. The transition from ExpressPass to FasTrack did not affect the monthly rate of total Express Lanes and volume, which was constant over both projects. By the end of 1999, the Express Lanes were much better utilized than before the start of the project, which represents an important step towards one of the primary project objectives to maximize the use of the I-15 Express Lanes.
- A rise in the number of HOV and ExpressPass/FasTrack vehicles contributed to improved utilization of Express Lanes. HOV volume on the I-15 Express Lanes, however, surged during the ExpressPass period and subsequently moderated during the FasTrack period. Program subscriber volume was virtually flat during the ExpressPass phase, and then accelerated substantially during the FasTrack phase. Violator volume was generally higher during the FasTrak phase than during the ExpressPass phase, yet substantially smaller than during the pre-project period.
- Study results indicate that congestion pricing can be successfully implemented on an existing HOV lane on a major urban freeway. Both fixed monthly fee-based and dynamic per-trip-based versions of congestion pricing proved feasible, operationally successful, capable of generating measurable and statistically significant system-wide traffic impacts within the affected corridor, and able to cause measurable and significant changes in travel behavior, at least among the program participants.
- Congestion pricing can be an effective tool to achieve better utilization of HOV lanes. However, the fixed monthly pricing system did not contribute to the spreading of traffic throughout the peak period; instead, it seemed to delay morning departures for work and increase trip concentration in the middle of the peak period. In contrast, the dynamic per-trip pricing can effectively redistribute part of the traffic from the middle of the peak period to the peak period shoulders.
- Both versions of congestion pricing create an identifiable new travel option, which is highly valued by the participants and can be designed in a way that protects the interest of carpoolers and keeps them satisfied. In contrast to fixed

monthly pricing, dynamic per-trip pricing offers a customized use of the HOT facility, which allows participants limited use of the facility

An extensive community outreach program was completed in 2002 to obtain feedback on the I-15 HOT lanes and on the proposed managed lane extension (now under construction). The program is documented in the ***I-15 Managed Lanes Value Pricing Project Planning Study*** report. The program began in 2001 and included three focus groups of 14 participants, 25 key stakeholder interviews, intercept surveys of 50 carpoolers and 50 transit riders, a telephone survey of 600 general lane users and 200 transponder-owners, and an environmental justice assessment. Several key recommendations for the proposed managed lanes project expansion were made based on the outreach program. These included speeding up the project delivery so benefits can be realized sooner, enhancing public education and information about the project, considering lowering the level of service or having peak only operations for the system, and providing transit service that responds to local needs, and addressing long-range, comprehensive, and inter-county planning issues. Negative perceptions of equity and fairness of the proposed expansion were generally greatly improved when the proposed expanded bus service was explained in detail. A very low understanding on how revenues were used in the current HOT lanes system was found to exist in the outreach process. Explaining how excess toll revenues were used to fund transit also positively impacted perceptions of equity and fairness.

CHAPTER 8

CASE STUDY: QUICKRIDE PROGRAM

BACKGROUND

In 1984 a reversible high-occupancy vehicle (HOV) lane opened along the Katy Freeway (I-10) in Houston to allow transit vehicles and vanpools to bypass congestion in the general purpose lanes. After opening, occupancy requirements to use the lane where changed to allow two person carpools. Over time, with this occupancy restriction, traffic volumes increased on the HOV lane to the point where volumes exceeded capacity during weekday peak periods. In 1988, occupancy requirements were raised to only allow three person carpools during the weekday peak periods (6:45 to 8 AM and 5 to 6 PM). This caused traffic on the HOV lane to return to free-flow conditions but also created excess capacity on the lane.

The Houston QuickRide program was implemented in January of 1998 to allow vehicles with two passengers to utilize the HOV lane on the Katy Freeway during peak periods for a fee of $2. Eligible vehicles were charged electronically with transponders and were also required to hang a QuickRide tag in their vehicle. The objectives of the program were to increase overall person throughput along the Katy Freeway during peak periods, increase travel speeds on the mixed-flow lanes, and to more efficiently manage demand on the corridor.

The program expanded in 2000 to the HOV lane on US 290 (Northwest Highway). The program expansion had similar operating characteristics to the Katy Freeway but only charged two person carpoolers in the AM peak period. Two person carpoolers continued to travel for free during the less congested PM peak on US 290.

In October, 2008 reconstruction of a significant portion of the Katy Freeway was completed. The construction began in 2003 and affected the Katy HOV lanes at various points during the construction effort. The construction has replaced the single, reversible HOV lane with two managed lanes in each direction and plans to allow single occupant drivers to access them if they pay a dynamically changing toll. The lanes are separated from the general lanes by candlestick pylons. The lanes opened for initial operation in

October 2008 and are expected to be fully operational in spring 2009. Overall congestion on the corridor is expected to significantly decrease as, in addition to the managed lane additions, the 3 general lanes in both directions has been expanded to at least 4 and the 2 frontage road lanes in each direction has been expanded to 3.

EVALUATION

A paper titled *Potential Single-Occupancy Vehicle Demand for High-Occupancy Vehicle Lanes: Results from Stated-Preference Survey of Travelers in High-Occupancy Toll Corridors* discussed usage rates for the QuickRide program:

> "The average QuickRide demand on the Katy Freeway HOT lane in 1998 was 103 trips per day. After the introduction of QuickRide on the Northwest Freeway, the total average demand on the two HOT lanes rose to 131 trips per day in 2000 and 182 trips per day in 2002, significantly below the targeted demand of 600 QuickRide vehicles per peak hour. The traffic flow on the HOV lanes usually decreased during the off-peak hours, so excess capacity existed on these HOV lanes during the off-peak hours."

The paper *HOT Lanes in Houston- Six Years of Experience* gives an overview of the benefits of the QuickRide program. The program offers benefits to two person carpools by allowing them to travel during their preferred time period instead of the off-peak period and giving them travel time savings compared to travel on the general lanes. The travel time savings gained on the HOV lane as compared to the general lanes was considerable and is shown for 2001 in Figure 8-1. Note that the average distance traveled on the Katy HOV lane was 12.8 miles and on the Northwest HOV lane was 10.6 miles.

Figure 8-1: 2001 Average Time Savings of the QuickRide Program

	Time	Vehicles per Day	S_{main} (mph)	S_{HOV} (mph)	Time Savings (min/veh)
Katy AM	6:45–7:00	11.11	29.76	53.98	11.58
	7:00–7:15	19.48	27.25	59.81	15.35
	7:15–7:30	23.61	24.48	60.21	18.62
	7:30–7:45	23.49	23.37	60.11	20.08
	7:45–8:00	10.18	24.79	59.48	18.06
	Weighted Average (AM)		*25.50*	*59.22*	*17.33*
Katy PM	5:00–5:15	7.03	28.35	57.19	13.66
	5:15–5:30	14.15	26.13	58.34	16.23
	5:30–5:45	12.18	26.97	57.63	15.15
	5:45–6:00	6.71	28.61	58.70	13.76
	Weighted Average (PM)		*27.19*	*57.98*	*15.04*
Northwest AM	6:45–7:00	2.83	34.36	53.01	6.27
	7:00–7:15	8.01	31.89	57.91	8.62
	7:15–7:30	14.02	28.72	58.85	10.91
	7:30–7:45	16.15	27.44	59.52	12.02
	7:45–8:00	7.25	30.09	59.82	10.11
	Weighted Average (AM)		*29.35*	*58.72*	*10.51*

Source: HOT Lanes in Houston- Six Years of Experience

In addition to time savings alone, the QuickRide program also offers a much more reliable trip than on the general lanes. Assuming an average value of travel time savings of $15.56 per hour per person and predicted QuickRide trips over 10 years the paper estimated the net present value of the benefits of travel time savings to be approximately $2.35 million. The value of travel time savings was taken to be a conservative 35 percent of hourly wage as reported in a user survey. The total benefits may be an underestimate as, since QuickRide users are mainly occasional users, they likely only choose to use the lane when their value of time is much higher than average. An estimation of fuel savings using MOBILE 5a modeling over 10 years was $13,500. This was conservative as it was only calculated based on average speeds and did not include fuel consumption due to intensive acceleration and deceleration patterns in congestion. Other, non-quantified benefits that were mentioned include benefit to general lanes users when some vehicles leave the main lanes and buy into the HOV lane.

A look at QuickRide usage in this paper identified a significant decrease on Fridays and on days with fewer school children traveling. These school impacted days include grade school holidays and summer break. They cause fewer carpools where one member is a grade school child and also decreased traffic congestion on the general lanes, thereby less incentive to pay to use the HOV lanes. Usage rates also showed that most enrollees made an average of fewer than 1.5 QuickRide trips per week. The paper partially attributes the modest usage of the program (208 trips per day in 2003) to limited amount of available buy-in capacity on the HOV lanes during peak periods.

A 2000 paper *Katy Freeway High-Occupancy Vehicle Lane Value Pricing Project, Houston, Texas: Evaluation of Usage* discussed the results of an early survey on usage of the QuickRide progam on the Katy Freeway. It found that the average Quickride user was: "a 38 to 49 year old professional or manager living beyond the west end of the HOV lane and working in downtown Houston; one who has used the Katy Freeway HOV lane before; and one who is making over $100,000, with a household size of three or four. More generally, the data suggest that the vast majority of users are affluent professionals who are familiar with both the operation and potential time savings of the HOV lane." The paper also discussed substantial shifts in mode and time of travel after the implementation of the QuickRide program. Over 50 percent of program trips came from previous SOV trips and one-third of the trips came from outside the peak hour.

CHAPTER 9

CASE STUDY: MNPASS

BACKGROUND

The MnPass HOT lanes on I-394 in Minnesota became operational in May 2005 as a conversion from existing HOV lanes. However, the concept of congestion pricing as a tool to manage congestion in Minneapolis had been discussed since 1994. After several unsuccessful attempts to implement a congestion pricing pilot project in the 1990s, the MnPASS project was authorized by the Minnesota Legislature in 2003.

The I-394 MnPASS Express Lanes, which stretches about 9 miles from I-94 to I-394, opened on May 16, 2005. In the past, there were 3 lanes in each direction and 2 reversible, barrier-separated HOV lanes in the center median from I-94 to Highway 100 (about 3 miles), and 3 regular lanes and a single, non-barrier-separated HOV (diamond) lane in each direction from Highway 100 to I-394 (about 6 miles).

In the past, the reversible HOV lanes were open only to buses, motorcycles and HOV with two or more passengers in the inbound (eastbound) direction (6:00 a.m. to 1:00 p.m.), and open in the outbound (westbound) direction (2:00 p.m. to midnight) on weekdays. These lanes were also opened to buses and HOV traffic on a limited basis on weekends, usually in support of special event traffic.

As for the diamond HOV lanes, they were designated for use by buses, motorcycles and HOV (2+) vehicles during the morning commute period (6 a.m. to 9 a.m.) for the inbound direction, and during the afternoon commute period (3 p.m. to 6 p.m.) for the outbound direction for weekdays. The lanes were available for use by all traffic for the remaining hours of the day.

The MnPASS Express Lanes are HOT lanes converted from the HOV lanes. While it remains free for buses and HOV (2+) vehicles, it allows solo drivers to use the HOV lanes for a fee. Usually tolls average $1 - $4 during rush hours with the minimum of $0.25 and the maximum of $8. Fees are posted on overhead signs at entrances. In addition, there is a monthly fee of $1.50 for each MnPASS transponder being leased. To ensure a free traffic flow of 50-55 miles per hour, fees are determined fully dynamically and can be changed as often as every 3 minutes based on traffic levels in the express lanes. Table 9-1 gives the characteristics of the MnPass system.

Table 9-1: The MnPass System Characteristics

MnPass HOT Lanes			
General			
Location	Minneapolis, Minnesota on I-394		
Type of System	HOV to HOT conversion		
Year Implemented	May 2005		
Length	11 miles		
Number of Lanes	Two reversible lanes in the same direction for the first three miles from downtown (B to C in Figure 2.1) and two lanes in opposite directions for the remaining eight miles (A to B in Figure 2.1)		
Lane Separation	Concrete barrier for the first three miles from downtown and two-foot painted buffer zone for remaining eight miles		
Access Points	Six midpoint at-grade		
Operating Strategy			
Objectives	Maximize the capacity in the I-394 corridor, maintain free flow speeds for transit and carpools, improve the corridor with the revenues generated		
Times	For reversible lanes weekdays EB 6am to 1pm, WB 2pm to 5am; For remaining section weekdays EB 6am to 10am, WB 2pm to 7pm (other times the non-reversible lanes are open to general traffic)		
Range of Tolls	Average peak period fee ranges from $1 to $4 with an $8 maximum		
Toll Setting Policy	Tolls are adjusted dynamically by demand level and vehicle usage on the HOT lanes		
Free Vehicles	Carpools, Motorcycles, Buses		
Enforcement	Police cars equipped with remote transponder readers for toll violations and police enforcement for HOV violations.		
Violation Fines	$142 (crossing the painted buffer)		
Financial			
Capital Cost	$10 million (2005 Dollars), funded through a loan from a downtown parking ramp fund (not debt financed so toll revenue bonds are not an issue)		
	5-2005 to 4-2006	**5-2006 to 4-2007**	**5-2007 to 4-2008**
Toll Revenue	$574,499	$1,057,334	$1,083,098
System Usage (total tolled trips)	874,154	908,899	942,348

EVALUATION

During the long planning process before the MnPASS system was implemented several issues were considered as potential concerns before the project opened and are described in the paper ***I-394 MnPASS High-Occupancy Toll Lanes: Planning and Operational Issues and Outcomes (Lessons Learned in Year One)***. One concern was that the lane separation strategy of using a painted buffer zone for the western 8 miles of the system would cause excessive weaving and enforcement issues. However, one of the surprises after implementation was how well this system worked. It was found that violation rates for crossing the lines were low and enforcement was not a major problem with the painted buffer zone.

Another issue was that of how to use projected net revenues from the project. This has not been a problem thus far as revenues have recently only been covering operating expenses. Net revenues have been lower than expected for several reasons. One is shorter HOT lane operating times and a lower minimum toll than were assumed in the original revenue estimates. The first year revenues on the system were also much lower because the dynamic price setting algorithm originally caused rapidly fluctuating prices which, in turn, led to erratic vehicle flows onto the system. The algorithm was adjusted which led to a more steady and predictable number of users and a slightly higher average toll. Even though the main focus of the project was to make efficient use of an underutilized HOV lane and not to raise revenue, the expectation that the lane would pay for itself continues to be an issue with several MnDOT and government officials.

A third issue was that of how much marketing to do to achieve an appropriate level of demand. There was concern that too many single occupant users would cause congestion and high prices especially during the opening days or that too few users would represent a failure of the system. It was found that more transponders were ordered than expected but usage was lower than expected (at about twice per week for MnPASS customers).

As of April, 2008 over 11,300 transponders are leased out with more opening every day. On average, a transponder user chooses to use the express lanes twice a week. For 95 percent of the time, traffic in the express lanes is maintained at the free flow speed.

The I-394 MnPASS Technical Evaluation Final Report in November 2006 concluded the MnPASS deployment "has enjoyed success in achieving many of the identified goals", including but not limited to:

- An increase in vehicle throughput by up to 5% during the peak hour in the corridor while a decrease was observed in regional volumes
- An increase in vehicle speeds by about 6% in the general purpose lanes
- A dramatic decrease in violation rates while the violation rates on the non-MnPASS equipped I-35W HOV section has significantly increased
- A decrease in the crashes by about 14% in the year following the deployment compared with the previous year
- No significant increase occurred in corridor noise levels
- No negative CO emission impacts observed

- No significant impacts on transit operations occurred as a direct result of the program

The report was inconclusive to determine if there is any change in mode share due to the program, because “significant decreases in the numbers and mode shares of carpools were observed” on both MnPASS and I-35 W, “suggested a regional shit in carpool usage”.

A survey, documented in ***I-394 MnPASS: A New Choice for Commuters***, was conducted in late 2005 and early 2006 by the Attitudinal Evaluation Team headed by the University of Minnesota. The survey found that transponder holders are not substantially different from other commuters. About 60% of the 950 Twin Cities residents including 151 transponder users surveyed support the program, “with little variation in support across income, education levels, or gender”. And 95% of the 151 transponder users like the program and have a very high level of satisfaction (more than 90%) with many aspects of the system.

One negative outcome was criticism of the initial deployment which operated on a 24/7 basis. The public criticism was largely because they were used to being able to use the lanes during off-peak times when there was no congestion (the HOV lanes were only opened during peak periods). This issue was addressed quickly and the operation schedule was adjusted to that shown in Table 9-1.

The I-394 MnPASS project has been considered a success, showing policy leaders, transportation professionals, and the public how HOT lanes can be used to manage congestion and address a wide range of transportation problems. Building on the success of the I-394 HOT lanes, the MnPASS system is currently being planned to expand to implement congestion pricing on I-35W south of Minneapolis.

CHAPTER 10

REFERENCES

Listed in order of first appearance:

Washbrook, K. *Assessing the Potential for Road and Parking Charges to Reduce Demand for Single Occupancy Vehicle Commuting in the Greater Vancouver Region.* Simon Fraser University, 2002.

O'Mahony, M., Geraghty, D., and Humphreys, I. *Distance and Time Based Road Pricing Trial in Dublin.* In *Transportation*, Vol. 27, No. 3, 2000.

Cambridge Systematics, Inc. *I-394 MnPASS Technical Evaluation Final Report.* Prepared for the Minnesota Department of Transportation, 2006.

Sullivan, E. *Continuation Study to Evaluate the Impacts of the SR 91 Value-Priced Express Lanes: Final Report.* Submitted to State of California Department of Transportation, 2000.

Bhatt, K., Higgins, T., and Berg, J. T. *Value Pricing Pilot Program: Lessons Learned Final Report.* Prepared for Federal Highway Administration U.S. Department of Transportation, 2008.

Zmud, J. *The Public Supports Pricing If…A Synthesis of Public Opinion Studies on Tolling and Road Pricing.* In Tollways: Connecting People, Places & Ideas, Winter 2008. International Bridge, Tunnel and Turnpike Association (IBTTA), Washington, D. C., 2008.

Collier, T. and Goodin, G. *Marketing the Managed Lanes Concept.* For the Texas Department of Transportation in Cooperation with the Federal Highway Administration U.S. Department of Transportation, 2002.

Evans, R. *Central London Congestion Scheme: ex post Evaluation of the Quantified Impacts of the Original Scheme.* For Congestion Charging Modelling and Evaluation Team, Transport for London, 2007.

Ozbay, K., et al. *Evaluation Study of New Jersey Turnpike Authority's Time of Day Pricing Initiative.* Federal Highway Administration U.S. Department of Transportation, Washington D.C., 2005.

Ozbay, K., Yanmaz, O., and Holguin-Veras, J. *The New Jersey Turnpike Road Pricing Initiative: Analysis Traffic Impacts.* PLARC Seminar on Road Pricing with Emphasis on Financing, Regulation and Equity, Cancun, Mexico, 2005.

Ozbay, K., Yaanmaz-Tuzel, O., and Holguin-Veras, J. *The Impacts of Time-of-day Pricing Initiative at NY/NJ Port Authority Facilities Car and Truck Movements.* Transportation Research Board, Washington D.C., 2006.

"T-Z Trucks Will See Congestion Pricing – But New Driver Discounts Could Spur Congestion". *Mobilizing the Region.* A publication of the Tri-State Transportation Campaign, Issue 113, 1997.

"Region's First Congestion Pricing Trial Set to Proceed". *Mobilizing the Region.* A publication of the Tri-State Transportation Campaign, Issue 127, 1997.

"Tappan Zee Congestion Relief Pricing Program Shows Promising Start". *Mobilizing the Region*. A publication of the Tri-State Transportation Campaign, Issue 196, 1998.

"Thruway Completes Tappan Zee Toll Study". *Mobilizing the Region*. A publication of the Tri-State Transportation Campaign, Issue 238, 1999.

Draft Alternatives Analysis for Rehabilitation or Replacement of the Tappan Zee Bridge. For the Tappan Zee Bridge/I-287 Environmental Review, New York State Thruway Authority, 2008.

Burris, M., Konduru, K., and Swenson, C. *Long-Run Changes in Driver Behavior Due to Variable Tolls.* In *Transportation Research Record: Journal of the Transportation Research Board, No. 1864*, Transportation Research Board of the National Academies, Washington, D.C., 2004, pp. 78-85.

Burris, M., Pietrzyk, M., and Swenson, C. *Observed Traffic Pattern Changes Due to Variable Tolls.* In *Transportation Research Record: Journal of the Transportation Research Board, No. 1732*, Transportation Research Board of the National Academies, Washington, D.C., 2000, pp. 55-59.

Sullivan, E. *Evaluating the Impacts of the SR 91 Value-Priced Express Lane Facility: FinalReport.* Submitted to State of California Department of Transportation, 1998.

Supernak, J., et al. *San Diego's Interstate 15 Congestion Pricing Project: Traffic-Related Issues.* In *Transportation Research Record: Journal of the Transportation Research Board, No. 1812*, Transportation Research Board of the National Academies, Washington, D.C., 2002, pp. 43-52.

Wilbur Smith Associates (WSA). *I-15 Managed Lanes Value Pricing Project Planning Study.* For the San Diego Association of Governments, 2002.

Burris, M. W. and Xu, L. *Potential Single-Occupancy Vehicle Demand for High-Occupancy Vehicle Lanes: Results from Stated-Preference Survey of Travelers in High-Occupancy Toll Corridors*. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1960*, Transportation Research Board of the National Academies, Washington, D.C., 2006, pp. 108-118.

Burris, M. W. and Stockton, B. R. *HOT Lanes in Houston- Six Years of Experience.* In *Journal of Public Transportation*, Vol. 7, No. 3, 2004.

Hickman, M., Brown, Q., and Miranda, A. *Katy Freeway High-Occupancy Vehicle Lane Value Pricing Project, Houston, Texas: Evaluation of Usage.* In Transportation *Research Record: Journal of the Transportation Research Board, No. 1732,* Transportation Research Board of the National Academies, Washington, D.C., 2000, pp. 32-41.

Munnich, L. and Buckeye, K. *I-394 MnPASS High-Occupancy Toll Lanes: Planning and Operational Issues and Outcomes (Lessons Learned in Year One).* In Transportation *Research Record: Journal of the Transportation Research Board, No. 1996,* Transportation Research Board of the National Academies, Washington, D.C., 2007, pp. 49-57.