Commuter Impacts and Behavior Changes during a Temporary Freeway Closure: The Fix I-5 Project in Sacramento, California

Liang Ye
PhD Candidate in Transportation System Planning
School of Transportation Engineering, Tongji University
4800 Cao'an road, Shanghai, 201804, P.R.CHINA
e-mail: yel1231@gmail.com
Visiting Researcher at the Institute of Transportation Studies
University of California, Davis
One Shields Avenue
Davis, CA, 95616, USA
Phone: 1 530 400 1952
Fax: 1 530 752 6572
e-mail: lye@ucdavis.edu

Patricia L. Mokhtarian
Department of Civil and Environmental Engineering
and Institute of Transportation Studies
University of California, Davis
One Shields Avenue
Davis, CA, 95616, USA
Phone: 1 530 752 7062
e-mail: plmokhtarian@ucdavis.edu

and

Giovanni Circella
Institute of Transportation Studies
University of California, Davis
One Shields Avenue
Davis, CA, 95616, USA
Phone: 1 530 554 6600
e-mail: gcircella@ucdavis.edu

TRB 89th Annual Meeting, January 10-14, 2010
Submission date: August 1, 2009; Revision date: November 15, 2009
Word count:
8,304 words (262-word abstract)
5 tables and 1 figure=1,500 words equivalent
9,804 words total

Abstract

In the nine weeks between May 30 and July 31, 2008, a one-mile stretch of Interstate 5 (I-5) in downtown Sacramento, California was intermittently closed for a reconstruction (“the Fix I-5 project”, or “the Fix”). To study the impacts of the Fix on commuters’ travel behavior, a series of three internet-based surveys was conducted. The present paper offers a preliminary analysis of the first two of those surveys. We address the (passive) impacts of the closure on commuters, and the (active) choices of commuters during the closure. The passive impacts of the Fix do not appear to be excessive: majorities of respondents in all relevant subsamples that were analyzed did not find conditions to be worse than usual, and sizable minorities found them to be better. Among the active changes to commute trips, the easiest options – avoiding rush hour and changing route – were the most common responses (adopted by 48% and 44%, respectively). Among the changes that reduce vehicle-miles traveled, increasing transit use and increasing telecommuting were the most common (each adopted by about 5% of the relevant subsample). Evidence suggests that conditions, and commuters’ behavior, began to revert to normal as the Fix progressed. A binary logit model of the choice to increase transit use suggests that persuading current transit users to increase the frequency they use transit is easier than convincing nonusers to switch to transit. Women and (counter to expectation) those in larger households were more likely to increase their transit use. Employer transit subsidies supported increases in transit, while variable work hours and free on-site parking discouraged it.

Keywords: Behavior change, Mode choice, Transit users, Network disruption, Transportation Demand Management (TDM)

1 INTRODUCTION

In the nine weeks between May 30 and July 31, 2008, a one-mile stretch of Interstate 5 (I-5) in downtown Sacramento, California was intermittently closed for a $27 million reconstruction (“the Fix I-5 project”, or “the Fix”). With average daily traffic of 190,000 vehicles, this portion of I-5 is part of a major north-south conduit for interregional traffic (extending from Canada to Mexico), as well as a key commute route serving downtown Sacramento (the state capital) and other job locations in the region. To mitigate the impact of the Fix, a number of strategies were implemented by Caltrans and other public agencies, including providing extensive information on the Fix and commute alternatives through the media, seminars, and the internet; funding increased transit service and (in some cases) reducing transit fares and offering free parking at some facilities; reducing off-street parking rates in downtown Sacramento after 5 p.m., to motivate commuters to travel after the evening peak; and providing roving tow truck service to promptly remove disabled vehicles on other portions of the regional highway network. Two weeks before the Fix (May 16), Gov. Schwarzenegger issued Executive Order S-04-08 (1), directing State executive agencies to promote commute alternatives (such as telecommuting, alternative work schedules, and transit) for their employees to the fullest extent possible, and encouraging other public agencies and private companies to do so as well.

The Executive Order also authorized a study of the impacts of the Fix, with a view to evaluating the effectiveness of the commute modification strategies being promoted, and the extent to which more sustainable commute patterns would be the longer-term result.

As the interstate highway system and other elements of the transportation infrastructure continue to age, reconstruction projects like Fix I-5 will occur quite frequently. Therefore, it is important to learn as much as possible about commuter reactions to such projects, to enable future projects to be implemented in the most effective way. At the same time, such projects offer valuable opportunities to disrupt habitual behavior in a natural way, and to use that disruption to motivate shifts toward more sustainable commute choices (2).

Accordingly, the University of California, Davis was funded by the California Environmental Protection Agency (through the California Air Resources Board) to conduct an evaluation of the impacts of the Fix on commuter behavior. As part of that evaluation, a series of three internet-based surveys was conducted. The present paper offers a preliminary analysis of the first two of those surveys. Specifically, we address the passive impacts of the closure on commuters, and the active choices of commuters during the closure. By "passive impacts" we mean the situation experienced by commuters in terms of factors largely outside their control (e.g. the number of times they were delayed), whereas by "active choices" we mean strategies that commuters may have exercised to cope with the closure (e.g. taking vacation, telecommuting, or changing mode). In addition to presenting descriptive statistics, we develop a binary logit model of the most frequently adopted active choice that reduces vehicle-miles traveled (VMT), namely the choice to increase the use of transit during the Fix.

The remainder of the paper is organized as follows. The next section briefly reviews previous related research. The subsequent section describes the data collection, survey contents and variables used in this study. Then, we discuss descriptive statistics for the passive impacts experienced and active choices made by commuters. The binary logit model is presented in the following section. The last section summarizes the study and suggests future research directions.

2 LITERATURE REVIEW

A number of studies have analyzed the impacts of traffic network disruptions. Such disruptions can be either planned (such as partial or complete highway closures for reconstruction) or unplanned (natural or human-caused disasters such as earthquakes or major accidents). In the first category, several studies have examined the travel behavior impacts of major reconstruction projects, and evaluated some strategies implemented during these projects (3-7). Fujii, et al. (3) studied the changes in perceptions and use of public transportation among 335 drivers in Osaka, Japan, by surveying them before and during an 8-day temporary closure of a freeway. The authors suggest that a temporary structural change may be an important catalyst that triggers cooperation in a social dilemma. The study showed that the expected commute time by public transportation was overestimated by automobile commuters in the sample, and indicated that by inducing the use of public transportation, a temporary modification in the road network may contribute to adjusting the perceived travel time by transit to more realistic values.

In the I-195 Providence River [Rhode Island] Bridge Repair Project (4), traffic management strategies were compiled, selected, and implemented to move people through and around the project area. These strategies included interventions on (*i*) education (public information and community liaison activities), (*ii*) traffic engineering (coordination of traffic control signals and emergency routes), (*iii*) enforcement (monitoring and enforcing speed limits), and (*iv*) ridesharing and transit (carpool matching, free bus service and park-and-ride lots). The paper notes that each project is unique. Therefore, strategies should be selected in order to conform to the project area and each project's characteristics.

Other studies have focused on the outcomes of unplanned disruptions to the transportation system (8-10). An analysis (8) of travelers' responses to the 1994 Northridge earthquake in

Southern California indicates that most travelers adjusted to the emergency conditions on the road network by changing routes and travel time schedules, and avoiding discretionary trips in the damaged areas. The impact of the 14-month closure of Centre Street Bridge for reconstruction in Calgary, Canada (9) also shows a small decline in vehicle trips. Auto users mainly stuck to their mode, and only a limited increase in transit use was registered. On the other hand, a study by Tsuchida and Wilshusen (10) shows evidence that the conversion of Route 17 to a carpool facility after the 1989 Loma Prieta (Bay Area, California) earthquake led many people to adopt ridesharing, with 57% of the adopters continuing to carpool even after the route was reopened to general traffic.

Several studies also focused on mode shifts and on the persistency of the adoption of the new mode in the future. Planned projects, in particular, may provide opportunities to promote active changes in commuters' behavior, especially switching from the often predominant "drive alone" mode to a more sustainable mode like carpooling or transit. However, drivers tend to develop a habit (or routine) with regard to their regular commuting behavior. This increases the resistance, or inertia, to eventual changes in the travel mode. Therefore, larger efforts are required to convince travelers to switch from the use of a private car to other more sustainable travel modes (11). Some strategies may be used to trigger a change in travel behavior, while different strategies may be needed to help commuting drivers develop a new habit of, for instance, using public transportation (12).

3 SAMPLING PLAN AND SURVEY CONTENTS

3.1 Data Collection

Since UC Davis was not approached about conducting the study until a few weeks before the closure, there was not enough time to draw a rigorous, geographically-based random sample and recruit participants by mail. Instead, respondents were recruited via e-mail invitations, delivered by willing organizations in the study area to their constituencies. Cooperating organizations primarily included:

a. Numerous State agencies, who broadcast the invitation to their staff in the Sacramento area;
b. The Fix I-5 listserv (which included around 6,000 people who signed up to receive daily updates on the Fix);
c. Transportation Management Agencies (TMAs), who transmitted the invitation to their members – generally employer-based transportation coordinators – who in turn could have transmitted it to the employees of their organization;
d. The Commuter Club of the Sacramento TMA, comprising about 25,000 individuals who signed up to receive commute-oriented information and services; and
e. The University of California, Davis, which issued a press release publicizing the study and the link at which the survey could be taken.

Given the *ad hoc* nature of the recruitment process, we can neither compute a response rate, nor expect a completely representative sample. It is likely that State workers are overrepresented (although they do comprise a plurality of the workforce in downtown Sacramento), as well as internet-literate workers, workers with especially burdensome commutes, those most heavily affected by the Fix, and those who made environmentally-beneficial changes to their behavior. At the same time, self-employed and small-business workers are probably underrepresented, some of whom (together with the less computer-literate) may also have been heavily affected by the Fix, so biases in the sample are counteracting each other to an unknown extent.

Accordingly, the descriptive statistics presented in Section 4 should be viewed with caution. Nevertheless, we suggest that some data are better than no data, and we also believe that *comparisons* in the data should be largely robust (e.g., a ranking of active changes in order of frequency). Thus, we encourage the reader to focus on trends, conditional relationships, and the model (which is a specific type of conditional relationship): in these cases, it is less critical to have a sample that is representative of the total population (13, 14).

Two internet-based surveys were administered during the period of the Fix (a third, follow-up survey was distributed seven months later, and is not analyzed here). The first, hereafter referred to as the Wave 1 survey, sought information on behavior during the first closure of the freeway, of all lanes in the northbound direction (Monday, June 2 – Sunday, June 8, 2008, for our purposes). The second survey (Wave 2) addressed the first closure of the freeway in the southbound direction (June 16-22). At several points in the analysis below, we compare the responses between Wave 1 and Wave 2. The reversed direction of the closure is a confounding factor in the interpretation of the results, but since commute behavior could be expected to be relatively symmetric, our expectation is that any differences found across waves are more reflective of the dynamic adjustments commuters made as the Fix progressed, than of differences due to the directionality of the closures.

The invitations for the two surveys were sent to the same organizations, in the hope that the same respondents would complete both surveys. However, due to delivery problems at the organizational level, many respondents received an invitation for only one of the waves. Many others also chose to complete Wave 1 but declined to complete Wave 2 (or conversely). The final usable sample comprises 4520 valid responses to the Wave 1 survey, and 4976 for Wave 2, including 1528 people who have taken both surveys. An additional group of 1034 Wave 2 respondents stated that they had completed the first survey too, but did not provide enough information for us to be able to match those cases to their Wave 1 responses. This means that only 2414 Wave 2 cases comprise respondents who had not taken the first survey.

In future work, it will be of interest to analyze the 1528 matched responses, to take a more rigorous look at the dynamic aspect of adjustments to the Fix. For the present study, however, we wanted to avoid the complication of having a sizable fraction (about a third) of the sample not being independent across waves (making descriptive statistics and model coefficients less trustworthy). Accordingly, for this analysis we have retained the 4520 Wave 1 cases and the 2414 *new* Wave 2 cases, for a pooled sample of 6934 cases.

TABLE 1 presents the sample statistics for some selected characteristics, including all variables significant in the final model presented in Section 6. The “average” characteristics are: age 47, female, college graduate, in a household with 2.7 members, 2.1 cars, and having an annual income of \$75,000 - \$99,999. Altogether, the sample seems fairly typical of the white-collar, career government workforce to be expected in a state capital. Even the high proportion of female respondents (nearly two-thirds) is not as unbalanced as it may seem, in view of the fact that in general about 60% of state and local government workers are women (15). Average age, educational level, income, household size, and number of licensed drivers are similar between the two waves, but Wave 2 respondents report a slightly longer commute, on average (33 minutes), than Wave 1 respondents (31 minutes). The average number of vehicles per household is also slightly higher in Wave 2 (2.3) than in Wave 1 (2.0).

TABLE 1 Selected Characteristics of the Sample, by Wave

Characteristic (sample sizes)	**Pooled data N (%)**	**Wave 1 N (%)**	**Wave 2 N (%)**
Number of cases	6934	4520	2414
Number of females (6407, 4160, 2247)	4160 (64.9)	2679 (64.4)	1481 (65.9)
Average age (years) (6053, 4016, 2037)	40.6	41.0	39.9
Average educational level [a] (6284, 4097, 2187)	4.06	4.05	4.08
Annual household income (5977, 3886, 2091)			
Less than $15,000	29 (0.5)	16 (0.4)	13 (0.6)
$15,000-$29,999	106 (1.8)	74 (1.9)	32 (1.5)
$30,000-$44,999	493 (8.2)	350 (9.0)	143 (6.8)
$45,000-$59,999	715 (12.0)	468 (12.0)	247 (11.8)
$60,000-$74,999	1070 (17.9)	699 (18.0)	371 (17.7)
$75,000-$99,999	1243 (20.8)	787 (20.3)	456 (21.8)
$100,000 or more	2321 (38.8)	1492 (38.4)	829 (39.6)
Average household size (6328, 4166, 2162)	2.72	2.66	2.85
Number of licensed drivers (6387, 4163, 2224)	6333 (99.2)	4134 (99.3)	2199 (98.9)
Average number of household operational vehicles (5722, 3572, 2150)	2.08	1.97	2.27
Residential neighborhood (6359, 4137, 2222)			
A lot of retail/ commercial within a 10-minute walk	598 (9.4)	403 (9.7)	195 (8.8)
Some retail/ commercial within a 10-minute walk	1809 (28.4)	1212 (29.3)	597 (26.9)
Almost all residential	3559 (56.0)	2285 (55.2)	1274 (57.3)
Few other buildings around	243 (3.8)	148 (3.6)	95 (4.3)
Other	150 (2.4)	89 (2.2)	61 (2.7)
Distance from home to the nearest bus stop or light-rail station (6356, 4136, 2220)			
Less than a 5-minute walk	1680 (26.4)	1127 (27.2)	553 (24.9)
5 - 10-minute walk	1729 (27.2)	1139 (27.5)	590 (26.6)
10 - 20-minute walk	1042 (16.4)	668 (16.2)	374 (16.8)
More than a 20-minute walk	1501 (23.6)	932 (22.5)	569 (25.6)
Don't know	404 (6.4)	270 (6.5)	136 (6.0)
Average commute minutes (6878, 4484, 2394)	31.9	31.3	33.0
Average commute miles (6872, 4483, 2389)	17.8	17.6	18.0
Primary job work schedules (6920, 4513, 2407)			
Part time [b]	388 (5.6)	237 (5.3)	151 (6.3)
Conventional [c]	3221 (46.5)	2173 (48.1)	1048 (43.5)
Variable [c]	1461 (21.1)	930 (20.6)	531 (22.1)
Compressed 9-80 work week [d]	1504 (21.7)	966 (21.4)	538 (22.4)
Compressed 4-40 work week [d]	261 (3.8)	168 (3.7)	93 (3.9)
Other	85 (1.2)	39 (0.9)	46 (1.9)
Number using transit as primary commute mode (6595, 4302, 2293)	1183 (17.9)	698 (16.2)	485 (20.1)
Number currently using transit but not primary commute mode (6595, 4302, 2293)	1098 (16.6)	664 (15.4)	434 (18.9)
Employer-provided free on-site parking (6575, 4289, 2286)	1618 (24.6)	1203 (28.0)	415 (18.2)
Employer-provided paid on-site parking (6575, 4289,2286)	1627 (24.7)	1164 (27.1)	463 (20.3)
Employer-provided reduced-rate transit passes (6575, 4289,2286)	4122 (62.7)	2639 (61.5)	1483 (64.9)
Employer-provided variable start/ end times (6575, 4289,2286)	4109 (62.5)	2725 (63.5)	1384 (60.5)

[a] 1=Some grade or high school; 2=High school graduate; 3=Some college or technical school; 4=Four-year college, university, or technical school graduate; 5=Some graduate school; 6=Completed graduate degree(s).
[b] Less than 35 hours per week.
[c] 7 ½ - 8 hours per day. Conventional: with a start time between 8:00 and 9:00 a.m.; variable: with a variable start time.
[e] 9-80: one day off every two weeks; 4-40: one day off every week

As shown in FIGURE 1, we applied three filters to the data at various points in the analysis. (1) We excluded the respondents who were out of the region for the entire week of the closure from the remainder of the analysis. However, it is a pertinent finding that some 5% of the sample (4.2% in Wave 1, 6.5% in Wave 2) left the region altogether during the closure. (On the other hand, only 0.87% of the total – 0.85% in Wave 1, and 0.91% in Wave 2 – did so because of the Fix; the rest did so for other reasons, e.g. planned summer vacations). (2) We additionally excluded (the small fraction of) respondents who did not commute to work during the closure week from the analysis of commuters' active choices for work-related trips (Section 5.1). (3) Finally, we further excluded respondents who already used transit for all their commuting trips from the model of the choice to increase transit use (Section 6).

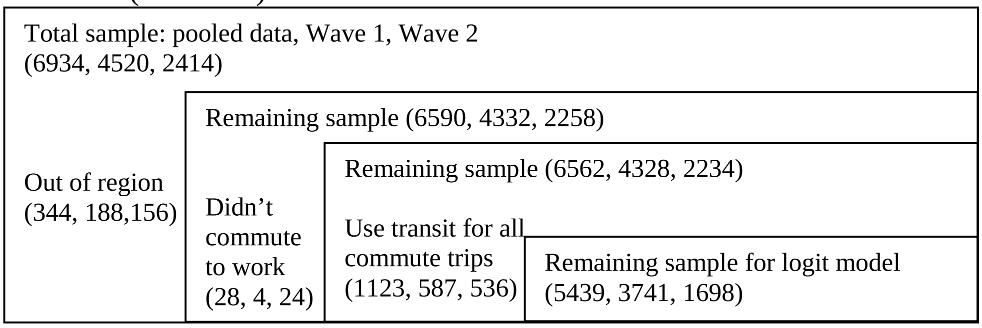

FIGURE 1 Data filters and remaining sample sizes for pooled data, Wave 1, and Wave 2

3.2 Survey Contents

The contents of the Wave 1 and Wave 2 surveys are nearly identical (aside from referring to different dates and directions of closure). There were four parts in each survey:

Part A collects information on "normal" (pre-Fix) work and commute patterns, including occupation, work schedule, commute distance and time, frequency of commuting, means of transportation used for commuting trips, etc.

Part B seeks information about travel changes made during the target week. Additionally, it explores whether those changes were made due to the Fix, or for some other reasons. Although this part of the survey includes several potential dependent variables of interest, the model of this study only focuses on the choice to increase transit use.

Part C explores the programs that were available to respondents, possible facilitators and barriers to changing commuting habits, and sources of information on Fix I-5.

Part D collects information on sociodemographic characteristics, including age, gender, household size, auto ownership, income, and education.

4 PASSIVE IMPACTS ON COMMUTERS

In this section, we focus on the passive impacts of the Fix I-5 project. We asked four questions regarding those impacts: a general question about travel conditions during the closure week, followed by three more detailed questions on the number of times they were delayed, number of times they arrived at a destination *more* quickly than usual, and number of times they had to take an unplanned detour during the closure week. Respondents who reported being out of the region during the entire week were excluded, leaving 6,590 respondents to answer these questions.

Turning first to the pooled data (TABLE 2), we see that the Fix certainly had an impact, but not a universal nor a uniform one. Around 47% of the sample reported that traffic conditions were worse for them during the closure week, and similar shares reported encountering delays and forced detours (generally on multiple occasions). But that leaves more than half the sample reporting that conditions were as good as (35%) or better than (18%) usual, and nearly a quarter reporting sometimes arriving at their destination *more* quickly than usual (again, generally on multiple occasions). Thus, it appears that the various coping strategies adopted by commuters actually improved conditions for some (whether those who themselves made changes, or those who benefitted from the changes made by others – presumably some of both), and to some extent helped compensate for the deterioration in conditions for others. Overall, the passive impacts of the Fix do not appear to be excessive.

Wave 1 and Wave 2 show some systematic differences in response, with Wave 1 reflecting stronger impacts. Compared to Wave 1, a smaller share of respondents in Wave 2 found travel conditions to be better than usual, while a larger share found them to be "about the same" as usual. Smaller proportions in Wave 2 than in Wave 1 also reported experiencing each of the three specific impacts. Thus, it appears that the effects of the Fix, both positive and negative, diminished over the course of the project.

TABLE 2 Passive Impacts, by Wave

Passive Impacts (sample sizes)	Pooled data N (%)	Wave 1 N (%)	Wave 2 N (%)	Average Number of Times (for those reporting this impact)	Pooled data	Wave1	Wave 2
Travel conditions (6547, 4300, 2247)[a]							
(1) Much worse	488 (7.5)	326 (7.6)	162 (7.2)				
(2)	926 (14.1)	594 (13.8)	332 (14.8)				
(3)	1645 (25.1)	1120 (26.0)	525 (23.4)				
(4) About the same	2289 (35.0)	1377 (32.0)	912 (40.6)				
(5)	460 (7.0)	335 (7.8)	125 (5.6)				
(6)	319 (4.9)	227 (5.3)	92 (4.1)				
(7) Much better	420 (6.4)	321 (7.5)	99 (4.4)				
Number reporting delays[b] (6553, 4300, 2253)	3016 (46.0)	2071 (48.2)	941 (41.8)	Occasions delayed	4	3.17	
Number reporting arriving more quickly[b] (6495, 4241, 2254)	1520 (23.4)	1125 (26.5)	395 (17.5)	Occasions arriving more quickly	4.09	4.01	4.31
Number reporting forced detours[b] (6552, 4297, 2255)	2894 (44.2)	2102 (48.9)	792 (35.1)	Forced detour occasions	3.93	3.96	3.83

[a] During the week of [June 2-8 or June 16-22] (Mon – Sun), how were travel conditions in the affected area for you?
[b] During the week of [June 2-8 or June 16-22] (Mon – Sun), on how many occasions …
… were you substantially delayed when travelling through the affected area, **because of Fix I-5?**
… did you arrive at your destination more quickly than usual when traveling through the affected area?
… were you forced to take a detour in the middle of your trip, **because of Fix I-5?**

5 COMMUTERS' ACTIVE CHOICES

As noted earlier, the term "active choices" refers to the behavior changes made to deal with the changes in travel conditions. In view of the significantly different natures of work- and non-work related trips (16, 17), we treat each category separately. Most of the questions on work-related trips deal specifically with commuting, but one asks about the use of teleconferencing to avoid traveling to work-related meetings.

5.1 Changes in Work-Related Trips

As discussed above, this portion of the analysis excludes all respondents who did not travel to work in the region at all during the week in question. The literature identifies a number of possible active choices that can be made in these circumstances (18-21). In the subsections below, we respectively discuss making fewer commute trips (via telecommuting, alternative work schedules, and/or vacation), changing commute mode, and other changes (departure time, route, and teleconferencing). For the first two categories, after asking about making each change, we also asked how many days the respondents performed each action, how well the choice worked for them, whether they had made that choice before, and how likely they were to continue the action after the Fix.

5.1.1 Making Fewer Commute Trips

Respondents were asked whether, during the closure week, they made "fewer commute trips than you normally would", with response options "Yes, because of Fix I-5", "Yes, for some other reason", and "No". We discuss only the changes made because of the Fix. About 14% of respondents made fewer commute trips (because of the Fix) during the closure week (see TABLE 3). Among those reporting fewer trips, about half achieved it by telecommuting, and about a fourth achieved it via each of compressed work week and taking some vacation days (multiple answers were possible). Interestingly, however, the share of respondents making fewer commute trips in Wave 2 (8%) is only about half that of those making fewer trips in Wave 1 (15%), suggesting that the motivation to change one's commute patterns is diminishing as the Fix progresses. Among those making fewer commute trips, similar proportions telecommute across both waves (47%), whereas Wave 2 shows a substantially smaller proportion of cases reporting compressed work week changes (22%) than in Wave 1 (28%), and a larger proportion of respondents reporting taking some vacation days (30%, compared to 24% in Wave 1).

It is desirable, of course, to estimate the overall shares of people using each means of making fewer commute trips during the Fix. However, our ability to do so is complicated by the fact that more than a third (315) of the 923 cases reporting making fewer commute trips did not state the means by which they did so. If we conservatively assume that those 315 cases represent mistaken responses to the initial question, and that *none* of them actually reduced their commuting, then we find, for example, that overall, 297/6552 = 4.5% increased their use of telecommuting, while 2.5% achieved the reduction by each of compressed work schedules and vacation days. On the other hand, if we assume that the 315 non-responses *all* reduced their commutes, distributed among the available means in the same proportions as those who responded, we can estimate the share of those increasing telecommuting to be 47.4% of the 14.1% reporting making fewer commute trips, i.e. 6.7%. Similarly, reducing commute trips via compressed work schedules and taking vacation days would have been adopted by 3.7% each. The true shares are likely to be enclosed by these two extremes, and if we use the midpoints of the ranges as our best guess, we find that increased telecommuting, compressed work schedules, and vacation days are adopted by about 5.6%, 3.1%, and 3.1%, respectively.

TABLE 3 Commuters' Active Choices, by Wave

Number Making these Choices (sample sizes)	**Pooled data N (%)**	**Wave 1 N (%)**	**Wave 2 N (%)**	**Average Number of Times (by those who made this choice)**	**Pooled data**	**Wave 1**	**Wave 2**
Work related trips				***Work related trips***			
Made fewer commute trips (6552, 4328, 2224)	923 (14.1)	665 (15.4)	258 (8.0)				
Made fewer work-related trips (6552, 4328, 2224) [a]	3 (0.1)	0 (0.0)	3 (0.1)				
Made fewer trips, trip purpose not specified (6552, 4328, 2224) [b]	36 (0.5)	12 (0.3)	24 (0.7)				
Means of avoiding the commute trips (627, 406, 221) [c]				Means of avoiding the commute trips (433, 333, 100)	2.63	2.84	1.91
Telecommuted	297 (47.4)	193 (47.5)	104 (47.1)	Days avoided commuting by telecommuting (290, 193, 97)	2.17	2.28	1.94
Adopted compressed work week	163 (26.0)	114 (28.1)	49 (22.2)				
Took some vacation	165 (26.3)	99 (24.4)	66 (29.9)	Days avoided commuting by compressed work week (157, 114, 43)	2.92 [d]	3.30 [d]	1.93
Other	2 (0.3)	0 (0.0)	2 (0.9)				
Missing responses for means of avoiding the commute trips[f] (923, 665, 258)	315 (34.1)	258 (38.8)	57 (22.1)	Days avoided commuting by taking vacation (99, 99, 0)	1.80	1.80	N/A [e]
Teleconferenced (6468, 4264, 2204)	203 (3.1)	140 (3.3)	63 (2.9)	Trips avoided by teleconferencing	2.34	2.31	2.41
Avoided rush hour (5506, 3326, 2180)	2642 (48.0)	1677 (50.4)	965 (44.3)	Days avoided rush hour	3.90	3.89	3.92
Changed route (5254, 3352, 1902)	2371 (45.1)	1640 (48.9)	731 (38.4)	Days changed route	3.44	3.46	3.38
Non-work related trips				***Non-work related trips***			
Changed location (6098, 3892, 2206)	1302 (21.4)	890 (22.9)	412 (18.7)	Times changed location	2.62	2.53	2.82
Changed route (6325, 4119, 2207)	2768 (43.8)	1951 (47.4)	817 (37.0)	Times changed route	2.85	2.92	2.68
Changed the day activity was conducted (6316, 4121, 2195)	1160 (18.4)	820 (19.9)	340 (15.5)	Times changed the day	2.47	2.43	2.56
Changed the time activity was conducted (6300, 4105, 2195)	1370 (21.7)	990 (24.1)	380 (17.3)	Times changed the time	3.15	3.16	3.14
Used internet instead (2191, N/A, 2191)	142 (6.5)	N/A	142 (6.5)	Times used internet instead	3.21	N/A	3.21
Canceled the activity (6290, 4099, 2191)	1342 (21.3)	960 (23.4)	382 (17.4)	Times canceled the activity	2.53	2.45	2.74

[a] The survey directly asked about changes to commute trips and to non-work trips, but not about changes to (non-commute) work trips (such as business meetings). The responses reported here were obtained from write-in descriptions to the "other (please specify)" option on the commute reduction question described in footnote c. As such, they certainly understate the actual level of changes made to non-commute work trips in the sample, and are included here only for completeness.

[b] These responses were also write-ins to the "other (please specify)" option on the commute reduction question.

[c] During the week of [June 2-8 or June 16-22] (Mon-Sun)… … , how did you avoid the commute trips that you would have otherwise made? (Options: Telecommuted to work; Adopted a compressed work week; Took vacation time; Other). Categories are not mutually exclusive.

[d] This unexpectedly high average suggests that a number of respondents failed to read the word "avoid" in the question ("how many days did you avoid physically travelling to and from work by …"), and responded with the number of days they commuted to work. The same could be true of the telecommuting and vacation strategies, as well.

[e] N/A: Not asked.

[f] Cases which reported they made fewer commute trips but did not indicate how they avoided the commute trips.

Telecommuting is a TDM strategy which has been promoted by transportation and environmental agencies in the United States and elsewhere (22, 23). However, it is known to have disadvantages as well as advantages (24), so it is of interest to assess how the experience was perceived by those who adopted (or increased) it during the Fix. Only a few respondents who used it felt that it worked poorly or very poorly for them: 2.1% of the 192 respondents who had ever telecommuted before and 6.3% of the 98 who had not (results not tabulated, to conserve space). However, people who had telecommuted before were also more inclined to continue it: among the 51 who were currently already telecommuting (and simply increased it during the Fix), 58.8% indicated being very likely to continue – compared to 50.5% among the 117 who had used it before but were not currently telecommuting, and only 20.6% among those who had not telecommuted before.

The results are similar for compressed work schedules. About half of the 75 respondents who had tried compressed work schedules before were very likely to continue to adopt them and only 1.4% of those who had tried them before reported that they felt it worked poorly or very poorly for them. By contrast, only about a third of the 78 respondents who had not tried compressed work schedules before were very likely to continue them, even though only 3.9% felt it did not work well for them.

5.1.2 Changing Modes

Respondents were asked whether, during the closure week, they traveled "to or from work using a different means of transportation than you normally would", with the same response options as in Section 5.1.1. Again, we analyze only the changes made because of the Fix. Respondents reporting such changes were then asked which mode(s) they used on more occasions than normal (multiple answers were possible). Similarly to the strategies involving reducing commute trips (telecommuting, compressed work week, and vacation), we also want to know the overall shares of people changing their use of each mode. Applying the same approach discussed in Section 5.1.1 to the 117 people who report changing their mode usage but did not indicate which mode(s) they changed, we find the following (lower – upper) bounds: 4.6 – 6.1% increased their use of transit, 0.5 – 0.6% increased driving alone, 1.3 – 1.5% increased carpool or vanpool use, and 2.3 – 2.7% increased walking or biking. Taking the midpoints of those ranges as our best guess, we find that increased transit, driving alone, carpooling or vanpooling, and walking or biking are adopted by about 5.4%, 0.6%, 1.4%, and 2.5%, respectively. Thus, increasing transit use was the most common mode change, adopted by 68.2% of those who altered their commute mode patterns.

After the question regarding which mode(s) they used on more occasions than normal, respondents were asked what they would have ordinarily done on those days (again, multiple answers were possible). TABLE 4 crosstabulates the results, for the pooled sample. The vast majority (92.9%) of those making commute mode changes increased their use of more sustainable modes, most often at the expense of driving alone. For example, 69.9% of those who increased their transit use would otherwise have driven alone to work.

TABLE 4 Commute Mode Changes due to Fix I-5 (Pooled Data)

Ordinarily used instead	Increased use during (& because of) Fix I-5 [a]									
	Drive alone		***Car or vanpool***		***Walk or bike***		***Transit*** [b]		***Row total respondents***	***Row total responses***
	N (Row %)	***Column %***	***N (Row %)***	***Column %***	***N (Row %)***	***Column %***	***N (Row %)***	***Column %***		
Drive alone	0 (0.0)	0.0	59 (17.4)	71.1	108 (31.9)	72.0	235 (69.3)	69.9	339	402
Carpool or vanpool	10 (12.7)	28.6	2 (2.5)	2.4	13 (16.5)	8.7	67 (84.8)	19.9	79	92
Walk or bike	0 (0.0)	0.0	1 (33.3)	1.2	0 (0.0)	0.0	3 (100.0)	0.9	3	3
Transit [b]	23 (26.4)	65.7	19 (21.8)	22.9	27 (31.0)	18.0	25 (28.7)	7.4	87	94
Other [c]	2 (16.7)	5.7	2 (16.7)	2.4	2 (16.7)	1.3	6 (50.0)	1.8	12	12
Column total cases	35	100.0	83	100.0	150	100.0	336	100.0	493	603

[a] An initial question about whether the respondent "traveled to or from work using a different means of transportation than you normally would" (because of the Fix) was followed by questions asking which modes were increased, and which were decreased. The specific wording of the latter two questions was: "During the week of [June 2-8 or June 16-22] (Mon-Sun)… … which did you use on more occasions than you normally would have?" and "What would you ordinarily have done on those days, instead of commuting by [the indicated mode(s)]?" The table includes only cases which answered both follow-up questions, which constitutes 80.8% of the 610 cases answering the initial question in the affirmative. Multiple answers to both follow-up questions were possible; *all percents in the table are calculated on the basis of respondents (e.g. 493 total respondents), not responses (603 total reported mode changes),* and therefore may not sum to 100. However, no one except transit users (see note b) reported replacing more than one ordinarily-used mode, so in columns for the first three modes, respondents and responses are equal.

[b] "Transit" includes bus, light rail, and Amtrak, which are not mutually exclusive. Thirty-six cases which reported increasing the use of two transit modes were counted twice in the "Transit" column (so that the 336 responses in this column correspond to 300 respondents), and 4 cases which reported using two different transit modes as their ordinary commute mode also were counted twice in the "Transit" row. In both instances they are multiply-counted as responses, but only once as respondents.

[c] "Other" includes telecommuting.

Given that the freeway closure motivated some commuters to change their travel habits and try a new mode (18), we are interested to know more details about those commuters and their experience. Due to space limitations, we focus on the most common mode change – increasing transit – and briefly summarize some key descriptive results for the pooled data. Among the 224 respondents who increased transit use during the closure week and answered the follow-up questions about the experience, only 8.9% felt that it worked poorly or very poorly for them. Thus, it seems that using transit was largely a positive experience for those who took it during the Fix. With respect to likelihood of continuation, a sizable fraction of respondents who increased their transit use reported being "very likely" to continue commuting by transit, but that fraction differed considerably depending on prior history. Among the 148 who were currently already using transit to commute (and simply increased their use during the Fix), 51.4% indicated being very likely to continue, but among the 52 who had used it before but were not currently commuting by transit, that figure was 34.6%, and among the 13 who had never used transit before, no one was very likely to continue. Thus, it seems that the overall proportion of commuters who both increased their use of sustainable modes during the Fix and are likely to maintain that change beyond the Fix is relatively small – around 2%, in the case of transit. Nevertheless, the composite outcome of a number of such small effects could be sizable.

5.1.3 Other Changes

The active choices discussed so far are considered to be potentially somewhat costly (in a generalized sense of the word), in that they may require lifestyle adjustments (e.g. conforming one's work hours to a transit schedule, enforcing self-discipline to work at home) and/or affect other people (e.g. household members, co-workers) (25). By contrast, the remaining changes shown in TABLE 3 are considered relatively low-cost, entailing minimal change to established patterns. Accordingly, a number of studies have found such changes to be the most common responses to increasing congestion or disrupted commute patterns (26), and the present analysis is no exception. Nearly half the respondents reported making a special effort to avoid rush hour during the closure week (on an average of four days out of the week), and 44% of those driving/carpooling to work that week reported making planned changes to their commute route (on an average of 3.4 days). Again, the motivation to make these changes appears to diminish as the Fix continues, with marked decreases between Waves 1 and 2 in the shares doing them.

Teleconferencing is often touted as a way to reduce work-related travel, especially when conditions are disrupted (27). Apparently its adoption is still not widespread, however – at least in our sample, only about 3% of respondents took advantage of this strategy, avoiding an average of 2.3 trips each.

Altogether, 60.0% of respondents in the pooled sample made at least one of the active changes analyzed in Section 5.1. Interestingly, this proportion remained relatively stable across waves: 61% in Wave 1, and 58% in Wave 2.

5.2 Changes in Non-work Related Trips

TABLE 3 also includes descriptive statistics on commuters' active choices with respect to non-work trips. Five questions in Wave 1 respectively asked respondents how many times they changed the location, changed the route, changed the day or the time of day they performed a non-work activity, and did not do a non-work activity at all because of the Fix. Wave 2 added a sixth question that asked how many times respondents used the internet to do a non-work activity instead of traveling to it because of Fix I-5.

Among these six active choices for non-work related trips, the most popular option was changing the route to avoid the Fix I-5 area, exercised by about 44% of eligible respondents. Changing the location or the time of an activity, or canceling it altogether, were each adopted by more than a fifth of the eligible respondents, while nearly that many (18%) changed the day on which an activity was conducted. The least common option was internet substitution for traveling to an activity, exercised by just 6.5% of (Wave 2) respondents. In all of these cases, those who exercised a given option did so an average of 2.5 – 3.2 times during the closure week.

Similar to the results for the passive impacts, proportionally fewer commuters made active changes in Wave 2 than in Wave 1. Interestingly, however, those who adopted a non-work strategy in Wave 2 did so on a similar or greater number of occasions, on average, compared to their Wave 1 counterparts.

6 "INCREASE TRANSIT USE" MODEL

Although it is helpful to see descriptive statistics on how commonly various changes were made, it is also desirable to better understand the types of people who make a given change. This is perhaps best done in the context of a model (as opposed to crosstabulations), in which multiple covariates can be controlled for simultaneously. Space does not permit providing models for all the changes we see in our sample, but we choose to present a model for the most common mode change that reduces vehicle travel, namely the choice to increase the use of transit for commuting.

The dependent variable is created from the survey question which asks (of those who previously indicated traveling to or from work using a different means of transportation during the closure week than they normally would, because of the Fix), "During the week of … which did you use on more occasions than you normally would have?" with seven possible response options: "Carpool or vanpool", "Bus", "Light rail", "Amtrak train", "Walking or biking", "Driving alone", and "None of the above". In our model, we combine "Bus", "Light rail" and "Amtrak train" into a single "transit" variable, equal to 1 if respondents selected any of those modes, and 0 otherwise. In addition to our previous filter excluding respondents who were out of the region for the entire week or did not travel to work any days that week, we also excluded from our model respondents who already take transit for all of their commute trips, since in none of these cases would increasing transit use be a feasible option. After this additional filter, 5439 cases were left, including 287 (5.3%) who increased their transit use due to the Fix (this differs from the 300 cases mentioned in footnote b of Table 4, due to the additional filter: 13 cases reported increasing their transit use due to the Fix, but also reported that they already use transit for all of their commute trips). As described in the "Survey Contents" section, a number of potential explanatory variables are available, including sociodemographic traits and the availability of various employer-based commute modification instruments such as preferred parking for car/vanpools and reduced-rate transit passes.

Due to missing data, our preferred model (**TABLE 5**) has 205 (4.6%) respondents who increased their transit use during the closure week and 4251 who did not. The ρ^2 goodness-of-fit measure (28), with the equally-likely model as base, is 0.770, which, taken at face value, is considered quite good in the context of disaggregate discrete choice models. With shares this unbalanced, however, the market-share model alone (the model containing just the constant term) has a ρ^2 value of 0.731, initially suggesting that the true explanatory variables only add 0.039 to the goodness of fit. On the other hand, when we re-estimate the same model except without the constant term (not shown), we find a ρ^2 value of 0.713, which indicates that most (93%) of the explanatory power of the model lies in the "true" variables. That is, the true variables are substantively helping to explain *why* the shares are so unbalanced.

TABLE 5 Binary Logit Model of Increased Transit Use, Pooled Data (1=Increased transit use, 0=Did not increase transit use)

Variable Name	Model	
	Coefficient	***P-value***
Constant	-4.628	0.000
Sociodemographics		
Female (dummy variable – DV)	0.452	0.007
Household size	0.199	0.000
Live in neighborhood with a lot of retail/ commercial within a 10 minute walk (DV)	-0.673	0.046
Mode usage		
Transit is primary commute mode (DV)	1.255	0.000
Currently uses transit but is not primary mode (DV)	2.066	0.000
Employer-provided Commute Strategies		
Free on-site parking (DV)	-0.466	0.028
Paid on-site parking (DV)	-0.546	0.003
Reduced-rate transit passes (DV)_	0.725	0.000
Variable start/end times (DV)	-0.303	0.052
Valid number of cases, N	4456 (yes: 205; no: 4251)	
Final log-likelihood, $LL(\beta)$	-711.817	
Log-likelihood for market share model, $LL(MS)$	-831.405	
Log-likelihood for equally-likely (EL) model, $LL(0)$	-3088.664	
No. of explanatory variables, K (including constant)	10	
$\rho^2_{ELbase} = 1 - LL(\beta)/LL(0)$	0.770	
Adjusted $\rho^2_{ELbase} = 1 - [LL(\beta) - K]/LL(0)$	0.766	
$\rho^2_{MSbase} = 1 - LL(\beta)/LL(MS)$	0.144	
$\rho^2_{MS} = 1 - LL(MS)/LL(0)$	0.731	
χ^2 (between the final model and the EL model)	4753.694	
χ^2 (between the final model and the MS model)	239.176	

Nine variables besides the constant are retained in the model: two mode usage variables, four employer strategies, and three sociodemographic variables. We discuss each of these in turn.

We hypothesized that people who already used transit to some extent would be more likely to increase their use of it than others would be to start using it. Accordingly, we tested several indicators of transit use. Two dummy variables, marking those who use transit as their primary commute mode (defined as respondents who use transit on at least as many commute days as they do any other commute mode in a typical month) and those who currently use transit but do not have it as their primary commute mode, are strongly significant and positive, as expected. Our interpretation is that people who currently use transit are familiar with the schedule, stop/station locations, and riding experience, and would therefore find it easier to step up their use. By contrast, nonusers may have erroneous impressions of transit, e.g. an overestimation of commute time (3), or may have simply decided it is not practical for them, while those who already use transit as their primary commute mode have little room to increase their use. The impact of transit being the primary mode is weaker (coefficient 1.26) than that of transit being currently used but not the primary commute mode (coefficient 2.07). The interpretation is that those who are already using transit as their primary commute mode have less room to increase their transit use than those who currently use transit but not as their primary mode.

We believe it is valuable to realize that it may be more effective to try to persuade current transit users to increase their use than to try to convince nonusers to switch – although we recognize that both potential markets are important. On the other hand, it could also be argued that including user history variables such as these two is not as insightful as identifying the "first principles" that influence whether one *does* currently use transit or not, and including those in the model instead. Thus, we also tested excluding these two variables from the model (results not shown). When we did so, all other variables remained significant, and the ρ^2 value was 0.74, a goodness of fit not much lower than that of our selected model. Accordingly, we view these variables as incrementally informative, but they are by no means having an undue influence on the model.

Four employer-provided commute strategies are significant in the model, all with expected signs: employer provision of reduced-rate transit passes increases the probability of using transit more during the Fix, while free on-site parking, paid on-site parking, and the availability of flextime decreases it. The free on-site parking variable is consistent with previous studies showing that free worksite parking discourages transit use (29-31), but our model also suggests that even paid parking, if it is conveniently located on-site, has a similar deterrent effect in this context. The interpretation of the flextime result is that if people can change their departure times to avoid congestion caused by the Fix, then their current commute mode (most often the automobile) may remain viable.

Finally, three sociodemographic traits are also significant in the model. The gender variable indicates that women are more likely than men to increase transit use, consistent with other evidence (32-34) finding women to be more likely to use transit in general. The positive coefficient of household size was initially unexpected, but is also saying something meaningful. We assume that people in larger households have more complex activity-travel patterns, and therefore our original expectation was that commuters in such households would be more likely to find the car to be most practical, and more likely to stick with the car. However, further reflection and responses to open-ended questions of the survey suggest another possibility. It may be that the more complex patterns of larger households are more vulnerable to disruption, and have less ability to absorb a disruption without much change. Thus, commuters in larger households may have a greater *need* to change than those in single- or two-person households, while at the same time, there might be more limitations on the ability of such commuters to choose certain other actions such as changing route or departure time. The speculation that larger households are more susceptible to disruption in general found some support in our data. Specifically, based on independent-samples t-tests of whether mean household size differed with other commute pattern changes, we found that *most* of the changes we studied are associated with larger household sizes, including telecommuting, taking vacation (both statistically significant), adopting compressed work schedules, increasing car/vanpool use, and increasing driving alone (but not increasing bike/walk). Nevertheless, we also tested excluding household size from the model; there were some small differences between the two models but the one including household size had a better overall fit than the one excluding it. So we decided to retain household size.

Similarly, the negative coefficient for living in a denser/mixed-use residential neighborhood may at first seem counterintuitive (we tested each of the levels of the "Residential neighborhood" variable shown in Table 1, both as individual dummy variables, and as a single ordinal variable excluding "other"), since conventional wisdom holds that living in a denser mixed-use neighborhood is associated with *greater* transit use. In our sample, however, existing (pre-Fix) transit commute shares are similar across neighborhood types, and even somewhat higher among those living in lower-density areas (30.5% for those living in purely residential neighborhoods and 32.6% for those living in very low-density areas) than among those living in the densest/most mixed-use areas (29.3%). However, the latter group also has the highest shares of walking/biking to work (22.8%, compared to 9.0% and 4.2% for the lower-density categories, respectively). *Transit* achieves its highest share, then, for the *medium-density/mixed-use* neighborhoods (33.3% for those living near “some” retail/commercial activity, compared to 14.7% for walking/ biking in those neighborhoods), losing share in the denser areas to walking/biking, and in the less dense areas to cars. With that as the baseline pattern, then, and keeping in mind that this is a model for *incrementally increasing* the use of transit (although including those who were not otherwise using it right before the Fix), it is perhaps not surprising that those living in lower-density, more purely residential environments are more likely than others to increase their use of transit: those living in more conducive environments are more likely either to have already maximized their transit use to the extent practical, or to have found walking/biking to be more practical than transit.

This is a somewhat encouraging result, suggesting that there *is* room to increase transit commuting even when the residential neighborhood is not stereotypically conducive to it. We also had variables representing the walking time to the nearest bus stop/rail station (shown in Table 1), and found a similar relationship when they were allowed to enter the model: the farther the distance to the nearest transit node, the more likely the respondent was to increase her transit use. Using the density/mixed-use variable in Table 5 resulted in a better significance and goodness of fit, so we chose to retain it rather than the distance variables (the ordinal forms of the residential neighborhood and distance-to-transit variables were strongly correlated, at -0.659).

It is pertinent to mention the variables that were *not* significant in the model, as well as those that were. Besides the variables just discussed, we tested a number of other variables, including work schedule type (part-time, conventional, flexible, compressed), occupation, commute time and distance, income, number of vehicles per household member and per licensed driver, and a geographically-based indicator of how strongly the respondent’s commute might have been affected by the Fix. However, none of these variables were significant in the final model.

7 SUMMARY AND SUGGESTIONS FOR FUTURE RESEARCH

This study analyzed passive impacts on commuters of the Fix I-5 reconstruction project, and their active choices to mitigate those impacts. Two waves of surveys were implemented (for this study, effectively constituting repeated cross-sections), during successive closures of all lanes in one direction (southbound and northbound, respectively) of the interstate highway. The two subsamples have similar characteristics on key variables such as gender, age, educational level, and income.

The passive impacts during the Fix do not appear to be excessive. It appears that the various coping strategies adopted by commuters actually improved conditions for some, and to some extent helped compensate for the deterioration in conditions for others. However, the two waves show some systematic differences in response, with Wave 1 reflecting stronger impacts (both positive and negative). It appears that the effects of the Fix, both positive and negative, diminished over the course of the project.

Among the active changes to commute trips, the easiest options (such as avoiding rush hour and changing route) were the most common responses (adopted by 48% and 44%, respectively) – a result supported by several other studies. Among the active changes that reduce the number of commute trips made, our best estimate is that about 5.6% of the total eligible respondents increased telecommuting, and about 3.1% each increased their use of compressed work schedules and vacation days because of the Fix. Commute mode changes were made by 7.8% of the eligible sample, including increasing transit (5.4%), increasing walking or biking (2.5%), increasing car/vanpooling (1.4%), and increasing driving alone (0.6%). Thus, the vast majority (94%) of those making mode changes increased their use of more sustainable modes, most often at the expense of driving alone. Altogether, 60.0% of eligible respondents made at least one of these active changes to their commute.

Focusing on the most common mode change, using transit was apparently a largely positive experience for those who tried it during the Fix: only 9% of those increasing their use of transit felt that it worked "poorly" or "very poorly" for them. On the other hand, only about 44% of those who increased their transit use report being "very likely" to continue after the Fix, including none of the (13) brand-new transit users. Thus, it seems that the amount of permanent new transit ridership generated by the Fix is relatively small.

A binary logit model was built to better understand the choice to increase transit use during the Fix. Nine variables appear in the model: two relating to mode usage, four marking employer commute policies, and three sociodemographic traits. Despite the unbalanced shares (4% / 96%), the true explanatory variables in the model account for a considerable portion (about 71%) of the information in the data. The significance of dummy variables for those who currently use transit in their commute suggests that persuading current transit users to increase their use may be easier than convincing nonusers to switch to transit. The employer's subsidy of transit naturally supports increasing its use, while provision of on-site parking – interestingly, whether free *or* paid – and variable start/end times discourage increasing transit use. The latter result in particular illustrates the conflict that sometimes arises among policy instruments: making work hours more flexible is considered beneficial for reducing congestion and for balancing work and family needs, but the increased flexibility in avoiding peak-period congestion may enhance the appeal of continuing to commute by driving alone. Finally, women and (counter to expectation) those in larger households and in lower-density single-use residential areas were more likely to increase their transit use. The result for households appears to reflect a greater vulnerability to disruption of the complex activity patterns in larger households, with the result that commuters in such households have a stronger impetus to make *any* change when disruption occurs. The result for neighborhood density/mixture suggests that those living in more "transit-conducive" environments are more likely to have already maximized their transit use to the extent practical, but also suggests that there *is* room to increase transit commuting even when the residential neighborhood is not stereotypically conducive to it.

Several directions for future research are indicated. Using the same data set, we can model not only other behavioral changes beyond the one explored here (increased transit use), but also the reported likelihood of continuing to use a strategy adopted (or increased) during the Fix. With the addition of geocoded home and work location information (for those who reported nearby street intersections), we can explore a number of geographic relationships with observed outcomes. Ultimately, we will be merging the attitudinal and behavioral data collected in Wave 3 with Waves 1 and 2, to provide a rich basis from which to further investigate the persistence of behavioral changes prompted by the Fix.

8 ACKNOWLEDGMENTS

Data collection was funded by a grant from the California Air Resources Board. Kristin Lovejoy, Laura Poff, and Julia Silvis were essential to the design and administration of the survey, and in initial data handling and analyses. Ryan Huang, Calvin Iwan, Charmine Solla, and Aayush Thakur provided invaluable assistance in data cleaning. The first author was supported by a fellowship under the State Scholarship Fund in P. R.China. The third author was partially supported by a fellowship from the Sustainable Transportation Center at the University of California Davis, which receives funding from the U.S. Department of Transportation and Caltrans, the California Department of Transportation, through the University Transportation Centers program. The comments of several anonymous reviewers have improved the paper.

REFERENCES

1. *Governor Schwarzenegger Issues Executive Order to Help Ease Congestion During Fix I-5 Project*. GAAS:258:08, http://gov.ca.gov/index.php?/press-release/9631/. Accessed April 9, 2009.
2. Gardner, B. Modelling Motivation and Habit in Stable Travel Mode Contexts. *Transportation Research Part F,* Vol. 12, 2009, pp. 68-76.
3. Fujii, S., T. Gärling, R. Kitamura. Changes in Drivers' Perceptions and Use of Public Transport During a Freeway Closure: Effects of Temporary Structural Change on Cooperation in a Real-Life Social Dilemma. *Environment and Behavior,* Vol. 33, 2001, pp. 796-808.
4. Devine, S. A., J. A. Bucci, D. J. Berman. Traffic Management During the I-195 Providence River Bridge Repair Project. In *Transportation Research Record*, No. 1360, Transportation Research Board, Washington, D.C., 1992, pp. 1-3.
5. Hendrickson, C. T., R. E. Carrier, T. J. Dubyak, R. B. Anderson. Traveler Response to Reconstruction of Parkway East (I-36) in Pittsburgh. In *Transportation Research Record*, No. 890, Transportation Research Board, Washington D.C., 1982, pp. 33-39.
6. Meyer, M. D. Reconstructing Major Transportation Facilities: The Case of Boston's Southeast Expressway. In *Transportation Research Record*, No. 1021, Transportation Research Board, Washington D.C., 1985, pp. 1-9.
7. Nam, D., J. Lee, P. Dunston, F. Mannering. Analysis of the Impacts of Freeway Reconstruction Closures in Urban Areas. In *Transportation Research Record*, No. 1654, Transportation Research Board, Washington D.C., 2007, pp. 161-170.
8. Giuliano, G., J. Golob. Impacts of the Northridge Earthquake on Transit and Highway Use. *Journal of Transportation and Statistics*, 1998, pp. 1-20.
9. Hunt, J. D., A. T. Brownlee, K. J. Stefan. Response to Centre Street Bridge Closure: Where The "Disappearing" Travellers Went. In *Transportation Research Record*, No. 1807, Transportation Research Board, Washington D.C., 2002, pp. 51-58.
10. Tsuchida, P., L. Wilshusen. *Studies on the Loma Prieta Earthquake No. 4*. Berkeley, CA. University of California Transportation Center, 1991.
11. Dahlstrand, U., A. Biel. Pro-Environmental Habits: Propensity Levels in Behavioral Change. *Journal of Applied Social Psychology,* Vol. 27, No. 7, 1997, pp. 588-601.
12. Gärling, T., S. Fujii, O. Boe. Empirical Tests of a Model of Determinants of Script-Based Driving Choice. *Transportation Research F: Traffic Psychology and Behavior,* Vol. 4, 2001, pp. 89-102.
13. Brownstone, D. Multiple Imputation Methodology for Missing Data, Non-Random Response, and Panel Attrition. *Theoretical Foundations of Travel Choice Modeling*. Amsterdam, Elsevier, 1998, pp. 421-449.
14. Babbie, E. *The Practice of Social Research*. Wadsworth Pub. Co., Belmont, CA, 1998.
15. Caldwell, C. The Pink Recovery: Men Are Paying a Higher Price in This Recession Than Women. Perhaps That's Fair. *Time*, 2009, pp. 21.
16. Agarwal, A. *A Comparison of Weekend and Weekday Travel Behavior Characteristics in Urban Areas*. Florida, University of South Florida, 2004.
17. Aguiléra, A., M.-H. Massot, L. Proulhac. Exploring the Relationships between Work and Travel Behavior on Weekdays: An Analysis of the Paris Region Travel Survey over 20 Years. *Presented at 88th Annual Meeting of the Transportation Research Board*,Washington D.C., 2009.
18. Gärling, T., D. Eek, P. Loukopoulos, S. Fujii, O. Johansson-Stenman, R. Kitamura, R. Pendyala, B. Vilhelmson. A Conceptual Analysis of the Impact of Travel Demand Management on Private Car Use. *Transport Policy,* Vol. 9,

2002, pp. 59-70.

19. Giuliano, G. Transportation Demand Management. *Journal of the American Planning Association,* Vol. 58, No. 3, 1992, pp. 327-342.

20. Möser, G., S. Bamberg. The Effectiveness of Soft Transport Policy Measures: A Critical Assessment and Meta-Analysis of Empirical Evidence. *Journal of Environmental Psychology,* Vol. 28, 2007, pp. 10-26.

21. Shiftan, Y., J. Suhrbier. The Analysis of Travel and Emission Impacts of Travel Demand Management Strategies Using Activity-Based Models. *Transportation,* Vol. 29, 2002, pp. 145-168.

22. Mokhtarian, P. L. Telecommuting and Travel: State of the Practice, State of the Art. *Transportation,* Vol. 18, No. 4, 1991, pp. 1-22.

23. Mokhtarian, P. L., I. Salomon. Modeling the Desire to Telecommute: The Importance of Attitudinal Factors in Behavioral Models. *Transportation Research Part A,* Vol. 31, No. 1, 1997, pp. 35-50.

24. Mokhtarian, P. L., I. Salomon. Modeling the Choice of Telecommuting: Setting the Context. *Environment and Planning A,* Vol. 26, 1994, pp. 749-766.

25. Salomon, I., P. L. Mokhtarian. Coping with Congestion: Understanding the Gap between Policy Assumptions and Behavior. *Transportation Research Part D,* Vol. 2, No. 2, 1997, pp. 107-123.

26. Mokhtarian, P. L., E. A. Raney, I. Salomon. Behavioral Response to Congestion: Identifying Patterns and Socio-Economic Differences in Adoption. *Transport Policy,* Vol. 4, No. 3, 1997, pp. 147-160.

27. Denstadli, J. M. Impacts of Video Conferencing on Business Travel: The Norwegian Experience. *Journal of Air Transport Management,* Vol. 10, 2004, pp. 371-376.

28. Ben-Akiva, M., S. R. Lerman. *Discrete Choice Analysis: Theory and Application to Travel Demand*. The MIT Press, Cambridge, Massachusetts, 1985.

29. Shoup, D. C. Employer-Paid Parking: The Problem and Proposed Solutions. *Transportation Quarterly,* Vol. 46, No. 2, 1992, pp. 169-192.

30. Shoup, D. C. Evaluating the Effects of Cashing out Employer-Paid Parking: Eight Case Studies. *Transport Policy,* Vol. 4, No. 4, 1997, pp. 201-216.

31. Hess, D. B. Effect of Free Parking on Commuter Mode Choice. In *Transportation Research Record*, No. 1753, Transportation Research Board, Washington D.C., 2001, pp. 35-42.

32. Johansson-Stenman, O. Estimating Individual Driving Distance by Car and Public Transport Use in Sweden. *Applied Economics,* Vol. 34, 2002, pp. 959-967.

33. Hanlon, S. Where Do Women Feature in Public Transport? In *Women's Travel Issues Second National Conference*, Australia, 2000, pp. 648-662.

34. Pisarski, A. Commuting in America III: The Third National Report on Commuting Patterns and Trends. *Transportation Research Board of the National Academies of Science,* Vol. Washington, DC, 2006.