PROCEEDINGS OF THE 42ND ANNUAL MEETING OF THE TRANSPORTATION RESEARCH FORUM

Annapolis, MD
November 29 - December 1, 2000

Estimating the Cost of Travel: Evidence from the State Route 91 in California

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November 1, 2000

Abstract

This paper studies a number of commuters' traveling choices using survey and loop data. From their revealed choices of tolled or untolled lanes on State Route 91 in California, the values of travel time and reliability are derived; the former is about 52% of one's gross wage rate whereas people are clearly more aversive to travel time uncertainty: the value of reliability is about 150% of that of travel time savings. The results show that income is the most important factor whether one purchases an electronic transponder to use the tolled lanes or not; males are found less likely to use the tolled lanes.

*Work in this paper is financially supported by the University of California Transportation Center. I would like to thank David Brownstone for lending me the WESMLE code, Jia Yan for his assistance and helpful comments; I'm especially grateful to my thesis advisor, Professor Kenneth Small, for his invaluable advice. All errors are strictly mine.

1 Introduction

This paper studies people's travel behavior using survey and loop data; one of the objectives is to estimate those key parameters in the travel cost function presented in earlier chapter. A variety of choice models will also be attempted, among which, the value of travel time and variability will be obtained from estimations of people's route and time-of-day choice. These estimates will also be used for calibration in the simulation model in next chapter.

Voluminous studies have been dedicated to estimate people's valuations of travel time and travel time reliability, no consensus has yet been reached. While the estimate of value of travel time ranges between 20% and 100% of one's gross wage rate, for practical purpose, it is generally accepted as 50% of one's wage rate (Small [1992]). This disparity of estimates may be ascribed to the paucity and quality of the data; most of earlier studies used either data of travelers' mode choice in which travelers' unobservable disutility for certain mode of transport may bias the estimates; others using Stated Preference (SP) data may be vulnerable to problems such as framing of questions (Kroes and Sheldon [1988], Wardman [1988])

The measurement of value of travel time reliability is further hampered by the difficulty of presenting its concept in a manner understandable to the lay men but precise enough for research purpose. As a result, most studies use SP data; the travel time uncertainty is usually defined as the standard deviations from the mean travel time. These studies find that people are willing to pay more to reduce travel time uncertainty than to save travel time.

This paper aims to contribute to the literature in following aspects:

First, this study employs a survey data on commuters using the State Route 91 in California or SR91; in 1995, four 10-mile toll lanes (Express Lanes), two on each direction, were built in the median of the highway to ease the heavy traffic between Riverside and Orange Counties; entrances and exits are only located at either end of the roadway. Toll, which varies time of day according to a predetermined toll schedule, is deducted from drivers' accounts electronically for each usage through a transponder tagged on the screen of drivers' vehicles. As the Express Lanes are along four untolled lanes, commuters' choices of lanes reflect their trade-off of travel time savings, toll and reduction in travel time uncertainty. The data are thus free of many of common problems mentioned earlier in SP data.

Second, travel time savings and travel time variability are computed using the real time traffic data recorded by loop detectors on SR91; these single loop detectors send out an electronic pulse to a road side computer when a vehicle passes over the loop of wire, which is later transmitted to traffic control center and processed to yield meaningful traffic data. Though the loop data are subject to mechanical malfunctions of the detectors, they are far more reliable than the travel time savings reported by the commuters; users of the Express Lanes tend to overstate their time savings [1] to justify

[1]Sullivan [1998] finds that one-third of Express Lanes users overestimate the time savings by at least 7

their patronage—a phenomenon called cognitive dissonance in psychology, this will probably result in downward bias of the estimate of value of travel time. Moreover, the loop data circumvents the practical difficulties of presenting the concept of travel time variability in survey questions.

Advantages said, there are a few problems to tackle:

- Loop data of 1997 are used as proxies to compute mean and standard deviation of travel time for survey respondent in 1998. This may cause the value of travel time to be overstated because the toll scheduled have been adjusted upward twice in that elapse of one year; this may reflect higher travel time savings enjoyed by users of the Express Lanes in 1998.

- Since toll is set to reflect the travel time savings the tolled lanes users enjoy at different time of day, it may be highly correlated with the difference of mean travel time on toll and free lanes; worse still, high correlation exists between the mean and variance of travel time as well. These pose a serious problem in identifying the parameters of travel time and variability, which cast doubt on the estimates values of travel time and variability. A dilemma arises since omission of either variable will cause positive bias in the estimate of the other; as a matter of fact, travel time savings and reduction of travel time uncertainty are the two most important reasons that people take the Express Lanes.

minutes(p.xv, point 11)

While the first problem can only be addressed by collection of new traffic data, the second poses serious challenge to the estimations of choice models, and will be treated in detail in the following sections. This chapter is organized as follows: A brief discussion of the empirical specification of the route and time–of–day choice, followed by discussion of the empirical results of route choice, time-of-day choice, their joint estimations. For comparison and completeness, other choice models are also estimated such as mode choices, acquisition of the electronic transponders. Their results will also be briefly discussed before the conclusion.

2 Empirical Specification

Recall from previous chapter that people's choice of route given time-of-day choice depends on:

$$\Delta EC = \alpha \Delta E(T) - \text{Toll} + \beta \Delta E(SDE) + \theta \Delta P_L + \gamma \Delta E(SDL) \tag{1}$$

The first term is just the travel time savings, and the last three terms (SDL, SDE and P_L)are the cost associated with uncertainty, which is called "scheduling cost" in Small, Noland and Koskenoja [1995]. Following the authors' argument, let us assume that total travel cost is the sum of the scheduling cost and planning cost. The planning cost arises because travel time uncertainty may also impose an inconvenience due to the inability to plan one's activities exactly. The planning cost is assumed to be a function of the standard deviation of travel time ($h(\sigma)$). The total cost is therefore

$$\Delta ETC = \alpha \Delta E(T) - \text{Toll} + \beta \Delta E(SDE) + \theta \Delta P_L + \gamma \Delta E(SDL) + \beta_\sigma h(\sigma) \tag{2}$$

This full specification will be done in a joint estimation of the route and time-of-day choice in Section (5); the estimation of route choice will only include planning cost whereas that of time-of-day choice has the scheduling cost.

All the choice models will be estimated with Multinomial Logit or Nested Logit; it assumes that individual n maximizes his utility from I alternatives which comprises two components:

$$U_{in} = V_{in} + \epsilon_{in} \tag{3}$$

where V_{in} is the systematic utility and ϵ_{in} is the random utility which capture all the unobservable attributes relevant to one's choice decision. Logit assumes that the random component,ϵ_{in}, follow a Weibull distribution. This assumption allows the probability of choosing alternative i be written in a simple form as

$$P_{in} = \frac{\exp V_{in}}{\sum_{j \in C_J} \exp V_{jn}} \tag{4}$$

where $V_{in} = \beta' Z_{in}$; Z_{in} contains a vector of alternative-specific attributes x_{in} and individual-specific factors w_n which do not vary across alternatives; they are usually interacted with

x_{in} in estimation. β' is the vector of parameters to be estimated.

3 Route Choice

In the case of route choice model, the choice set C_J contains free and tolled lanes,

$$V_{in} = \alpha_i + \beta_t t_{in} + \beta_\sigma h + \beta_c c_{in} \tag{5}$$

where t and h are measures of the mean and variability of travel time computed from loop data on SR91; c is the toll.

The coefficients of travel time β_t, and travel time variability β_σ can not be identified in the estimation of Eqn.(5) because of their high correlation. To attenuate this problem, different measurements of t and $h(\sigma_{time})$ are experimented. The correlation between these variables are tabulated in Table (1); the descriptions of the variables are listed in Table (3). As expected, difference of mean travel time, $\Delta t5$, is highly correlated both the toll c and difference of standard deviation of travel time, $\Delta sd5$; comparatively, median travel time ($\Delta medt$) and the difference of 90th percentile and median travel time, $\Delta dmp90$, are less correlated with each other and with the toll. This is probably because median travel time is less sensitive to minute–to–minute fluctuations generated by mechanical aberrations of loop detectors; moreover, $\Delta dmp90$ may be a better meassure of travel time variability than standard deviation because commuters are usually more concerned with the positive rather

Table 1: Correlation of Δ Variables

Δ Variables	$\Delta t5$	$\Delta medt$	$\Delta dmp90$	$\Delta sd5$	c	(c/w)	(c/w)
$\Delta t5$	1						
$\Delta medt$	.934	1					
$\Delta dmp90$	.518	.229	1.				
$\Delta sd5$	.693	.436	.756	1			
c	.599	.528	.379	.452	1		
(c/w)	.168	.163	.077	.08	0.208	1	
(c/w)	.282	.263	.112	.168	.552	.557	1

than negative deviations from median travel time. It is not coincident that model (1c), i.e., the specification using 15-minute median travel time (*medt*), and (*dmp*90) have the best fit and t-statistics among (1a) and (1c) in Tables (5) and (6). None, however, yields statistically significant or plausible coefficients of travel time, variability and toll.

In models (1d)—(1h), toll is divided by the average vehicle occupancy in a week (*cplno*); it is logical to assume that the tolled lanes users split the toll with their passengers, moreover, since vehicles with 3 occupants only pay half the regular toll effective on January 1998, the toll becomes $c/(2cplno)$ for those respondents whose average weekly vehicle occupancy is more than 2.5. This simple adjustment improves t-statistics of all the coefficients tremendously suggesting a possible reduction of the high correlation between travel time savings and toll. Among all the specifications, model (1f) is chosen as the base model for comparison of subsequent estimations because it has the lowest log-likelihood value as well as the best t-statistics.

It is reasonable to expect that one's decision of taking the tolled lanes depends on his income; in fact, addition of the income interacted with tolled lane dummy (y*lane) in model (2a) of Table (6) easily passes the Likelihood Ratio test [2]. As microeconomic theory argues that individuals' value of time depends on its opportunity cost which is usually taken as the wage rates for practical purpose; *medt*, *dmp*90 and c are interacted with (w), which is an estimate of wage rate constructed from household income, in models (2b)—(2d) of Table (6). Their ratios, i.e., the value of time and reliability, are thus proportional to the computed wage rate $\bar{w}$.

All these models yield coefficients of plausible signs and magnitude; β_σ is greater than β_t for each of the measures of travel time t and reliability h we use, confirming the theoretical prediction that travel time variability is more onerous than travel time per se. These models also clearly show that income is an important factor in explaining people's willingness to pay for time saving, of the three which value of time is proportional to income, the best fitting is model (2d), in which the time and cost variables are multiplied by $\bar{w}^{1/2}$. The best fitting model of all is (2a).

[2]Model (1f) is re-estimated excluding all the data with missing income so that it has the same sample size as model (2a); the LR value is $-2(-228.371 + 219.335) = 9.036 > \mathcal{X}_{1,0.05}$ which rejects the null hypthesis that coefficient of y*lane is zero.

3.1 Value of Travel Time and Reliability

Given the estimated coefficients of *medt*, *dmp*90 and *c*, the value of travel time and reliability can be computed with the following formulae:

$$\begin{aligned} \text{VOT} &= \frac{\beta_t + \sum_i \beta_{x_i} x_i}{\beta_c + \sum_j \beta_{x_j} x_j} \cdot 60 \\ \text{VOR} &= \frac{\beta_\sigma + \sum_k \beta_{x_j} x_k}{\beta_c + \sum_j \beta_{x_j} x_j} \cdot 60 \end{aligned}$$

where x_i, x_j and x_k are variables interacted with travel time, toll and time variations respectively. The subscript n for individual will be dropped hereafter for sake of clarity unless confusions arise.

The values of travel time and reliability are presented in Table (7) as a fraction of estimated wage rate $\bar{w}$. Value of travel time varies from \$17.03/hour to \$42.24/hour compared with the mean wage rate of \$32.95/hour, or 52% to 128% of of the gross wage rate. This is far greater than that found by Calfee and Winston [1998], but except for Model (2b), they are all within the reasonable range mentioned earlier. The coefficient ratio of travel time variation and travel time is around 1.5, implying that an increase of one minute in travel time variation (as measured by difference between 90th and 50th percentile) is as onerous as 1.5 minute of travel time. In the best fitting models (2a) and (2d), value of time is 40% of the mean estimated wage rate and 82% of the wage rate respectively.

3.2 Other Demographics

Estimations with more complete set of demographics are presented in Models (3a)–(5a) of Table (8). As expected, high income earners and professionals are more likely to take the tolled lanes; respondents who speak other languages beside English at home are the opposite; one explanation may be that these respondents often come from immigrant background and tend to have lower income, or they may not be very comfortable with toll announcement in English. It is hypothesized that men are more risk-loving than women, and thus find travel time uncertainty less onerous. It is confirmed by the positive and significant coefficient of male*$dmp90$. On the other hand, it is a bit surprising that people with college education are less likely to use the tolled lanes, age is not significant in explaining people's route decisions.

The effect of trip distance is non-linear but increases until $D = 50$ miles; this suggests that tolled lanes are an increasingly attractive option for commuters with trip distance less than 50 miles, but lose its appeal beyond. This seems to agree with the simple simulation results in Chapter 4 when trip distance is assumed mildly negatively correlated with value of travel time; moreover, a longer trip implies that thc travel time savings and reduction of uncertainty afforded by the 10-mile tolled lanes decrease as a proportion of the entire commute, thus watering down the benefits of taking tolled lanes.

Commuters who have flexible work start time are expected to be less likely to take the tolled lanes; this is not supported by the finding, likewise, the hypothesis that those commuters are less sensitive to travel time variation (Model 5a) is not supported either. This perhaps can be explained by the high correlation between flexibilty and socioeconomic factors like income, education and job status—people with high income or high education tend to have jobs with more flexible work start time. Lastly, people who have switched to other routes in the past week are less likely to take tolled lanes; the opposite is true for people who have switched their departure time the past week. The former may have other alternatives besides SR91, and the latter may be more sensitive to travel time savings.

3.3 Weighting the Choice–based Data

The tolled lanes users were purposely over-sampled in the survey for budgetary concern; this choice-based sampling scheme, as shown by Manski and Lerman [1977], yields inconsistent estimates for parameters associated with the alternative-specific constants in conditional logit model. They also suggest a practical remedy to the problem: consistent estimates can be obtained by weighting each individual observation by the ratio of population shares individually by sample share. Table (2) presents the relevant shares and weights; the population share are obtained by vehicle counts in two field trips on SR91 when the survey was conducted. This is a normal practice by transportation engineers. The weighted estimations of route choice are shown as models (3b)–(5b) in Table (8); only coefficients associated with the tolled lane dummy are affected noticeably. Note since the population shares are only collected for each choice model, they are not applicable to estimations of joint choices model.

Table 2: Choice–based Sampling Weights

Choice j	**Population share**	**Sample Share**	**Weight**
	Route Choice		
Express Lanes	.283	.417	.68
Free Lanes	.717	.583	1.23
	FasTrak or Not?		
Transponders	.489	.615	.80
No transponder	.511	.385	1.33
	Mode Choice		
HOV2+	.221	.256	.86
Drive Alone	.779	.744	1.05

4 Time-of-Day Choice

Based on the respondents' arrival time for work, 12 alternatives, each of 30 minutes, are constructed between 4:00am and 10:00am. T_e is defined as the difference between the respondents' work start time and the lower limit of each 30-minute time-of-day alternative. Schedule Delay Early (SDE) and Late (SDL) can then be defined as the maximums of $\{T_e, 0\}$ and $\{-T_e, 0\}$ respectively.

Since the variations of trip time with respect to different time of day is not known, proxies are used instead. One proxy ($D/10 * medt$) is constructed by multiplying median travel time on free lanes by the trip distance reported by the respondents; this assumes that respondents' trip time vary similarly as that on the free lanes with time of day. The second proxy (*tt*) computes the travel time variations between different time of day by adding to the respondents' reported trip time the difference of the median travel time they actually traveled and those of other times of day on the free lanes. This is a very good proxy for the true trip time variations for people whose commutes are comparable with the 10-mile corridor. Some of the estimation results are shown in Table (10); estimations using *tt* as proxy for travel time yield insignificant coefficients for many of the variables, and that of travel time (*tt*) has wrong sign. Given that the average trip length is about 46 miles, variations of travel time on the free lanes is too small compared to the actual variations of trip time. Estimations using the first proxy ($D/10 * medt$) yield more reasonable results; the coefficients of the time–specific constants seem to suggest that respondents have an inverted U-shaped utility curve with regard to departure time at different time of day, and it reaches the maximum at the time from 7:30–8:00am. The coefficient of SDL is almost twice as large as that of SDE, which has the implication that arriving one minute late for work is twice as onerous as 2 minutes of early arrival, however, the result does not support the hypothesis that $\beta_{SDE} < \beta_t < \beta_{SDL}$ partly because the true variations of trip time is not known, but proxy depends on the trip distance.

4.1 Other Demographics

The results of model (tc2b) confirm conventional belief that age has a positive effect on one's likelihood to arrive for work early; commuters who have flexible work start time also seem to have lower cost of late arrival; males, on the other hand, are more likely to arrive early for work. One plausible explanation is that men have less family obligations than women do, which seems to be supported by the positive albeit insignificant coefficient of the interacted term of female and number of children with SDL (fkid*SDL).

5 Route and Time-of-day

As Eqn.(2) suggests, route and time-of-day choice may be correlated. To capture this correlation, Eqn.(2) is estimated by Multinomial and Nested Logit. The structure of data is such that only median travel time (medt), difference of 90th and 50th percentile travel time (dmp90) and toll (c) vary with both route and time of day.

The results of the joint estimations in Table (11) closely replicate those of earlier separate estimations of either route or time-of-day choice. The coefficients of SDE, SDL and travel time (tcmedt) are still not in the order suggested by theory, i.e., $\beta_{SDE} < \beta_t < \beta_{SDL}$. This is probably because scheduling costs are already accounted in planning cost (β_σ) as both the coefficients of SDE and SDL are smaller than they are in time-of-day choice model; another possible reason might be that SDE and SDL do not vary with choice of route, thus rendering comparison of their coefficients with those of travel time and variability difficult. Model (rtc2a) seems to indicate that some demographic variables are more important in explaining people's route choice and time-of-day choice and vice versa.

Next, a Nested Logit model of route and time-of-day choice is estimated using the Full

Information Maximum Likelihood method or FIML; model (nrtc) assume that respondents choose time-of-day choice conditional on their route choice, whereas the (ntrc) has the opposite decision structure. Both of them yield similar results as the earlier one using the Multinomial Logit, but neither yields plausible coefficient of inclusive value which should be less than one.

6 Carpooling and Route Choice

In order to understand more completely people's travel behaviors, commuters' other traveling choices are also estimated. Firstly, a reduced form of carpooling choice model is estimated using Logit. To reflect the fact that vehicles with 3 or more occupants pay half the normal toll, three carpooling alternatives are constructed based on information about respondents' most recent work trip, namely driving alone (SOV), carpool with one passenger (HOV2) and carpool with more than 1 passenger (HOV3). The results of the basic mode choice model are presented in Table (14). Negative coefficients of both HOV2 and HOV3 indicate that they are less preferred modes of travel compared to solo driving; people with fewer years of schooling tend to carpool with 1 passenger as shown by the positive coefficient of *ledu*HOV2*; the results also show that people who have more vehicles in their households are less likely to carpool with 1 passenger. For people who carpool with 2 passengers, they tend to work in large company which usually offer incentives to carpool; they tend to have longer commutes and come from immigrant background. Significant and positive coefficients of *lane*HOV2* and *lane*HOV3* also indicate that carpoolers are more likely to take the tolled lanes, which warrants joint estimations of carpooling and route choices.

Table (15) tabulates the results of route and carpooling choices estimated using Multinomial and FIML Nested Logit. Model (nrplc2) assumes that respondents' carpooling decision is conditional on their route choice, whereas Models (nrplc3) and (nrplc4) assume the opposite structure of decision; moreover, model (nrplc4) relaxes the constraint that the coefficient of inclusive value of HOV3 be equal to those of SOV and HOV2. None of estimations yield plausible coefficients for the inclusive value regardless of structure of decision tree; coefficients in Model (nrplc2) have implausible sign while those in Models (nrplc3) and (nrplc4) are around one. This seems to suggest that the Multinomial Logit estimation is better. Moreover, it is worth noting that toll, c, shows significant and negative coefficient; this assuages the suspicion that toll, c, is significant and negative in earlier route choice model because it is divided by average vehicle occupancy *cplno*, which indirectly accounts for people's mode decision.

7 Transponder Choice

Since using tolled lanes requires an electronic transponder, it is natural to assume that people's route choice is conditional on their decision to acquire a transponder—or simply "tag" for short. Model (tagc) in Table (16) is just the transponder choice, it shows that people who have high gross income and carpooling habit are more likely to acquire a transponder; men and people with immigrant background, on the other hand, are less likely to purchase one.

The next two models in Table (16) consider transponder and route as a joint choice. Model (rtagc2) employs the Multinomial Logit to estimate their joint choice, whereas model (nrtagc3) uses FIML Nested Logit for estimation. Both assumes a structure of decision in which *No tag* choice disallows choice of tolled lanes. Many of the variables which were significant in route choice models are no longer so. This is not surprising because those variables may have picked up the effects relevant to transponder choice. The coefficient of inclusive value for *Tag* is greater than that of *No Tag* as expected, but neither are less than one.

7.1 Transponder, Mode and Route Choice

Lastly, Table (17) shows the estimation results of joint choices of transponder, route and carpooling; model (mrtagc1) uses the Multinomial Logit while models (nmrtagc1) and (nmrtagc3) use FIML Nested Logit. Of the two models which uses FIML Nested Logit, model (nmrtagc1), the 2nd column, assumes that commuters' carpooling decision are conditional on their route choice based on their transponder choice; model (nmrtagc3) has the bottom two nests reversed, i.e., people decide whether to purchase a transponder, they then make their carpooling choices, which impact on their route decisions. The former nesting sequence fits far better, but still not as well as the joint logit; in addition, the inclusive value coefficients are not significantly different from 1.0, suggesting joint logit as an adequate description.

8 Conclusion

This paper employs discrete choice model to study a variety of people's travel decisions which includes their choices of route, mode, time-of-day and transponder. By estimating people's revealed choice of route, their evaluation of travel time and variability are computed; the results find that people are willing to pay more to reduce the travel time uncertainty vis-á-vis travel time savings, a ratio of 1.4 to 1.7. People's likelihood of taking tolled lanes increase with income, but significantly lower for men; these two demographic factors, as we will find in the transponder choice model, seem to affect more directly people's decision to purchase an electronic transponder. Trip distance shows non-linear effect on people's likelihood to take tolled lanes, partly because it is inversely correlated with value of travel time.

The estimations of time-of-day choice shows that people find it more costly to arrive late for work than being early; 1 minute of late arrival is almost twice as onerous as arriving early for work. It is also found that cost of early arrival decreases with age while men are more likely to arrive early for work; coupled with the finding that women with children are likely to be late for work, this suggests that men may have less family obligations which allows them to leave home early.

The estimation of carpooling choice model find that people with less education tend likely to carpool with one passenger, the 3+ carpoolers are more likely to be working for large company which provides carpooling incentives; it is also found that carpoolers are slightly more likely to take tolled lanes. The multinomial and nested logit estimations of the carpooling and route choice yield significant estimates for the three variables: travel time, variability and toll. This gives support to the robustness of the estimates of value of travel time and variability, which ranges from 57% of one's mean wage rate.

In an attempt to better understand the decision-making of people's travel behavior, the paper also considers their decision whether to acquire an electronic transponder; the results reveal that high income earners are more likely to purchase one, but men are more reluctant to purchase one. The nested logit estimations with route and carpooling choices yield coefficients of inclusive value around one.

The results of all the estimations gives evidence that people's travel decisions are inter-related; certain demographics may be more relevant to one's decisions, for example, income may be more important in explaining people's decision whether to acquire a transponder while flexibility of work start time to time-of-day choice. Because of the limitation of the survey, all these complex inter-relationship between one's travel behavior can not be studied more completely, which warrants more future research effort.

Table 3: Definitions of Explanatory Variables (I)

Variables	Description
Variables computed from Loop Detector Data on SR91	
$t5$	Mean travel time in 5-minute interval (minutes).
$sd5$	Standard deviation of 5-minute travel time (minutes).
$t15$	Mean travel time in 15-minute interval (minutes).
$sd15$	Standard deviation of 15-minute travel time (minutes).
medt	Median travel time of 15-minute travel time (minutes).
dmp90	90th percentile of 15-minute travel time - median 15-minute travel time (minutes)
tt	Self-reported trip time) – difference of median travel time passing the west exit of Express Lanes and that of other times of day
c	Full toll applying to non-carpoolers
Time-of-day-related variables	
Te	(work start time)– (lower limit of each time-of-day alternative)
dml	lateness dummy; 1 if $Te < 0$, 0 otherwise
SDE	Schedule Delay Early; $\text{Max}\{Te, 0\}$
SDL	Schedule Delay Late; $\text{Max}\{-Te, 0\}$
Socio-economic Characteristics	
y	Annual household income (in thousands); made continuous by taking the mid-points of each interval. People with more than $ 95,000 are assigned arbitrary figure of $100,000.
w	Hourly wage rate in dollars; It is made continuous by taking the mid-points of each interval except for the first interval which is assigned $7.50 per hour the people whose wage is less than $10.00 per hour.
w	Estimated wage rate; (Annual gross household income) ÷ (2000 work hours).
edu4	Dummy for college graduate
ledu	Dummy for graduates of high school or lower
D	Trip distance
flex	Flexibility of work arrival time in minutes; it is made continuous by taking the mid-points of each category of Q7. An arbitrary 120 minutes are assigned to commuters who can arrive for work any time.

Table 4: Definitions of Explanatory Variables (II) (continued)

Socio-economic Characteristics	
prof	dummy for professionals (doctor, lawyer...); 0 otherwise
age	Age of the respondents
kid	Number of children aged 15 and under
lang	1 if another language besides English is spoken at home, 0 otherwise
female	Dummy for female
male	Dummy for male
fkid	female*kid.
cplno	Average vehicle occupancy per trip in a week; cplno ≥ 1. (total number of occupants in all work trips in a week) $\div$ (total number of trips)
swrc	1 if respondents have experiences of switching to other routes other than tolled lanes in the past 2 weeks.
swtm	1 if respondents have experiences of shifting scheduling time because of radio reports in the past 2 weeks.
Alternative-specific constants	
lane	Dummy variable for tolled lanes
d4h	1 if 4:00am–4:30am
d5	1 if 4:30am–5:00am
d5h	1 if 5:00am–5:30am
d6	1 if 5:30am–6:00am
d6h	1 if 6:00am–6:30am
d7	1 if 6:00am–7:00am
d7h	1 if 7:00am–7:30am
d8	1 if 7:30am–8:00am
d8h	1 if 8:00am–8:30am
d9	1 if 8:30am–9:00am
d9h	1 if 9:00am–9:30am
d10	1 if 9:30am–10:00am
SOV	1 if respondent drove alone as indicated on Q.11 of the survey
HOV2	1 if carpooled with 1 other person
HOV3	1 if carpooled with 2 other people
tag	1 if transponder owner

Table 5: Unweighted Logit Estimation of Route Choice
(t-statistics in parentheses)

Variable	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)	(1g)	(1h)
lane	-1.028	-1.037	-1.197*	.136	.054	-.176	.027	-.118
	(-1.541)	(-1.551)	(-1.800)	(.318)	(.122)	(-.411)	(.065)	(-.269)
*t*5	-.011			-.062				
	(-.133)			(-.767)				
*t*15		-.0078			-.068			-.126
		(-.498)			(-.749)			(-.080)
medt			-.076			-.133*	-.071	
			(-1.007)			(-1.926)	(-.975)	
sd5	-.154**			-.185***				
	(-2.319)			(-2.640)				
sd15		-.221**			-.268***		-.289***	
		(-2.405)			(-2.828)		(-3.771)	
dmp90			-.170***			-.228***		-.197***
			(-3.205)			(-4.279)		(-3.389)
c	.208	.189	.141					
	(.762)	(.681)	(.551)					
(*c*/cplno)[a]				-.413***	-.433***	-.47***	-.434***	-.465***
				(-3.391)	(-3.515)	(-3.743)	(-3.521)	(-3.716)
N	394	394	394	389	389	389	389	389
Log Likelihood	-262.571	-263.158	-261.905	-252.192	-252.740	-250.304	-252.545	-250.845
Pseudo R^2	.0386	.0364	.0410	.0647	.0627	.0717	.0634	.0697
VOT($/h)	–	—	–	8.99	9.48	17.03	9.77	16.21
VOR($/h)	–	–	–	26.84	37	29.15	39.97	25.41
VOR/VOT	–	–	–	2.985	3.910	1.712	4.092	1.567

* Coefficient is significant at 10 % level.
** Coefficient is significant at 5 % level.
*** Coefficient is significant at 1% level.
[a] Vehicles with 3+ occupants pay half the normal toll so that

$$c/cplno = \begin{cases} c/cplno & : \quad 2.5 \geq cplno \geq 1 \\ c/2cplno & : \quad \text{cplno} > 2.5 \end{cases}$$

Note: The measure of fitness is computed by the Pseudo R^2, which is defined as $1\text{-}L/L_0$, where L_0 is the log-likelihood value evaluated with constant terms only, and L is the log-likelihood value evaluated at the estimated parameters.

Table 6: Unweighted Logit Estimation of Route Choice
(t–statistics in parentheses)

Independent Variable	(1f)	(2a)	(2b)	(2c)	(2d)
Lane	-.176 (-.411)	-1.630*** (-2.914)	-.653 (-1.584)	-.137 (-.380)	-.367 (-.841)
y*lane		.019*** (4.133)			
medt	-.133* (-1.926)	-.160** (-2.151)	-.149** (-2.030)		
medt*$\bar{w}^a$				-.0039** (-2.361)	
medt*$\bar{w}^{1/2}$					-.0233** (-1.991)
dmp90	-.228*** (-4.279)	-.222*** (-2.151)	-.209*** (-3.777)		
dmp90*$\bar{w}$				-.0056*** (-3.540)	
dmp90*$\bar{w}^{1/2}$					-.034*** (-3.607)
$(c/\text{cplno})^b$	-.47*** (-3.743)	-.428*** (-3.185)		-.398*** (-3.039)	
$c/(\text{cplno}*\bar{w})$			-6.986*** (-4.358)		
$c/(\text{cplno}*\bar{w}^{1/2})$					-1.711*** (-3.230)
N	389	351	351	351	351
Log Likelihood	-250.304	-219.335	-220.512	-220.657	-219.922
Pseudo R^2	.0717	.0985	.0936	0.0930	0.0961
VOT	\$17.03/h	\$ 22.47/h	$1.282\bar{w}$	$.583\bar{w}$	$.817\bar{w}$
VOR	\$29.15/h	\$31.16/h	$1.796\bar{w}$	$.855\bar{w}$	$1.207\bar{w}$
VOR/VOT	1.712	1.387	1.401	1.451	1.476

* Coefficient is significant at 10 % level.
** Coefficient is significant at 5 % level.
*** Coefficient is significant at 1% level.
[a] w is a crude estimate of wage rate computed by the formula: (Annual Gross Income) ÷ (2000 work hours). The mean and median $\bar{w}$ are \$32.95 and \$30 respectively.
[b] Vehicles with 3+ occupants pay half the normal toll so that

$$c/cplno = \begin{cases} c/cplno & : \; 2.5 \geq \text{cplno} \geq 1 \\ c/2cplno & : \; \text{cplno} > 2.5 \end{cases}$$

Table 7: Values of Travel Time and Reliability

	Value of Travel Time ($/hour)				
w(percentile)	(1f)	(2a)	(2b)	(2c)	(2d)
7.5 (5%)			9.62	4.37	6.13
20 (25%)			25.64	11.66	16.34
30 (50%)			38.46	17.49	24.51
32.95 (mean)	17.03	22.47	42.24	19.21	26.92
41.25 (75%)			52.88	24	33.70
50 (90%)			64.1	29.15	40.85
	Value of Reliability ($/hour)				
7.5 (5%)			13.47	6.41	9.05
20 (25%)			35.92	17.1	24.14
30 (50%)			53.88	25.65	36.21
32.95 (mean)	29.15	31.16	59.18	28.17	39.77
41.25 (75%)			74.09	35.27	49.79
50 (90%)			89.8	42.75	60.35

[a] w is a crude estimate of wage rate computed by the formula: (Annual Gross Income) ÷ (2000 work hours).

Table 8: Comparison of Unweighted and Weighted Logit Estimation of Route Choice
(t-statistics in parentheses)

Independent Variable	Unweighted			Weighted		
	(3a)	(4a)	(5a)	(3b)	(4b)	(5b)
Lane	-2.523**	-1.193	-1.008	-3.148***	-1.759*	-1.538*
	(-2.200)	(-1.413)	(-1.199)	(-2.582)	(-1.940)	(-1.704)
y*lane	.0202***	.0202***	.0208***	.0191***	.0191***	.0197***
	(3.681)	(3.696)	(3.836)	(3.328)	(3.333)	(3.468)
edu4*lane	-.519*	-.522*	-.537*	-.552*	-.548*	-.567*
	(-1.775)	(-1.786)	(-1.831)	(-1.787)	(-1.777)	(-1.830)
age*lane	-.0122	-.0119	-.0127	-.0132	-.0128	-.0137
	(-.899)	(-.877)	(-.941)	(-.908)	(-.888)	(-.948)
lang*lane	-1.149***	-1.164***	-1.183***	-1.177**	-1.191**	-1.230**
	(-2.591)	(-2.611)	(-2.622)	(-2.330)	(-2.351)	(-2.383)
flex*lane	.0054*	.0053*		.0006**	.0006**	
	(1.947)	(1.934)		(2.167)	(2.129)	
prof*lane	.989*	.973*	1.012*	1.027*	1.02*	1.063*
	(1.808)	(1.801)	(1.867)	(1.834)	(1.841)	(1.913)
D*lane	.062**			.063*		
	(2.010)			(1.900)		
D^2*lane	-.0006**			-.0006*		
	(-1.994)			(-1.829)		
swrc*lane	-.851***	-.862***	-.851***	-.895**	-.906**	-.890**
	(-2.581)	(-2.607)	(-2.576)	(-2.392)	(-2.415)	(-2.378)
swtm*lane	.682*	.735*	.739*	.651	.693***	.693***
	(1.716)	(1.837)	(1.842)	(1.599)	(1.690)	(1.686)
medt	-.182**	.111	.103	-.186**	.108	.097
	(-2.205)	(.715)	(.665)	(-2.143)	(.650)	(.585)
D*medt		-.014**	-.013**		-.014**	-.013*
		(-2.188)	(-2.140)		(-2.004)	(-1.935)
D^2*medt		.00014**	.00014**		.00014*	.00013*
		(2.156)	(2.099)		(1.928)	(1.855)
dmp90	-.261***	-.255***	-.214***	-.271***	-.265***	-2.218***
	(-3.802)	(-3.710)	(-2.936)	(-3.911)	(-3.824)	(-2.949)
male*dmp90	.155**	.151**	.153**	.16***	.155**	.157**
	(2.542)	(2.476)	(2.485)	(2.586)	(2.514)	(2.510)
flex*dmp90			-.0012*			-.0013**
			(-1.836)			(-2.023)
c/cplno	-.388***	-.377**	-.386***	-.372**	-.363**	-.372**
	(-2.617)	(-2.553)	(-2.614)	(-2.480)	(-2.425)	(-2.487)
N	339	339	339	339	339	339
Log Likelihood	-195.680	-195.375	-195.532	-177.722	-177.513	-177.737
Pseudo R^2	.1672	.1685	.1679	.1852	.1861	.1851

* Coefficient is significant at 10 % level.
** Coefficient is significant at 5 % level.
*** Coefficient is significant at 1% level.

Table 9: Implied Values of Travel Time and Reliability

Trip Distance D,in miles	Value of Time($/h)					
	Unweighted			Weighted		
	(3a)	(4a)	(5a)	(3b)	(4b)	(5b)
13 (5%)		7.21	7.68		7.53	8.19
20 (10%)		17.43	17.44		18.07	18.12
27 (25%)		25.45	25.12		26.42	26.00
37 (50%)		33.09	32.49		34.55	33.73
40 (mean)	28.10	34.50	33.88	30	36.12	35.23
50[a] (75%)		36.31	35.74		38.45	37.54
65 (90%)		30.61	30.58		33.56	33.19
74 (95%)		22.34	22.91		25.81	26.08
92 (99%)		-5.1	-2.73		-0.56	1.74
Range of D	–	8.79	8.32	–	8.72	8.08
for +ve VOT[a]		89.27	90.46		91.70	92.99
% of sample	–	96.6	97		97	97.3
% SR91 users		100	100		100	100
Flexibility	Value of Reliability($/h)					
(in minutes)	Female					
0			33.36			35.19
5			34.27			36.21
10	40.37	40.61	35.18	43.63	43.78	37.24
15			36.09			38.27
20			36.99			39.29
25			37.90			40.32
	Male					
0			9.55			9.83
5			10.46			10.86
10	16.44	16.65	11.36	17.86	18.13	11.88
15			12.27			12.91
20			13.18			13.94
25			14.09			14.96

[a] Value of Travel Time is highest when D is approximately 50 miles (±1 mile) which is tru different specifications.

Table 10: Logit Estimation of Time-of-day Choice [a]
(t–statistics in parentheses)

Independent Variable	Models (tc1)		(tc2a)		(tc2b)	
d5	.3467	(.369)	.448	(.461)	.441	(.458)
d5h	1.517*	(1.830)	1.170	(1.329)	1.634*	(1.903)
d6	2.253***	(2.710)	1.293	(1.393)	2.402***	(2.786)
d6h	2.894***	(3.291)	1.021	(.952)	3.053***	(3.341)
d7	3.517***	(3.847)	1	(.828)	3.699***	(3.888)
d7h	4.007***	(4.347)	1.430	(1.157)	4.214***	(4.385)
d8	4.124***	(4.412)	1.311	(.999)	4.304***	(4.413)
d8h	3.318***	(3.698)	1.226	(1.069)	3.456***	(3.678)
d9	3.372***	(4.093)	2.751***	(2.987)	3.505***	(4.047)
d9h	3.567***	(4.317)	3.089***	(3.424)	3.694***	(4.255)
d10	2.734***	(3.262)	2.731***	(3.034)	2.945***	(3.354)
(D/10)*medt[b]	-.06***	(-2.745)	–		-.059***	(-2.658)
tt	–		.342*	(1.844)	–	
dml	-.955**	(-2.193)	-.705	(-1.492)	-.893***	(-2.007)
SDE	-.021***	(-8.512)	-.043***	(-4.645)	-.044***	(-4.820)
male*SDE	–		.011***	(2.580)	.0104***	(2.398)
age*SDE	–		.0004*	(1.869)	.0004**	(2.000)
SDL	-.0425***	(-4.566)	-.0572***	(-4.465)	-.053***	(-4.500)
flex*SDL	–		.00015	(1.441)	.00018**	(2.102)
fkid*SDL	–		.006	(1.213)	.0048	(1.011)
N	385		370		374	
Log Likelihood	-635.502		-629.597		-605.557	
Pseudo R^2	.3357		.3453		.3484	

* Coefficient is significant at 10 % level.
** Coefficient is significant at 5 % level.
*** Coefficient is significant at 1% level.
[a] There are 12 alternatives; each is a 30-minute interval between 4:00am–10:00am.
[b] Median travel time on free lanes with respect to each 30-minute time-of-day alternative.
Note:The measure of fitness is computed by the Pseudo R^2, which is defined as $1\text{-}L/L_0$, where L_0 the log-likelihood value evaluated with constant terms only, and L is the log-likelihood value evaluated the estimated parameters.

Table 11: Joint Estimation of Route and Scheduling Choice
(t–statistics in parentheses)

Independent Variable	rtc1		rtc2	
d5	.786***	(.680)	.811	(.702)
d5h	1.971***	(1.874)	2.039**	(1.936)
d6	2.418**	(2.319)	2.533**	(2.426)
d6h	2.615**	(2.496)	2.748***	(2.606)
d7	3.30***	(3.153)	3.449***	(3.266)
d7h	3.667***	(3.491)	3.857***	(3.631)
d8	3.943***	(3.730)	4.075***	(3.806)
d8h	3.427***	(3.217)	3.462***	(3.204)
d9	3.962***	(3.780)	3.952***	(3.720)
d9h	3.740***	(3.586)	3.773***	(3.570)
d10	2.970***	(2.807)	3.094***	(2.888)
lane	-.860*	(-1.718)	-2.105**	(-2.403)
y*lane	.0170***	(3.871)	.0175***	(3.662)
lang*lane	–		-.981**	(-2.443)
flex*lane	–		.0052**	(2.065)
D*lane	–		.0546**	(1.970)
D^2*lane	–		-.0006**	(-2.126)
medt[a]	-.094	(-1.300)	-.115	(-1.541)
dmp90[b]	-.124**	(-2.290)	-.153**	(-2.496)
male*tcdmp90	–		.094*	(1.812)
c/cplno	-.435***	(-3.339)	-.441***	(-3.181)
dml	-1.192***	(-2.637)	-1.062**	(-2.319)
SDE	-.021***	(-8.169)	-.051***	(-4.904)
male*SDE	–		.0123***	(2.717)
age*SDE	–		.00056**	(2.374)
SDL	-.0373***	(-4.051)	-.047***	(-4.046)
flex*SDL	–		.00018*	(2.085)
N	352		341	
Log Likelihood	-810.966		-763.729	
Pseudo R^2	.2751		.2953	

* Coefficient is significant at 10 % level.
** Coefficient is significant at 5 % level.
*** Coefficient is significant at 1% level.
[a] Median travel time on free and tolled lanes with respect to 30-minute time–of–day alternatives.
[b] Difference of 90% tile and median travel time on free and tolled lanes with respect to each 30-minut time–of–day alternative.

Table 12: Implied per–minute cost of Schedule Delay Early/Late

Age (%tile)	Marginal rate of substitution between SDE and travel time					
	(tc1a)	(tc2b)		(rtc1a)	(rtc2a)	
		male	female		male	female
21 (1%)		.425	.601		.236	.342
27 (5%)		.382	.559		.207	.314
29 (10%)		.368	.545		.198	.304
34 (25%)		.333	.509		.174	.280
41 (50%)		.283	.460		.140	.247
42 (mean)	.353	.276	..453	.226	.135	.242
49[a] (75%)		.227	.403		.102	.209
55 (90%)		.184	.361		.073	.180
60 (95%)		.149	.326		.049	.156
70 (99%)		.078	.255		.0017	.108

Flexibility (%tile)	Marginal rate of substitution between SDL and travel time					
	(tc1a)	(tc2b)			(rtc1a)	(rtc2a)
		male	female			
			< 1 kid	2 kids		
0		.904	.823	.742		.408
5		.889	.808	.727		.400
10		.874	.793	.711		.393
15	.709	.858	.777	.696	.398	.384
20		.843	.762	.681		.377
25		.828	.747	.665		.369

Table 13: Nested Logit Estimation of Route and Scheduling Choice
(t–statistics in parentheses)

Independent Variable	nrtcl		ntrc2	
d5	.634	(.562)	.814	(.700)
d5h	1.718*	(1.710)	2.354*	(2.067)
d6	2.130**	(2.144)	2.948**	(2.493)
d6h	2.233**	(2.245)	3.296**	(2.576)
d7	2.876***	(2.898)	4.083***	(3.052)
d7h	3.244***	(3.265)	4.534***	(3.280)
d8	3.40***	(3.396)	4.862***	(3.326)
d8h	2.850***	(2.800)	4.216***	(2.939)
d9	3.513***	(3.478)	4.478***	(3.593)
d9h	3.609***	(3.572)	3.941***	(3.621)
d10	2.958***	(2.875)	3.173***	(2.923)
lane	-3.530***	(-3.022)	-1.96**	(-2.336)
y*lane	.0186***	(3.731)	.017***	(3.539)
lang*lane	-1.011**	(-2.393)	-.96**	(-2.417)
flex*lane	.0052*	(1.985)	.0056**	(2.185)
D*lane	.061**	(2.134)	.0527**	(2.053)
D^2*lane	-.0006**	(-2.192)	-.0006**	(-2.185)
medt	-.015	(-.855)	-.115*	(-1.751)
dmp90	-.065**	(-2.072)	-.136**	(-1.963)
male*dmp90	.017	(1.365)	.0748	(1.230)
c/cplno	-.066*	(-1.626)	-.447***	(-3.412)
dml	-1.074**	(-2.362)	-1.061**	(-2.324)
SDE	-.050***	(-4.921)	-.051***	(-5.036)
male*SDE	.0116***	(2.585)	.013***	(2.771)
age*SDE	.00054**	(2.390)	.00055**	(2.388)
SDL	-.0466**	(-4.049)	-.047***	(-4.033)
flex*SDL	.00017**	(1.990)	.00018**	(2.073)
ρ^a_{route}	7.506**	(1.988)	–	
ρ^b_{time}	–		2.00	(1.360)
N	341		341	
Log Likelihood	-754.8063		-763.450	
Pseudo R^2	.3035		.2955	

Coefficient is significant at 10 % level.
' Coefficient is significant at 5 % level.
'* Coefficient is significant at 1% level.
The inclusive value for route choice has formula as $I_r = ln \sum_t^{12} \exp(\beta' x_{t|r})$.
The inclusive value for time-of-day choice has formula as $I_t = ln \sum_r^{2} \exp(\beta' x_{r|t})$.

Table 14: Logit Estimation of Reduced Form of Carpooling Choice[a]
(t–statistics in parentheses)

Independent Variable	cplc	
HOV2	-2.054**	-2.452
y*HOV2	.0122*	(1.937)
carno*HOV	-.441**	(-2.162)
ledu*HOV2	.899***	(2.578)
flex*HOV2	-.0044	(-1.378)
lane*HOV2	.553*	(1.813)
HOV3	-4.737***	(-3.895)
male*HOV3	-.458	(-1.215)
D*HOV3	.021**	(2.113)
lang*HOV3	1.131**	(2.134)
wksize*HOV3	.004**	(2.171)
lane*HOV3	.937**	(2.302)
c[b]	-.431	(-1.036)
N	336	
Log Likelihood	-256.217	
Pseudo R^2	.3059	

* Coefficient is significant at 10 % level.
** Coefficient is significant at 5 % level.
*** Coefficient is significant at 1% level.
[a] There are three alternatives: SOV when vehicle occupancy is 1, HOV2 if 2 and HOV3 if 3 or m ndicated on Q.11 of the survey.
[b]

$$c = \begin{cases} c & : \text{SOV} \\ c/2 & : \text{HOV2} \\ c/6 & : \text{HOV3} \end{cases}$$

Table 15: Logit Estimation of Carpooling and Route Choice
(t–statistics in parentheses)

Independent Variable	Joint		Nested					
	(rplc1a)		(nrplc2)		(nrplc3)		(nrplc4)	
HOV2	-0.869*	(-1.837)	-.919*	(-1.927)	-.904*	(-1.741)	-.910*	(-1.747)
carno*HOV2	-.378*	(-1.939)	-.377*	(-1.924)	-.379*	(-1.940)	-.389**	(-1.980)
ledu*HOV2	.784**	(2.412)	.773**	(2.361)	.789**	(2.417)	.796**	(2.435)
HOV3	-2.893***	(-7.895)	-3.001***	(-7.864)	-2.959***	(-5.421)	-3.800***	(-3.490)
lang*HOV3	1.041**	(2.027)	1.073**	(2.072)	1.065**	(1.990)	.877	(1.562)
wksize*HOV3	.0035**	(2.003)	.360**	(2.057)	.347**	(2.002)	.363**	(2.075)
lane	-2.744**	(-2.373)	-3.467***	(-2.705)	-2.788**	(-2.352)	-2.596**	(-2.116)
y*lane	.0197***	(3.580)	.191***	(3.465)	.196***	(3.557)	.210***	(3.752)
edu4*lane	-.526*	(-1.786)	-.538*	(-1.823)	-.522*	(-1.767)	-.566*	(-1.907)
age*lane	-.013	(-.967)	-.138	(-.995)	-.128	(-.915)	-.157	(-1.094)
lang*lane	-1.107**	(-2.324)	-.982**	(-2.045)	-1.097**	(-2.282)	-1.063**	(-2.200)
flex*lane	.005*	(1.717)	.498*	(1.770)	.484*	(1.726)	.456	(1.604)
prof*lane	.899*	(1.646)	.835	(1.533)	.877	(1.564)	1.038*	(1.774)
D*lane	.065**	(2.084)	.656**	(2.119)	.651**	(2.095)	.622*	(1.955)
D^2*lane	-.0006**	(-1.987)	-.630**	(-2.035)	-.617**	(-1.987)	-.604*	(-1.924)
swrc*lane	-1.036***	(-3.058)	-1.025***	(-3.030)	-1.038***	(-3.070)	-.996***	(-2.877)
swtm*lane	.826**	(2.032)	.830**	(2.036)	.823**	(2.028)	.807**	(1.991)
medt	-.217***	(-2.608)	-.166*	(-1.811)	-.217***	(-2.614)	-.214***	(-2.621)
dmp90	-.288***	(-4.11)	-.256***	(-3.496)	-.286***	(-4.053)	-.276***	(-3.876)
male*dmp90	.18***	(2.881)	.179***	(2.875)	.182***	(2.875)	.178***	(2.856)
c[a]	-.377***	(-3.028)	-.431**	(-3.265)	-.365**	(-2.497)	-.374**	(-2.554)
ρ_r^b	–		-.252	(-.281)	–		–	
ρ_{sov}	–		–		1.153	(1.197)	1.209	(1.282)
ρ_{hov2}	–		–		1.153	(1.197)	1.209	(1.282)
ρ_{hov3}	–		–		1.153	(1.197)	.880	(.908)
N	331		331		331		331	
Log Likelihood	-452.090		-451.211		-452.077		-451.632	
Pseudo R^2	.2377		.2392		.2377		.2385	

* Coefficient is significant at 10 % level.
** Coefficient is significant at 5 % level.
*** Coefficient is significant at 1% level.
[a]

$$c = \begin{cases} c & : \text{SOV} \\ c/2 & : \text{HOV2} \\ c/6 & : \text{HOV3} \end{cases}$$

[b] The inclusive value for route choice has formula as $I_r = ln \sum_m^3 \exp(\beta' x_{m|r})$, where m is the index for carpooling choice.

Table 16: Logit Estimation of Transponder[a] and Route Choice
(t–statistics in parentheses)

Independent Variable	Tag (tagc)		Joint (rtagc2)		Nested (nrtagc3)	
tag	.283	(.748)	-.921**	(-2.204)	-.138	(-.089)
y*tag	.024***	(4.313)	.025***	(4.144)	.264***	(3.914)
male*tag	-.896***	(-3.055)	-.561*	(-1.640)	-.827**	(-2.412)
pool*tag	.801**	(.339)	–		–	
lang*tag	-.669*	(-1.729)	-.779*	(-1.840)	-.795**	(-1.953)
lane	–		-.237	(-.230)	-.246	(-.758)
edu4*lane	–		-.222	(-.864)	-.204	(-1.073)
age*lane	–		-.009	(-.684)	-.0025	(-.259)
flex*lane	–		.005**	(2.074)	.0022	(1.100)
D*lane	–		.04	(1.451)	.025	(1.060)
D^2*lane	–		-.0004	(-1.476)	-.0003	(-1.082)
swrc*lane	–		-.971***	(-3.046)	-.715**	(-2.494)
swtm*lane	–		.571	(1.479)	.437	(1.550)
medt	–		-.137	(-1.740)	-.121	(-1.514)
dmp90	–		-.211***	(-3.099)	-.179***	(-2.762)
male*dmp90	–		.10	(1.127)	–	
c/cpno	–		-.320**	(-2.259)	-.246**	(-2.112)
ρ_{yes}^{b}	–		–		2.374***	(2.613)
ρ_{no}	–		–		1.446**	(2.486)
N	361		339		339	
Log Likelihood	-166.367		-301.438		-300.4945	
Pseudo R^2	.3351		.1906		.2858	

* Coefficient is significant at 10 % level.
** Coefficient is significant at 5 % level.
*** Coefficient is significant at 1% level.
[a] The transponder choices, *Tag* and *No Tag* are defined according to Q25 of the survey which asks if the respondents have ever owned a Fastrak transponder before.
[b] The inclusive value for *Tag* choice.

Table 17: Logit Estimation of Transponder, Carpooling and Route Choice
(t–statistics in parentheses)

Independent Variable	Joint		Nested			
	(mrtagc1)		(nmrtagc1)		(nmrtagc3)	
tag	-.853**	(-2.036)	-.607	(-1.009)	.247	(.329)
y*tag	.023***	(3.698)	.197***	(3.338)	.121**	(2.004)
male*tag	-.430	(-1.252)	-.571*	(-1.654)	-.804*	(-1.735)
lang*tag	-.574	(-1.306)	-.721*	(-1.845)	-.656	(-1.587)
lane	-1.204	(-1.351)	-1.564	(-1.527)	-2.322**	(-2.344)
edu4*lane	–	–	-.363	(-1.332)	-.275	(-.961)
flex*lane	.0048*	(1.806)	.0059*	(1.928)	.006*	(1.896)
prof*lane	.550	(1.104)	.764	(1.349)	.743	(1.266)
D*lane	.0515*	(1.803)	.094***	(2.746)	.055	(1.539)
D^2*lane	-.00049*	(-1.768)	-.001***	(-2.759)	-.00053	(-1.457)
swrc*lane	-1.143***	(-3.528)	-1.125***	(-3.303)	-1.221***	(-3.476)
swtm*lane	.762*	(1.921)	.766**	(1.994)	.766*	(1.895)
HOV2	-.860*	(-1.822)	-.628	(-1.263)	-.744	(-1.455)
carno*HOV2	-.372*	(-1.912)	-.562***	(-2.752)	-.152	(-.074)
ledu*HOV2	.768**	(2.371)	.675**	(2.019)	.181	(.493)
HOV3	-2.693***	(-7.894)	-3.015***	(-8.467)	-1.027***	(-4.033)
wksize*HOV3	.0031*	(1.855)	.0046***	(2.616)	.0015	(.931)
medt	-.185**	(-2.295)	-.0954	(-1.112)	-.0801	(-1.228)
dmp90	-.257***	(-3.717)	-.262***	(-3.257)	-.162*	(-1.942)
male*dmp90	.147**	(2.188)	.0950	(1.368)	.117	(1.599)
c^a	-.350***	(-2.848)	-.402***	(-2.998)	.559***	(3.755)
ρ_{yes}	–		.1.151**	(.2.904)	1.066**	(2.325)
ρ_{no}	–		1.075**	(3.265)	.879	(1.251)
$\rho_{free\|yes}$	–		.962	(.622)	–	
$\rho_{tolled\|yes}$	–		.822	(1.084)	–	
$\rho_{free\|no}$	–		1.075	(3.265)	–	
$\rho_{SOV\|yes}$	–		–		1.012***	(2.720)
$\rho_{HOV2\|yes}$	–		–		.915***	(2.575)
$\rho_{HOV3\|yes}$	–		–		1.081***	(2.847)
$\rho_{SOV\|no}$	–		–		.879	(1.251)
$\rho_{HOV2\|no}$	–		–		.879	(1.251)
$\rho_{HOV3\|no}$	–		–		.879	(1.251)
N	332		332		332	
Log Likelihood	-558.664		-561.729		-592.683	
Pseudo R^2	.2342		.277		.2367	

* Coefficient is significant at 10 % level.
** Coefficient is significant at 5 % level.
*** Coefficient is significant at 1% level.
a

$$c = \begin{cases} c & : \text{SOV} \\ c/2 & : \text{HOV2} \\ c/6 & : \text{HOV3} \end{cases}$$

Table 18: Implied Values of Travel Time and Variability

Model	Value of Time($/hr)	Value of Variability($/hr)	
		Male	Female
Route and Time of Day Choices			
rtcl	12.97	17.1034	
rtc2	15.65	8.01	20.8
nrtcl	14.05	43.83	58.91
ntrc2	15.38	8.18	18.22
Route and Carpooling Choices			
rplcla	34.54	17.19	45.84
nrplc2	23.11	10.72	35.64
nrplc3	35.67	17.10	47.01
nrplc4	34.33	15.72	44.28
Transponder, Carpooling and Route Choices			
rtagc2	25.81	20.77	39.53
nrtagc3	29.51	43.48	43.48
mrtagcl	31.71	18.86	44.06
nmrtagcl	14.24	24.93	39.10
nmrtagc3	8.60	4.83	17.39

Note: the average hourly wage rate computed by dividing annual gross household income by 2000 work hours is $32.95/hour, whereas the reported hourly wage rate by respondents is $26.55/hour.

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