Title
Studying Road Pricing Policy with Panel Data Analysis: The San Diego I-15 HOT Lanes

Authors
Golob, Jacqueline M
Golob, Thomas F.

Publication Date
2002-09-01

Studying Road Pricing Policy with Panel Data Analysis: The San Diego I-15 HOT Lanes

Jacqueline M. Golob

Jacqueline Golob Associates
1008 Westcliff Drive
Newport Beach, California 92660-5634 USA

Thomas F. Golob

Institute of Transportation Studies
University of California
Irvine, California 92697-3600 USA

1. INTRODUCTION

A three-year experiment is underway in San Diego County, California that allows solo drivers to pay a fee to use "Express Lanes" i.e. carpool lanes to avoid an eight-mile highly congested stretch of freeway. These lanes are also commonly referred to as High Occupancy Toll (HOT) Lanes. The facility has two reversible lanes in the freeway median separated by concrete barriers from the I-15 main lanes with access available only at the two end points. Tolls charged commonly range from $.50 to $4.00 per trip but in exceptionally congested conditions can go as high as $8. Fees charged can change dynamically every six minutes to reflect changing traffic in the carpool lanes. Changeable message signs post the price. The algorithm controlling the prices is adjusted to maintain free flow conditions in the carpool lanes at all times. Carpools of two or more persons retain free travel. Subscribers who chose to use the lanes are charged the posted toll using transponder technology and monthly credit-card billing. The opening hours for the Express Lanes are 5:45 to 9:15 a.m. inbound to San Diego and 3:00 – 7:00 p.m. outbound from San Diego.

The stated purposes of the project are to: (1) maximize use of the I-15 Express Lanes, (2) test whether allowing solo drivers to use the excess capacity of the Lanes can help relieve congestion on the main lanes, (3) improve air quality, (4) fund new transit and carpool improvements in the I-15 corridor, and (5) test using congestion pricing to set tolls. Many of the political questions to be answered relate to understanding changes in travel behavior. For this element of the evaluation, a five-wave panel survey was implemented to track changes in travel choice behavior and attitudes concerning the project. The sample was maintained at 1,500 persons using random refreshment, stratified by subscribers, other users of the I-15 Freeway, and a control group of users of another freeway in the San Diego area. The panel survey was initiated in fall 1997, with successive waves in spring 1998, fall 1998, spring 1999, and, finally, fall 1999.

The paper presents results that demonstrate the use of panel data for investigating transportation policies such as road pricing. Dynamic analyses of the full survey remain an ongoing task.

The implementation of road pricing projects is highly contentious. The I-15 experiment raises many policy questions with regard to the impact on the traveling public, responses in terms of changing travel behavior and most importantly attitudes and support for such policy initiatives. The panel study is designed to investigate changing responses in terms of mode shifts, departure times, the frequency of use of FasTrak as well as changing perceptions of congestion, speeds, costs, travel times and safety of travel. Attitudes towards the fairness and effectiveness of the project are also included. The need for understanding attitudes and perceptions, as well as travel behavior, in project evaluation is noted by Bhatt (1993), Golob (2000), Higgins (1997), Lo and Hickman (19970.

The social feasibility of road pricing on a broader scale has been investigated by several authors (e.g., Jones, 1994, 1998; Seale, 1993; Sheldon, Scott and Jones, 1993; Verhoef, Nijkamp and Rietveld, 1997). HOT lanes are however a special case in that they refer to high occupancy vehicle (HOV) facilities that are open to lower-occupancy vehicles upon payment of a fee or toll (Goodman, *et al*. 1998). Drivers are fee to choose to pay and use a faster, more predictable facility or to drive for free in regular congested traffic lanes. Many authors have alluded to problems with public acceptance when formerly free facilities are priced (e.g., Giuliano, 1992, 1994). For this reason, it has been predicted that the best chances for successful applications lie either with completely new facilities or with the conversion of HOV facilities with large excess capacity (e.g., Goodman, *et al*. 1998). The I-15 HOT lanes represent an example of the conversion of an under utilized carpool facility. The policy intent is to exploit an existing facility to the full, in order to try and reduce congestion in the regular lanes.

The broad evaluation study considers many issues. The critical study of the willingness to pay as tolls to save travel time and travel time variance is the subject of continuing research. Willingness-to-pay studies require detailed data on traffic conditions in order to estimate time savings over multiple days of travel. Preliminary findings, using cross-sectional data from the third wave of the panel are reported in Brownstone, *et al*. (1999) and Kazimi, *et al*. (2000). The latest work by Ghosh (2001) estimates choice models for the morning and afternoon commute revealing different responses. The value of time estimates range from a low of $15 for afternoon travelers to a high of $23 for those traveling in the morning peak with arrival time constraints. This paper is concerned with issues associated with public acceptance or rejection of the HOT lanes project concept and reports findings of relevance to the acceptability of this particular form of congestion pricing. It details travel behavior changes and responses to changes in toll structure as well as attitudes towards the concept.

2. THE I-15 CONGESTION PRICING PROGRAM

The project has been used to test pricing alternatives and had two distinct phases of implementation, as described in depth in Golob et al (1998) and Supernak et al (1999). Phase I of the project, was called ExpressPass, in which a limited number of solo drivers purchased monthly permits to use the I-15 Express Lanes (two peak hour only reversible carpool lanes.) The ExpressPass program allowed unlimited use of the Express Lanes for a flat monthly fee. Verification of authorized ExpressPass participants was performed by visual inspection by the California Highway Patrol (CHP). At the end of the ExpressPass phase in March 1998, 1,000 permits were available at a cost of $70 per month.

The second phase of the I-15 Congestion Pricing Project began on March 30, 1998. In this phase, called I-15 FasTrak the program is being marketed under the term FasTrak™. Solo drivers participating in the program pay a per-trip fee to use the Express Lanes. The per-trip fee varies by time of day and the traffic volumes in the Express Lanes (50 cents to $4), with the posted rate appearing at the entrance to the Express Lanes. A customer pays the fee electronically via an automated, electronic toll collection (ETC) system comprised of

in-vehicle transponders and overhead readers. In contrast with the first phase which presented a monthly commitment to purchase the right to use the Express Lanes. FasTrak registered solo drivers can now chose whether or not to pay a toll and use the Express Lanes on an individual per trip basis.

On 31 August 1998, prior to the third wave of the panel survey, the fee schedule was adjusted and tolls were lowered in the off-peak hours to encourage greater use in these periods. The busier peak demand periods of 7 a.m. to 8 a.m. and 4:30 p.m. to 5:30 p.m. remained unchanged in price structure. The lowered pricing is referred to as "shoulder pricing". The policy intent is to increase the use of the capacity of the Express Lanes to the greatest extent possible while still maintaining free flow conditions. At this point Kazimi *et al.* (2000) estimate a median toll paid was $1.50 with sixty percent paying less than $1.90. By the end of December 1999, 10,869 transponders had been distributed and there were 7354 open accounts with an average of 1.44 transponders per account.

3. THE I-15 PANEL STUDY

The principle of a panel study is to repeatedly interview the same individual on a number of occasions. The survey typically asks the same questions at each point in time. This allows for the measurement of change, which has taken place between the survey intervals. The approach is particularly useful for accurately measuring responses or reactions to a given initiative, in this case road pricing. Surveys are conducted by telephone and a FasTrak user survey takes approximately eighteen minutes on average to administer. In practice it is difficult to maintain a sample of panel survey respondents over any prolonged period and attrition occurs due to death, moving location, refusal to participate further, or more commonly difficulty in making telephone contact in a limited survey time period. For this reason refreshment of the sample is required to maintain the chosen survey population size. As reported in Kazimi et al (2000), panel attrition has averaged about 33 percent per wave.

Five waves of panel data have been collected: fall 1997 (Wave 1), spring and fall 1998 (Waves 2 and 3), spring and fall 1999 (Waves 4 and 5) and the evaluation is in its final year. Three approximately equal segments stratify the sample of 1,500 individuals and at each successive wave the panel was refreshed by segment to maintain the total numbers at 1,500. The segments are: (1) ExpressPass customers for Wave 1, recruited through program registration lists. This group became a FasTrak customer group in subsequent waves. (2) I-15 users (solo drivers and carpoolers) who were not ExpressPass users, recruited through random digit dialing, and (3) a control group of I-8 users (solo drivers and carpoolers), also recruited through random digit dialing (RDD sampling). Due to these two methods of recruitment used, segments are treated as separate populations for analysis purposes. Analyses can be conducted both cross-sectionally in which all responses are compared from wave to wave, and dynamically in which responses from the same individual are analyzed over time. The latter provides more accurate results, and using spring wave pairs 2 and 4 has the additional benefit of controlling for seasonal effects.

This is the second occasion on which panel evaluation methodology has been applied to the I-15 HOV Lanes. The impacts of the original opening of the reversible HOV Lanes were evaluated with the aid of a three-wave panel involving over 1,700 residents of the I-15 corridor (Supernak, 1991). One panel wave was conducted before and two waves after opening of the Lanes in 1989. A dynamic model was used to capture the effects of the new Lanes on both mode choice behavior and attitudes and perceptions (Golob, Kitamura and Supernak, 1997). Experiences with the 1988-1990 HOV Lanes panel survey helped guide design of the 1997-1999 HOT Lanes panel.

4. FASTRAK DEMAND

By fall 1998 (Wave 3 of the panel), the FasTrak phase of the project with its dynamic per-trip tolls was well established. Cross-sectional mode choice models were estimated with these Wave 3 data, as reported in Brownstone, *et al*. (1999), Golob (2000) and Kazimi, *et al*. (2000). A binomial logit model of the choice of subscription to the FasTrak program was also estimated for the 769 commuters who reported making regularly scheduled trips on I-15 in Wave 3. These are divided into 457 (57.4%) FasTrak customers and 339 (42.6%) non-customers (Golob, 2000). The results are listed in Table 1. The survey is choice-based, so the constant (not shown) is biased. There is no correction here for the effects of the choice-based sampling on standard errors of the coefficients.

Table 1. Logit model of choice of subscription to the FasTrak Program (N = 796)

Independent Variable	Coefficient	*z*-statistic	Probability
Age less than 35 years	-0.625	-2.80	0.0051
Age greater than 64 years	-1.623	-2.10	0.0358
Gender female and age 35 - 64	0.699	3.56	0.0004
Education beyond bachelors degree	0.561	3.05	0.0023
Household income less than $60,000	-0.727	-3.17	0.0015
Household income ≥ $80,000	0.771	4.11	0.0000
One-worker household	1.579	4.37	0.0000
Two-worker household	0.683	2.79	0.0052
One-vehicle household	-1.534	-3.64	0.0003
Household workers per vehicle	0.934	2.32	0.0202
Commute distance	-0.055	-1.53	0.1280
Commute distance squared (/1000)	1.209	2.14	0.0326
Access to I-15: Ted Williams Parkway	0.892	4.53	0.0000
Goodness of fit measures			
Initial log likelihood		-543.0	
Model log likelihood		-463.1	
Rho-squared		0.147	

FasTrak customers are more likely to be between 35 and 64 years of age, and they are more likely to be females in this age group. They are more likely to be higher educated, a variable which can be viewed as a proxy for professional occupations. They are more likely to come from households with annual household incomes in excess of $80,000, and are less likely to come from households with annual incomes less than $60,000. They are also more likely to come from households with either one or two household members working outside the home, as opposed to households with more than two workers or no workers.

Residential location is also important. Commute distance exhibits a quadratic effect that has a minimum at approximately 23 miles, indicating that FasTrak subscription is lowest for persons who commute 23 miles to their normal place of work or school, *ceteris paribus*. Golob (2000) demonstrates that this is primarily due to a corresponding peaking of carpooling at approximately this distance. The second spatial location variable is access to I-15 Express Lanes at their north end at Ted Williams Parkway. At this point there is access directly to the Express Lanes via a dedicated onramp. Users of the Express Lanes who enter at Ted Williams Parkway experience added time savings by avoiding queuing at the regular-lane ramps, which

have ramp-metering signals. The queuing times at these ramps are typically substantial during the morning peak period, and in fall, 1998, the mean queuing time for the peak 15-minute period was estimated to be five minutes (Brownstone, *et al.*, 1999; Kazimi, *et al.*, 2000).

It is not instructive to repeat this cross-sectional analysis of FasTrak demand at successive waves of the panel, nor are dynamic models possible, due to the low level of refreshment for the FasTrak segment and the fact that refreshment was drawn from all FasTrak customers. Failure to synchronize panel refreshment with growth of FasTrak demand was a mistake. If refreshment for the FasTrak segment at each wave had drawn only from customers who had signed up in the period immediately preceding the wave, we could have estimated dynamic models to reveal how demographic and socioeconomic descriptions of FasTrak demand might be shifting over time. We recommend that panel surveys be designed to sample refreshment in a way that takes advantage of growth in demand in future applications in project evaluation.

5. CHOICE BEHAVIOR

The Express Lanes were originally built to promote and support carpooling as part of both congestion management and air quality strategies. When the HOT lane concept was introduced there was concern that allowing solo drivers in the carpool lanes might have the unintended consequence of undermining carpooling. For this reason the first panel wave carpoolers were over-sampled to insure their adequate representation.

In order to test whether FasTrak customers are drawn more from carpoolers than solo drivers, we investigated the previous mode choices of all FasTrak customers who were originally recruited in the I-15 users segment i.e. they were randomly sampled. Forty I-15 users converted to FasTrak customers during the course of the panel. Thirty-four of these new customers reported making trips on I-15 in the Wave immediately preceeding their first wave as a FasTrak customer. There were no statistically significant differences in the former modal splits of the new FasTrak customers, when compared to the former modal splits of all the other I-15 users. For new customers, 18.5% had previously always carpooled over the course of a week and 66.7% always drove alone, the rest mixed the two modes. For other I-15 users, 18.4% always carpooled while 66.2% always drove alone. There is no evidence that FasTrak subscription has reduced carpooling on I-15.

It is also possible that FasTrak could help reduce carpooling by decreasing congestion on the regular lanes of I-15 and increasing congestion on the Express lanes. To explore this possibility, we conducted turnover analyses for seasonally paired waves by individual respondents that reported the same trip purpose for both waves. For the spring panel waves, 71% of other I-15 Users were solo drivers in 1998, compared to only 65% in 1999. The gross turnover (i.e. changes from solo driving or carpooling in either direction) is 15 percent and the net turnover is a 6 percent increase in carpooling. The Symmetry Chi-square of 3.77 indicates this change is significant only at the $p = .06$ level. The analysis of the fall Waves gives a different result. Here 66 percent of Other I-15 Users were solo drivers in Wave 3, compared to 68 percent in Wave 5. The gross turnover is 15% but the net turnover is a 2% increase in solo driving, a change that is not statistically significant. For the control group on the Interstate Route 8 corridor, there is no change across the spring periods and a noticeable but statistically insignificant increase in carpooling across the fall periods. We can conclude that there is no statistical evidence of carpooling policies being undermined and if anything carpooling has been supported and has increased. The seasonally adjusted wave pair comparisons are helpful in justifying such statements especially as these types of issue are politically very sensitive.

6. DYNAMICS OF FASTRAK USAGE

As indicated earlier registration of FasTrak customers has increased throughout the project. Toll rates charged were also adjusted prior to Wave 3 to encourage greater use in the off-peak "shoulder" periods. Questions to be answered are whether FasTrak use by customers remains stable or is increasing or decreasing and whether the shoulder pricing had the desired effect on FasTrak use. There are two sources of data about FasTrak use: an individual's estimate of their total number of one-way trips per week or month and information constructed from questions about in-bound weekday morning trips. We begin with the former.

Table 2 compares cross-sectional statistics of general usage for Waves 2 through 5. The median number of total FasTrak trips per week remains constant at 5 trips per week but drops to 4 trips per week at Wave 5. The means indicate minor fluctuations in usage. Due to high standard deviations, cross-sectional statistics do not reveal any statistically significant patterns.

Table 2. General Usage – Total Weekly FasTrak Use

	Wave 2 Spring 1998	**Wave 3 Fall 1998**	**Wave 4 Spring 1999**	**Wave 5 Fall 1999**
Mean	4.97	5.27	4.66	4.62
Standard dev.	3.02	3.12	3.24	3.35
Median	5.0	5.0	5.0	4.0
N	400	517	456	458

Seasonally adjusted paired-response t-tests of changes in FasTrak usage revealed that there was no significant change in FasTrak usage from spring 1998 to spring 1999. However, total weekly FasTrak use (both directions) fell by almost 0.6 trips per week fom fall 1998 to fall 1999, and this change is significant at the $p = .01$ level. The study team believes that some part of this decrease may be a panel age effect. However, it may also represent declining effectiveness of the shoulder pricing adjustment.

By looking at the results of questions about weekday trips and modes for in-bound trips we gain a different perspective. Dynamic tests of changes in weekly rates of FasTrak, solo driving without FasTrak, and carpooling, were computed from reports of frequencies of mode use for inbound trips. There was a statistically significant increase in FasTrak usage and a significant decrease in solo driving without FasTrak between spring 1998 and spring 1999. There was no significant change in carpooling by FasTrak customers. We can conclude that the increase in FasTrak use by established FasTrak customers is at the expense of solo driving without FasTrak. The estimated increase in FasTrak use is 0.45 trips per week (or 18%), plus or minus 0.26 trips (95% confidence interval). The estimated decrease in regular-lanes solo driving trips by FasTrak customers is 0.50 trips per week, plus or minus 0.24 trips. The slight increase in carpooling by FasTrak customers was not statistically significant. Increased FasTrak use occurred following the shift to lower tolls in the off-peak periods. Between fall 1998 and fall 1999 there was a decrease in FasTrak usage of from 3.10 to 2.86 trips per week, which is marginally significant ($p = .07$). There is a corresponding increase in carpooling by FasTrak customers, but this increase is not statistically significant.

Modal split changes for the morning trip were also investigated, dynamic tests of the distribution of modes used shows a significant increase in FasTrak use and a significant decrease in solo driving without FasTrak between spring 1998 and spring 1999. The estimated increase in FasTrak use is 0.45 trips per week (or 18 percent), plus or minus 0.26 (95 percent confidence level). The estimated decrease in regular-lanes solo

driving trips by FasTrak customers is 0.50 trips per week, plus or minus 0.24 trips (95 percent confidence level).

Dynamic analysis of the distribution of modes used shows a significant decrease in FasTrak use from 3.10 to 2.86 trips per week between fall 1998 and fall 1999. Similar dynamic tests were performed for Other I-15 Users. There was a marginally significant decrease –0.29 in solo driving between spring 1998 and spring 1999. There were no significant changes between fall 1998 and fall 1999. For the I-8 control group the timing is reversed. The dynamic analysis for I-8 identifies a significant decrease –0.37 in the rate of solo driving on I-8 from Wave 3 to Wave 5 (Fall 1998 to Fall 1999). The increase in FasTrak use between spring 1998 and spring 1999 is thought to be a response to the reduced off peak tolls. This is a hoped-for response to the pricing policy. However, this effect seems to have disappeared over time. There are no discernable impacts on carpooling."

From the above analysis we can conclude that overall FasTrak use appears to be relatively stable. The panel has however been capable of measuring small statistically significant changes indicating first a positive response to the shoulder pricing followed by a subsequent fading of that response. There appear to have been no discernable impacts on carpooling.

7. DEPARTURE TIMES AND PERCEIVED TIME SAVINGS

To further explore changes in behavior and responses to the shoulder pricing the analysis of departure times is valuable. In spring 1998, FasTrak Customers departed later than Other I-15 Users. In fall 1998, these differences disappeared as FasTrak Customers began leaving earlier. In spring 1999, FasTrak Customers began reverting to later departure times. By fall 1999, the differences between FasTrak Customers and Other I-15 Users resembled those of spring 1998. Turnover analysis was also used to investigate changes in behavior. Table 3 provides a cross-tabulation of departure times using half-hour categories for FasTrak Users, comparing spring 1999 to spring 1998. Forty-six percent of FasTrak Users left in the same time period at both waves. In August 1998 i.e. between Waves 2 and 4, the toll fee schedule was adjusted. Maximum tolls were lowered in the off-peak hours to encourage greater use in these periods. The maximum toll rates during the 7:00 a.m. to 8:00 a.m. period remained unchanged. Table 3 shows that at Wave 2, 25 percent departed in the 7:00 – 7:29 time period and at Wave 4, 20 percent were leaving in this period. The only significant change appears to be that in the 7:30 – 8:29 a.m. period 8 percent moved their departure later i.e. Wave 2, 7:30 – 7:59 a.m. to Wave 4, 8:00 to 8:29 a.m. However only 1 percent moved their departure time earlier i.e. Wave 2, 8:00 – 8:29 a.m. to Wave 4, 7:30 – 7:59 a.m. The move to a later departure is consistent with the intent of the modified toll rates i.e. to move FasTrak Users out of the peak of the peak. No similar shifts were found for Waves 3 and 5 (fall 1998 to fall 1999).

A very different perspective on time is gained from the analysis of time saved as a result of using FasTrak. FasTrak respondents were asked to estimate the usual time that they saved using FasTrak on the I-15 Express Lanes. Table 4 compares cross-sectional responses for Waves 2 – 5 about reported time saved for both the inbound a.m. (southbound) and outbound p.m. (northbound) trips. Wave 1 is excluded because the small number of ExpressPass Users represented a different traveling environment in the Express Lanes.

Changes in perceived time savings were analyzed using paired *t*-tests. None of the changes between Waves 2 and 4 were statistically significant. Between Waves 3 and 5, there was a significant decrease of -1.62 minutes (plus or minus 1.0 minutes) in perceived time savings for the inbound a.m. trip. This is also consistent with falling use of FasTrak in this period. The time saving estimates offered by respondents in no way represent the actual time saved driving in the Express Lanes compared with driving on the regular freeway lanes. Median floating car estimates for Wave 3 fall time savings are 8.5 minutes compared with a

median of 15 minutes offered by FasTrak users in the same period. Such responses are therefore too biased to be useful for value of time modeling see Brownstone, *et al*. (1999). However, the perception of the extent of time saved is important in explaining acceptance and support for the I-15 Congestion Management Program which is discussed further in the sections that follow.

Table 3. Comparison of Departure Times for In-bound Trips by FasTrak Users in Waves 2 and 4 (N = 171)

Departure Times Wave 4	Departure Times Wave 2							
	Before 6:00	**6:00 - 6:29**	**6:30 - 6:59**	**7:00 - 7:29**	**7:30 – 7:59**	**8:00 – 8:29**	**8:30 & later**	**Total Wave 4**
Before 6:00	5%	1%		1%				**7%**
6:00 - 6:29	1%	6%	2%	1%			1%	**11%**
6:30 - 6:59	1%	3%	7%	4%	1%	2%		**17%**
7:00 - 7:29		1%	3%	12%	2%	2%		**20%**
7:30 – 7:59		1%	1%	5%	8%	1%	1%	**17%**
8:00 – 8:29	1%		1%	1%	8%	6%	5%	**22%**
8:30 & later			1%	1%		4%	2%	**8%**
Wave 2 totals	**8%**	**12%**	**14%**	**25%**	**18%**	**15%**	**8%**	**100%**

Table 4. Perceived Usual Time Saved Using FasTrak (in minutes)

	Inbound				**Outbound**			
	Wave 2	**Wave 3**	**Wave 4**	**Wave 5**	**Wave 2**	**Wave 3**	**Wave 4**	**Wave 5**
Mean	16.4	17.6	16.89	16.10	22.4	23.2	21.04	22.12
Std. dev.	9.8	10.2	10.23	10.52	15.9	18.2	13.01	12.94
Median	15.00	15.00	15.00	15.00	20.00	20.00	20.00	20.00
N	377	497	421	408	390	501	418	408

8. SATISFACTION WITH TRAVEL CONDITIONS

Respondents were asked how satisfied they were with the travel conditions on their most recent weekday a.m. trip. For this analysis, an additional segment is considered: "FasTrak Non-users" are those commuters who are Current FasTrak Customers, but who chose to drive alone in the regular lanes rather than to use the I-15 Express Lanes with FasTrak for their most recent weekday a.m. trip. As shown in Table 5, FasTrak Users continue to be the most satisfied segment. I-15 Solo Drivers were the least satisfied segment at Wave 2 but appear to have modified their views with more than 50 percent being satisfied rather than dissatisfied. All other ratings remain unchanged from previous waves.

Table 6 shows the responses to satisfaction with travel conditions at Wave 5. The two changes that are noticeable are that FasTrak Users no longer seem quite so satisfied. This result would also be consistent with the falling use finding. Their median rating that has dropped from "very satisfied" to "Satisfied." Similarly, I-15 Solo Drivers have fallen back and their median rating has now returned to "dissatisfied."

Table 5. Satisfaction with Travel Conditions on Most Recent Weekday Trip by Segment – Wave 4

	FasTrak Users	FasTrak Non-users	I-15 Solo Drivers	I-15 Carpoolers	I-8 Solo Drivers	I-8 Carpoolers
Very Satisfied	141 (55%)	34 (28%)	21 (18%)	45 (46%)	74 (25%)	15 (25%)
Somewhat Satisfied	62 (24%)	48 (40%)	39 (34%)	36 (36%)	148 (50%)	31 (52%)
Somewhat Dissatisfied	27 (11%)	24 (20%)	25 (22%)	11 (11%)	47 (16%)	12 (20%)
Very Dissatisfied	25 (10%)	14 (12%)	30 (27%)	7 (7%)	28 (9%)	2 (3%)
Median Rating	Very Sat.	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied
Totals	255	120	115	99	297	60

Table 6. Satisfaction with Travel Conditions on Most Recent Weekday Trip by Segment – Wave 5

	FasTrak Users	FasTrak Non-users	I-15 Solo Drivers	I-15 Carpoolers	I-8 Solo Drivers	I-8 Carpoolers
Very Satisfied	119 (47%)	38 (35%)	11 (11%)	32 (38%)	42 (16%)	10 (16%)
Somewhat Satisfied	57 (22%)	32 (30%)	28 (28%)	26 (31%)	119 (46%)	28 (44%)
Somewhat Dissatisfied	37 (15%)	19(18%)	28 (28%)	13 (15%)	63 (24%)	20 (32%)
Very Dissatisfied	41 (16%)	19 (18%)	32 (32%)	14 (17%)	36 (14%)	5 (8%)
Median Rating	Satisfied	Satisfied	Dissatisfied	Satisfied	Satisfied	Satisfied
Totals	254	108	99	85	260	63

In order to pursue whether the changes are statistically significant dynamic analysis of seasonally adjusted wave pairs are required. Tables 7 and 8 list changes in satisfaction levels for various panel samples between the Spring Waves 2 and 4 and Fall Waves 3 and 5 respectively. For the period spring 1998 to spring 1999, the difference between FasTrak Customers and Other I-15 Users is statistically significant (based on two tests: Mann-Whitney Z = -2.096 corresponding to p = .036 and t = 2.117 for Kendall's tau, corresponding to p = .034). FasTrak Users were more evenly divided in terms of increasing and decreasing satisfaction levels, while Other I-15 Users were more inclined towards increased satisfaction. The changes in satisfaction levels for Other I-15 Users and I-8 Users are not significantly different.

9. PERCEPTIONS OF TRAFFIC CONDITIONS

The study team is interested in relating perceptions and attitudes to behavior in order to better explain the success of failure of the project. All respondents who had made a recent inbound weekday a.m. trip on I-15 were asked to rate traffic conditions for that trip on the I-15 Express Lanes (whether or not they used them), as well as the traffic conditions in the I-15 main lanes. I-8 Users who had made a recent inbound weekday a.m. trip were asked to rate traffic conditions on I-8 for that trip. All ratings were on a 10-point ordinal scale, with 1 representing bumper-to-bumper condition and 10 representing no traffic problems.

Table 7. Changes in Satisfaction with Travel Conditions on Most Recent Inbound Trip by Segment – Wave 2 (Spring 1998) to Wave 4 (Spring 1999)

	FasTrak Customers		Other I-15 Users		I-8 Users	
Decreasing satisfaction	43	(25%)	28	(19%)	38	(23%)
Equal satisfaction	88	(51%)	71	(48%)	79	(49%)
Increasing satisfaction	40	(23%)	50	(34%)	45	(28%)
Segment totals	171		149		162	

Table 15: Changes in Satisfaction with Travel Conditions on Most Recent Inbound Trip by Segment – Wave 3 (Fall 1998) to Wave 5 (Fall 1999)

	FasTrak Customers		Other I-15 Users		I-8 Users	
Decreasing satisfaction	65	(31%)	40	(26%)	48	(26%)
Equal satisfaction	84	(40%)	63	(40%)	87	(47%)
Increasing satisfaction	63	(30%)	53	(34%)	49	(27%)
Segment totals	212		156		184	

FasTrak users had a median rating of 8 across all four waves and thus expressed a continuous high level of satisfaction with traffic conditions in the Express Lanes. Similarly, and most importantly, carpoolers gave the same median rating across all four waves. This indicates that despite the buildup of registered FasTrak customers the level of service in the Express Lanes is perceived to be unchanged. I-15 Solo Drivers consistently gave a median rating of 9 to traffic conditions in the Express Lanes. FasTrak non-users vary in their median rating of the Express Lanes with scores of 9 in spring (Waves 2 and 4) and 8 in fall (Waves 3 and 5).

Both FasTrak users and carpoolers gave a median rating of 4 to the traffic conditions in the regular lanes at Waves 2 and 3. However the median rating drops to 3 at Waves 4 and 5, which suggests not only do they consider traffic conditions in the regular lanes to be bad they also think the conditions are deteriorating. The FasTrak non-users by comparison consistently rated the regular lanes at 5 and appear to be less sensitive to traffic conditions. Solo drivers also appear to perceive that conditions are deteriorating. They give a median score of 4 to traffic conditions for Waves 2 through 4 but drop to a score of 3 by Wave 5. This appears to indicate that solo drivers do not perceive benefits in terms of reduced congestion in the regular lanes resulting from the project. This finding is also consistent with the previous finding of a fall in satisfaction at Wave 5 for solo drivers with their most recent trip. The I-8 control sample carpoolers and solo drivers have very similar median ratings for traffic conditions that remain in the 5-6 ranges for all four waves.

10. ATTITUDES TOWARDS THE PROJECT

The panel has been used to track and monitor attitudes that are indications of support or lack of support for the project. Congestion pricing is a contentious issue in California, but users of the I-15 San Diego corridor have proven to be remarkably supportive of the project. The overwhelming majority (70 – 96 percent of the Wave 5 survey segments) considers that the project is fair to travelers who use the regular I-15 lanes. Similarly the overwhelming majority (69 –96 percent of the Wave 5 survey segments) considers that the project is fair to travelers in the carpool lanes. Likewise the majority of respondents in all segments agree with the principle of allowing solo drivers to use the carpool lanes and pay a toll. FasTrak customers firmly believe that the project helps to reduce traffic congestion overall on the I-15. The majority of other users

agree but less strongly. The majority of FasTrak customers and I-15 carpoolers believe the project to be a success. However, solo drivers are evenly divided in their views: 39 percent viewing it as a success and 39 percent viewing it as not a success, with 22 percent still undecided at Wave 5. Carpoolers have increased their support for the project over its duration. Finally there have been no perceived reductions in safety in the carpool lanes.

11. CONCLUSIONS AND DIRECTIONS FOR FUTURE RESEARCH

From the outset of this study, the research team believed that they would be required to measure and evaluate small changes caused by a project that could easily be overwhelmed by other external factors. This ambitious project raises many questions about how different segments of the traveling public respond to both congestion and the ability to pay to travel in less congested traffic. Changes during the course of the project have involved the introduction of a dynamic pricing system, since modified first by shoulder pricing and then by a maximum increased from $4 to $8. Meanwhile over the three-year period the local economy has turned from slump to boom with accompanying increases in congestion. The panel with its segmented sample and use of the I-8 Control Corridor have proven to be robust in distinguishing small changes in different directions. The findings do not necessarily always seem profound but they have nevertheless enabled the team to firmly answer complex policy questions with regard to traveler responses in terms of both attitudes and behavior. The sample size of 1,500 has proven sufficient for the policy purposes of the project. Without the panel methodology it would not have been possible to investigate such issues as whether or not carpooling had been adversely impacted or whether individual FasTrak use was increasing or decreasing.

The use and advantages of panel surveys as project evaluation tools is discussed by, among others, Kitamura (1990), Richardson, *et al.* (1995), Lee-Gosselin (1997), and Paaswell (1997). The extent and complexity of behavioral responses to the proposed HOT lanes demonstration requires that evaluators be able to distinguish "normal" volatility from actual apparent responses that might only emerge over extended time periods. As Goodwin (1997) has also commented, panel surveys aid our understanding by allowing the study of turnovers in the mode share market and the establishment of responses to stimuli over time.

Using a panel for the evaluation of changes in travel behavior and attitudes has given the study team the ability not only to measure traveler responses but also to pursue in depth the responses of particular segments. This means that it is possible not only to establish what the net changes in a given period have been but also look at the characteristics of those who have changed. The politically sensitive question of whether there have been negative impacts on carpoolers leading to their becoming solo drivers can be answered with certainty as a negative. Similarly the impact of the shoulder pricing policy can be seen to have had a positive outcome in that there were shifts from the peak to the off peak period in the short term but this impact appears to have decreased over time.

The explanation of the apparent success of the project would appear to lie in the lack of adverse impacts for the traveling public. Regular carpoolers have not suffered a perceivable degradation in their journey to work on the Express Lanes. Solo drivers have been offered a choice where previously they had none. FasTrak users believe that they save valuable time using the HOT lane facility. The majority considers that the project is fair to both travelers in the carpool lanes and the regular lanes and supports the concept of solo drivers paying tolls. There appears to be no large constituency of opposition believing they are suffering under an unfair policy. This is despite evidence that users of the facility are drawn from the highest income groups. The evaluation results suggest that in this example of congestion pricing there appear to be more winners than losers. To date, the findings from the panel analysis have proven valuable to help in extending

the life of the I-15 Congestion Pricing Experiment. Findings were used in support of the renewal of enabling state legislation, which passed in late 1999.

The main limitation of the panel survey is that there was no wave of the panel before the HOT lanes went into operation. Unfortunately the project evaluation team and the methodology were not selected until after the Project had begun. It is recommended that an evaluation team be selected and onboard before implementation of future demonstration projects.

Much remains to be achieved through further analyses of the panel data. This dataset will undoubtedly prove to support the application of advanced dynamic models of both attitudes and behavior long after its role as a monitor of project effects is concluded.

ACKNOWLEDGEMENTS

The authors would like to thank Janusz Supernak, Christine Kaschade and Camilla Kazimi of San Diego State University, David Brownstone and Arindam Ghosh of the University of California, Irvine, Kim Kawada and staff of the San Diego Association of Governments, and Tom Higgins of K.T. Analytics for their help and support. Kathy Happersett and her team at the Social Science Research Laboratory of San Diego State University ably collected the survey data. The views expressed are those of the authors, and the authors are solely responsible for any errors of omission or commission.

REFERENCES

Bhatt, K. (1993). Implementing congestion pricing: Winners and losers. *ITE Journal*, **63:** 33-37.

Brownstone, D., T.F. Golob and C. Kazimi (2000). Modeling non-ignorable attrition and measurement error in panel surveys: an application to travel demand modeling. Presented at the International Conference on Survey Nonresponse, October 28-31, Portland, OR.

Ghosh, A. (2001). To pay or not to pay: Commuters' mode choice under real time congestion pricing. Presented at the Annual meeting of the Transportation Research Board, January, Washington, DC.

Giuliano, G. (1992). An assessment of the political acceptability of congestion pricing. *Transportation,* **19**: 335-358.

Giuliano, G. (1994). Equity and fairness considerations of congestion pricing. In *Curbing Gridlock Vol. 2, TRB Special Report 242*. National Academy Press, Washington.

Golob, J.M., J. Supernak, T.F. Golob, and K. Kawada (1998). An evaluation of a high occupancy toll (HOT) lane demonstration project in San Diego. *Proceedings of Seminar C held at the European Transport Conference, Loughborough University*: 255-270. PTRC, London.

Golob T.F. (2000). Joint Models of Attitudes and Behavior in Evaluation of the San Diego I-15 Congestion Pricing Program. *Transportation Research, Part A Policy and Practice,* in press.

Golob, T.F., Kitamura, R. and Supernak, J. (1997). A panel-based evaluation of the San Diego I-15 Carpool Lanes Project. In T.F. Golob, R. Kitamura and L. Long, eds., *Panels for Transportation Planning: Methods and Applications,* 97-128. Kluwer, Boston.

Goodman, L., R.P. Jurasin, T.F. Larwin, C.K. Orski, K.F. Turnbull and R.A. Cunard (1998). High-Occupancy/Toll (HOT) Lanes and value pricing: A preliminary assessment. *ITE Journal, 68*: 30-40.

Goodwin, P.B. (1997). Have panel surveys told us anything new? In T.F. Golob, R. Kitamura and L. Long, eds., *Panels for Transportation Planning: Methods and Applications,* 79-96. Kluwer, Boston.

Higgins, T.J. (1997). Congestion pricing: Public polling perspective. *Transportation Quarterly,* **51**: 97-104.

Jones, P.M. (1994). Road pricing: The public viewpoint. In B. Johansson and L-G Mattsson, eds., *Road Pricing: Theory, Empirical Assessment and Policy*. Kluwer, Boston.

Jones, P.M. (1998). Urban road pricing: Public acceptability and barriers to implementation. In K.J. Button and E.T. Verhoef, eds., *Road Pricing, Traffic Congestion and the Environment: Issues of Efficiency and Social Feasibility*. Edward Elgar, Cheltenham, UK.

Kazimi, C., D. Brownstone, A. Ghosh, T. F. Golob and D. van Amelsfort (2000). Willingness-to-Pay to Reduce Commute Time and its Variance: Evidence from the San Diego I-15 Congestion Pricing Project. Presented at annual meeting of Transportation Research Board, January, Washington D.C.

Kitamura, R. (1990). Panel analysis in transportation planning: An overview, *Transportation Research,* **24A**: 401-415.

Lee-Gosselin, M. (1997) Panels as evaluation tools, in Golob, T.F., Kitamura, R. and Long, L., eds., *Panels for Transportation Planning: Methods and Applications,* 75-77. Kluwer Academic Publishers, Boston.

Lo, H.K. and M. Hickman (1997). Toward an evaluation framework for road pricing. *Journal of Transportation Engineering,* **123**: 316-324.

Paaswell, R.E. (1997). Why panels for transportation planning? In Golob, T.F., Kitamura, R. and Long, L., eds., *Panels for Transportation Planning: Methods and Applications*, 3-14. Kluwer, Boston.

Richardson, A.J., Ampt, E.S. and Meyburg, A.H. (1995). *Survey Methods for Transport Planning*. Eucalyptus Press, Melbourne.

Seale, K. (1993). Attitudes of politicians in London to road pricing. *PTRC Summer Annual Meeting, Proceedings of Seminar F*: 117-128. PTRC Education and Research Services, London.

Sheldon, R., M. Scott and P. Jones (1993). London congestion charging: Exploratory social research among London residents. *Proceedings of Seminar F, PTRC Summer Annual Meeting,*: 129-145. PTRC Education and Research Services, London.

Supernak, J. (1991). Assessment of the Effectiveness of the Reversible Roadway for High Occupancy vehicles on Interstate Route 15, Final Report Prepared for the California Department of Transportation, Department of Civil Engineering, San Diego State University.

Supernak, J., J.M. Golob, K. Kawada and T.F. Golob (1999). San Diego's I-15 Congestion Pricing Project: Preliminary findings. Presented at Annual Meeting of Transportation Research Board, January, Washington, DC.

Verhoef, E.T., P. Nijkamp and P. Rietveld (1997). The social feasibility of road pricing. *Journal of Transport Economics and Policy,* **31**: 255-276.