Do Travelers Pay for Managed Lane Travel as They Claimed They Would?
A Before-After Study of Houston Katy Freeway Travelers

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ABSTRACT

The purpose of this study is to examine if travelers are using the new Katy Freeway managed lanes (MLs) in Houston as they stated that they would in their responses to a previous survey conducted in 2008. This was before the MLs opened. To check the veracity of their intended behaviors a new stated preference survey was given to Houston’s Katy Freeway travelers in 2010. The 2010 survey yielded 869 responses who were also very likely to have been participants in the 2008 survey. Mixed logit models were developed from the 869 survey responses and their value of travel time savings (VTTS) were compared with the 2008 survey estimates. The implied mean VTTS based on the 2010 survey was found to be about 48 percent of the sample mean hourly wage rate, similar to values estimated using the 2008 surveys. The value of travel time reliability was estimated as 56 percent of the sample mean hourly wage rate. Combining both the value of time plus the value of reliability for these travelers results in a combined value of $61/hour. This is close to the amount travelers are valuing their travel time for their actual recent trips on the Katy Freeway (an average of $51/hour). Thus it appears that travelers are factoring in (consciously or subconsciously) some additional value for the MLs’ reliability when choosing to use the managed lanes. We argue that when estimating the value (in a benefit cost analysis) or usage (in a traffic and revenue study) of managed lanes the improved reliability of travel offered by the MLs should be included.

The percentage of travelers from 2010 survey who actually used the MLs was similar to the percentage of 2008 survey respondents who indicated they would definitely, or at least might use MLs, once they opened. The findings from this study suggest that travelers are actually using MLs and paying for this much as they said they would. The results also suggest that the maximum willingness to pay for travel did not change much from pre- and post- opening of the MLs.

Key Words: Managed lanes, Stated preference survey, Value of travel time savings, Value of travel time reliability.
INTRODUCTION

Managed lanes (MLs) are often newly constructed toll lanes set in the middle of an existing freeway. The toll rate is set to be large enough to ensure congestion does not occur on the MLs. Thus, the efficient toll rate varies by time of day: it increases during periods of peak demand and drops during off-peak periods. The tolls are also frequently reduced or eliminated for vehicles engaged in carpooling, thereby encouraging ride-sharing, which can further reduce congestion and induce possible environmental benefits related to reduced auto emissions. MLs also offer a revenue stream to help (1) finance their construction, and (2) pay for their on-going operation and management. This provides an innovative financing mechanism to widen congested urban freeway corridors—where congestion relief is most needed. The advantages that MLs offer are now well known to transportation officials and the public, and the use of MLs is gaining in popularity. This seems particularly true in the highly populated state of Texas, where there are 14 MLs being currently planned.

The research performed here helps to better understand the travelers who are using a new freeway system with managed lanes, specifically, the new Katy Freeway (I-10) MLs (see FIGURE 1) in the Houston Texas urban area. A survey was conducted in 2008 (see 1 or 2 for details on the survey), just as the new high occupancy vehicle (HOV) lanes opened on the Katy Freeway, but prior to them allowing single occupant vehicles (SOVs) on the lanes for a toll or fee. The 2008 travelers were asked about their prospective or intended travel on the forthcoming MLs in both typical travel scenarios and unusual (urgent or hurried) circumstances. Once the lanes were actually open to paying SOVs in 2010, it was of interest to find out how much actual users of the new MLs were actually willing to pay—and to compare that to their 2008 survey responses.
To accomplish the comparison, we conducted a follow-up survey of Katy Freeway travelers in 2010. This comparison provides a unique opportunity to better understand how travelers answer survey questions and how their actions in 2010 conformed to their answers in the 2008 study, and it also provides an opportunity to learn how to design stated preference (SP) surveys to better reflect actual travel behavior. Careful SP survey design and interpretation of behavior becomes increasingly important as more projects look at MLs as a critical source of revenue, but where officials must estimate potential revenue prior to construction. In this era of tight state and federal resources, all desired projects simply cannot be funded. Without accurate estimates of travelers’ maximum willingness to pay (WTP) through improved surveys, the scarce transportation funds might not get allocated to the most needed, or most efficient projects.

The 2008 survey gathered information from 3,077 interested respondents who stated that they were willing to take a follow-up survey. The new 2010 survey link was emailed to those same respondents and was also more broadly or widely advertised to all Katy Freeway users. The 2010 survey yielded 3,325 respondents, including approximately 869 respondents who had also responded to the 2008 survey.

This remainder of the paper is organized as follows. We begin with a brief review of the value of travel time savings (VTTS) and value of travel time reliability (VOR) literature, presented in the next section. That is followed by a brief description of the 2010 survey and data collection efforts. In the next section the mixed logit modeling is described. VTTS and VOR estimates and the comparisons between the 2010 and 2008 surveys are presented in the results section, followed by conclusions.
LITERATURE REVIEW

Value of Travel Time Savings

The value of travel time savings, often referred to as the value of time (VOT), has been an important area of research in transportation studies because travel time savings are one of the main benefits of transportation infrastructure investments. The earliest studies of VOT date back to the 1960s (5, 6, 7). VTTS represents the travelers’ willingness to pay to reduce their travel time (8). Travelers’ VTTS is typically estimated using SP surveys. It is calculated from discrete choice travel models and is derived as the marginal rate of substitution (MRS) between travel time and cost in the choice models (9). Conveniently, the MRS can typically be estimated in simple conventional discrete choice models like the one we use below, by using the ratio of two coefficients, the travel time coefficient divided by the cost coefficient, yielding the marginal WTP for travel time savings.

Cherlow (10) listed various studies conducted on the evaluation of VTTS. The estimated VTTS varied from as low as 9 percent of the travelers’ wage rate to as high as 140 percent of the travelers’ wage rate. He suggested that there is no single VTTS that can be applicable to all people in all circumstances. A more recent study by Lam and Small (11) estimated the average VTTS to be $22.87 per hour, or 72 percent of the average wage rate. Feather and Shaw (12) considered travel and on-site time for leisure rather than commuting and found support for the fact that time values for leisure trips, such as to outdoor recreation destinations, can in fact exceed the wage rate.

Both revealed preference (RP) data and SP have been used in the past to estimate the VTTS. RP data is generated when one has knowledge on actual commuting choices that individuals make. The two types of data were originally blended in the study by Ben-Akiva and Morikawa (13). Additionally, a few researchers have tried to discern whether there are any substantial differences in the estimates between these approaches, as some researchers are skeptics regarding the validity of stated preference results and warn of hypothetical bias in estimated values. A common concern is that SP yields larger values than RP methods do, but interestingly, several researchers have found that values estimated using the SP data from managed lanes were approximately half the values estimated using RP data (see 14, 15, 16, 17). Although the SP approach yielded these lower estimates as compared to RP data, by using careful design, it is capable of controlling for different levels of attributes and can give very precise estimates of VTTS (16).

Patil et al. (18) estimated the VTTS for different traveling situations including one normal and six urgent situations. They found that travelers place a higher value for travel time savings during an urgent, important travel situation, than during a normal situation. Among several different urgent situations tested, the situation when travelers were running late for an appointment/event had the highest value for travel time savings. This makes intuitive sense; if one is at risk of losing a job or income, the timing of the trip is especially important and of high value. They also found that travelers from the low- and middle-income groups had, on average, higher VTTS in urgent situations than travelers in the higher-income groups had in normal situations. Aside from the travel time savings, another important benefit of transportation infrastructure is the value of travel time reliability, which is next discussed, albeit briefly.
Value of Travel Time Reliability

Travel times may vary on the same route, from day to day, or even from hour to hour, for a host of reasons, including unexpected congestion. The value of travel time reliability or more succinctly, the value of reliability (VOR), indicates the value travelers place on the reliability of estimated travel time. According to Barry et al. (19), in the presence of substantial road congestion, reduced travel time variability is valued more than travel time savings. VOR is the travelers’ willingness to pay to reduce the variability of travel time. Economics and other fields have long found that individuals will pay to reduce uncertainty in a host of settings. Similarly to the VTTS, the VOR can also be calculated from discrete choice models of travel. It is derived as the MRS between travel time variability and the trip cost in the choice models. The variability in travel time is defined differently by different researchers.

Several researchers have defined variability to be the difference between the 90th percentile and 50th percentile travel time (11, 16), whereas, some have assumed it to be the difference between the 75th and the 25th percentile of travel time (20). Other researchers have defined it as the standard deviation of the travel time around the mean. In this study, we define variability as a range of potential travel times around the mean, based on a percentage of the average travel time. For example, if the average travel time is 20 minutes and varies anywhere between 80 percent (16 minutes) to 120 percent (24 minutes) of this average travel time, then the measure of reliability is 4 minutes. Higher values of our measure of reliability (such as 8 minutes) actually indicate lower reliability, so our measure could best be thought of as a measure of unreliability.

Empirical estimates of VOR found in the literature have varied considerably, ranging from as low as 0.55 times (17) to 3.22 times (21) the VOT. Brownstone and Small (22) listed several studies on SR-91 and I-15 high occupancy toll (HOT) lanes in which the VOR was found to vary between 95 and 140 percent of the value of travel time. Small et al. (20) calculated the median VOR using RP data from Los Angeles travelers and estimated it be 85 percent of the average wage rate ($19.56/hr). A recent study by Tilahun and Levinson (23) found that travelers value travel time reliability at a level very close to their value of time. The data for their study were collected using a stated preference survey. Concas and Kolpakov (24) reviewed the literature on VOT and VOR and recommended that the VOR be estimated at 80 to 100 percent of the VOT under ordinary travel circumstances with no major travel constraints. However, under the constraint of non-flexible arrival/departure, they recommended that the VOR be valued up to three times that of the VOT. In the next section we describe the data used to compare results between the survey periods.

DATA

Description of the Current (2010) Katy Freeway Survey

The 2010 survey consisted of four sections. The first section asked the respondents about their most recent actual trip on the Katy Freeway. About half of the respondents were asked about their actual trip toward downtown Houston and the other half about their trip starting from, and moving away from downtown. Questions included information about the purpose of the trip, day of the week of the trip, when the trip began, when it ended, where the respondent got on and off the Katy Freeway, the type of vehicle used, the number of passengers in the vehicle, if the respondent used MLs, etc. (see 25 for the complete survey questionnaire).
In the second section, respondents were introduced to the new MLs and asked several questions about their actual ML usage. There was also a question intended to identify the general risk-taking behavior or preferences of the respondents.

In the third section, the respondents were presented with SP questions. A total of six such questions were presented to each survey respondent. Of the six SP questions, three were those in which the respondent was asked to consider themselves to be in a normal situation and three were related to an urgent situation. Some of those urgent situations were such that the respondent was unusually pressed for time and had to reach his or her destination very soon. In this particular paper, only responses from normal situations are analyzed. In each question, the respondent was asked to consider a realistic travel scenario on the Katy Freeway with the following available travel modes.

1) Drive Alone on the General Purpose Lanes (DA-GPL).
2) Carpool on the General Purpose Lanes (CP-GPL).
3) Drive Alone on the Managed Lanes (DA-ML).
4) Carpool on the Managed Lanes (CP-ML).

These modes of travel varied based on travel time, travel time variability, and toll values. The different levels of these variables are generated using three survey design techniques: $D_b$-efficient, random attribute level generation, and adaptive random (see 25 and 26 (forthcoming, 2011) for details on the survey design techniques). Approximately one-third of respondents received questions generated using each design. Each respondent was asked to choose the mode that best suited his/her travel. Approximately half of the respondents received a question along with a picture format, while the other half received a question in word format (see FIGURE 2a and 2b). The last section of the survey contained questions regarding the respondents’ socio-economic characteristics.
Each of the following questions will ask you to choose between four potential travel choices on the Katy Freeway (1–10). For your most recent trip, please click on the one option that you would be most likely to choose if faced with these specific options. Remember that main lane traffic tends to be congested and could be slower than shown here if congestion is worse than usual. The managed lane traffic is fast moving. Also, carpooling may require added travel time to pick up or drop off your passenger(s).

You described your most recent trip away from downtown Houston on Katy Freeway last Monday as starting at 7:00 AM, ending at 7:45 AM in a passenger car, SUV, or pick-up truck. The reason for the trip was Commuting to or from my place of work (going to or from work).

If you had the options below for that trip, which would you have chosen? (The + and - values show the range of travel times)

Choose one of the following answers:

**Option A:** Drive by myself on Main freeway lanes
- Time of Day: morning rush hour
- Average travel time: 17 minutes but can be anywhere from 5 minutes faster to 5 minutes slower.

**Option B:** Carpool with others on Main freeway lanes
- Time of Day: morning rush hour
- Average travel time: 17 minutes but can be anywhere from 5 minutes faster to 5 minutes slower.

**Option C:** Drive by myself on Toll lanes
- Time of Day: morning rush hour
- Average travel time: 11 minutes but can be anywhere from 1 minute faster to 1 minute slower.

**Option D:** Carpool with others on Toll lanes
- Time of Day: morning rush hour
- Average travel time: 11 minutes but can be anywhere from 1 minute faster to 1 minute slower.

FIGURE 2a: A Typical Scenario in Picture Format with Different Modes of Travel

FIGURE 2b: A Typical Scenario in Word Format with Different Modes of Travel
Data Collection

The survey was posted on a Texas Transportation Institute server and was made available for public access through the www.katysurvey.org website. The data collection process started on June 1, 2010, and continued until July 15, 2010. Residents of Houston who used the Katy Freeway on a regular basis or who had used it recently were encouraged to participate in the survey. The existence of the survey was advertised to the public through online and news media. E-mails were also sent to the 3,077 respondents from the previous (2008) survey who had indicated an interest in participating in a follow-up survey. To increase the participation in the survey, two gas cards worth $250 each were given to two randomly chosen respondents. The contact information for the drawing was stored separately and could not be linked to the survey responses.

The 2010 data collection generated 3,325 responses that were completed to a point where they were useful for analysis. For the five days prior to June 17th there was an average of only 32 responses per day (see FIGURE 3). Early in the morning of June 17, e-mails requesting participation in the current survey were sent to the 3,077 respondents of the previous 2008 survey who had indicated their interest in a follow-up survey. No other advertising was initiated near this date. Therefore, almost all of those 869 responses on June 17 and June 18 were likely coming from travelers who had completed the prior survey. It should be noted that both 2008 and 2010 surveys were anonymous, so even if there was a common respondent for both the surveys, his/her exact responses could not be exactly matched. Although respondents’ personal information was not available to match the 2010 survey responses to the 2008 survey responses, the survey server recorded the referral URL of each respondent. After checking the referral URL for responses on June 17 and 18 it was found that almost all of those responses were redirected from e-mails, further increasing the likelihood most of these responses were from 2008 survey respondents.
Mixed Logit Modeling Methodology

The mixed logit model, or random parameter logit model, is a relatively recent innovation in discrete choice modeling. It is considered by many researchers as the most promising tool for modeling discrete choice data (27). A mixed logit model allows the researcher to account for both observed and unobserved heterogeneity of individuals in the models (28). With the mixed logit model, it is also possible to model repeated responses from individuals (panel data), scale differences in data sources (although this is also possible with more basic models), modify error structures, and accommodate heteroscedasticity (non-constant variance) from various sources (28, 29, 30, 31, 32, 33). Travelers need not be particularly similar to one another in any way except their shared use of the freeway, which is why the mixed logit modeling was used in this research.

Standard random utility theory suggests that the utility of an individual $i$ ($i = 1, 2, ..., n$) choosing an alternative $j$ ($j = 1, 2, ..., J$) in a given choice set $s$ ($s = 1, 2, ..., S$) can be written as Equation 1. Each individual chooses an alternative in a choice set that maximizes his/her utility ($U$), illustrated below in linear form.

$$U_{i,j,s} = \beta_{i,j,s}^T \theta + \varepsilon_{i,j,s}$$

(1)

where, $\theta$ = vector of coefficients,
\( \mathbf{X}_{ijk} \) is the \((K \times 1)\) vector of \(K\) independent variables which include alternative specific constants, characteristics of the individuals, characteristics of the alternative and other descriptive variables affecting the choice.

\( \epsilon_{ijk} \) is the error components which may be due to unaccounted measurement error, correlation in the parameters, unobserved individual preferences, and other similar unobserved characteristics of the choice-making.

The first term on the right hand side of Equation 1 is called the systematic part of utility function. The last term is called the stochastic part or random (error) part.

In a mixed logit model, the parameters in the random utility function (Equation 1) are assumed to be random and may vary across individuals to introduce heterogeneity among individuals. The parameters can be specified as in Equation 2.

\[
\beta_{ijk} = \bar{\beta}_k + \sigma_k u_{ijk} \tag{2}
\]

where, \( \bar{\beta}_k \) is the population mean for the \(k\)th attribute,

\( u_{ijk} \) is the individual specific heterogeneity with mean 0 and standard deviation (scaled to) 1, and

\( \sigma_k \) is the standard deviation of the (assumed) distribution of the \( \beta_{ijk} \)s around \( \overline{\beta}_k \).

For each or all of the random parameters or coefficients, various empirical distributions can be assumed, although in practice, the possibilities are usually limited to a few well-known families (the normal, the log normal, and the triangular). In our case, the travel time, toll, and travel time variability parameters can all be assumed to be random parameters and have different distributions. However, in this research, we are interested in estimating the value of travel time savings and value of travel time reliability, both of which are estimated as ratios of two parameters. Hence, assuming random distributions for travel time, travel time variability, and toll may add complexity in estimating the VTTS and the VOR (18). Choosing the right distribution is also critical for drawing meaningful inferences from the estimates.

One of the more commonly used distributions in practice is the triangular distribution for the travel time parameter (see 34 for more on this distribution).

Preference heterogeneity in the mean and heteroscedasticity relating to the variance can also be introduced in the mixed logit by specifying the random parameters to include additional terms to capture the observed and unobserved heterogeneity around the mean of the random parameters (see 18, 32).

The conditional probability with the above specification of utilities is given by Equation 3 (18, 32, 33).

\[
\mathit{Prob}_{ij}(j_i|X_{ij}, \Omega, \nu_i) = \frac{\exp(\beta_{ij}^\top \nu_i)}{\sum_{j=1}^J \exp(\beta_{ij}^\top \nu_i)} \tag{3}
\]
where, $\Omega$ = the parameter set that collects all the structural parameters (the underlying parameters in the model/equation).

The conditional probabilities (Equation 3) are functions of the unobserved individual specific random terms; because of this, these cannot be used to form the likelihood function for the estimation of the parameters (33). By integrating the heterogeneity out of the conditional probabilities, the unconditional choice probability can be formed. However, the integral does not exist in a closed form; in other words, it cannot be integrated using elementary mathematical functions. Therefore the integral has to be approximated using simulation methods (see 35, 36, 37). Random draws are taken from each of the random parameters, and the utilities are calculated for each of these draws. The calculated utilities are used to calculate the probabilities and finally are averaged to estimate the unconditional probabilities. Those simulated probabilities are used to form the simulated likelihood function. The estimation procedure is affected by the number of draws taken during the estimation process and the sample size. Halton draws are more efficient and give more precise results than random draws (38, 39). It is very common to find 100 to 500 Halton draws being used for the model estimation (28, 32, 33). In this research, we used 200 Halton draws to estimate the mixed logit models.

RESULTS

As described earlier, on June 17, 2010, emails were sent to the 3,077 previous survey respondents who indicated a willingness to take the follow-up survey. The emails alerted potential respondents to the new survey and encouraged them to participate. Upon verifying the referral URL to the survey, it was found that almost all of the 869 responses on June 17 and 18 were in response to the initial emails. Therefore, the 869 responses on those dates can reasonably be assumed to be responses from the previous survey respondents, although this is not guaranteed. The evidence (the referral URL plus timing of the responses [see FIGURE 3]) indeed suggests that most are repeat respondents. Further, the socio-economic characteristics of the 869-2010 survey respondents were compared to the 2008 survey respondents (see TABLE 1). The sample (869 respondents) closely resembled the 2008 survey sample in most of the categories presented in TABLE 1, further affirming that the 869 respondents participated in the 2008 survey.

Mixed logit models were developed for those 869 respondents (see TABLE 2) and were compared to models developed using all 2008 survey data. 200 Halton draws were used to estimate the mixed logit model for these 869 respondents. Travel time, travel time reliability parameters, and alternative specific constants (ASCs) were assumed to be random parameters. A triangular distribution was assumed for the travel time and travel time reliability parameters, and a normal distribution was assumed for the ASCs. Only the travel time, travel time reliability, toll/hourly wage rate, and ASCs were included in the model to easily compare results to the models developed from the 2008 survey responses. Note that the hourly wage rate was estimated as the respondents’ annual household income divided by 2,000 (approximate number of work hours in a year). In fact, this is often necessary because many households do not earn a known hourly wage so would have difficulty reporting one.
Devarasetty, Burris, and Shaw

TABLE 1: Comparison of Characteristics of 869-2010 Survey Respondents with 2008 Survey Respondents

<table>
<thead>
<tr>
<th>Variable of Comparison</th>
<th>Percentage of 869 Respondents from 2010 Katy Freeway Survey</th>
<th>Percentage of Total Respondents from 2008 Katy Freeway Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of Males</td>
<td>57</td>
<td>58</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 to 24</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>25 to 34</td>
<td>18</td>
<td>71</td>
</tr>
<tr>
<td>35 to 44</td>
<td>22</td>
<td>27</td>
</tr>
<tr>
<td>45 to 54</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>55 to 64</td>
<td>23</td>
<td>27</td>
</tr>
<tr>
<td>65 and older</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Average Number of People in Household</td>
<td>2.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.73&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Average Number of Vehicles in Household</td>
<td>2.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.40&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Household Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Adult</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>Unrelated Adults</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Married without Children</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>Married with Children</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>Single Parent Family</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than High School Graduate</td>
<td>Less than 1</td>
<td>Less than 1</td>
</tr>
<tr>
<td>High School Graduate</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Some College or Vocational School</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>College Graduate</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Post Graduate Degree</td>
<td>24</td>
<td>22</td>
</tr>
<tr>
<td>Annual Household Income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; $25,000</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>$25,000 to $75,000</td>
<td>35</td>
<td>29</td>
</tr>
<tr>
<td>&gt; $75,000</td>
<td>60</td>
<td>68</td>
</tr>
</tbody>
</table>

<sup>a</sup> Average value

The mean values of the ASCs are all negative, implying that DA-GPL (the base mode) is preferred to other modes, ceteris paribus. The estimated values of the travel time, travel time variability, and the toll/hourly wage rate coefficients are negative, which is in accordance with intuition, implying that higher values of these variables are less preferred in choosing a mode of...
travel. The implied mean VTTS for this model was estimated as 48 percent ($28/hr) of the sample mean hourly wage rate, and the VOR was estimated as 56 percent ($33/hr) of the sample mean hourly wage rate.

From the 2008 survey, the VTTS was estimated as 55 percent, 52 percent, and 40 percent of the hourly wage rate by D-efficient, random level generation, and smart random design strategies, respectively. By comparing those values with the current (2010) estimates, it was found that the 2008 values (from 40 to 55 percent of hourly wage rate) were quite similar to the current estimates (48 percent of the hourly wage rate).

TABLE 2: Mixed Logit Model for the 869 Survey Respondents Who Likely Also Participated in the 2008 Survey

<table>
<thead>
<tr>
<th>Variable</th>
<th>Alternative(s)</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Random Parameters in the Utility Functions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASC-CP-GPL</td>
<td>CP-GPL</td>
<td>-9.86$^*$</td>
<td>1.48</td>
<td>-6.67</td>
</tr>
<tr>
<td>ASC-DA-ML</td>
<td>DA-ML</td>
<td>-2.93$^*$</td>
<td>0.30</td>
<td>-9.87</td>
</tr>
<tr>
<td>ASC-CP-ML</td>
<td>CP-ML</td>
<td>-7.22$^*$</td>
<td>0.62</td>
<td>-11.66</td>
</tr>
<tr>
<td>Travel Time (minutes)</td>
<td>All</td>
<td>-0.12$^*$</td>
<td>0.03</td>
<td>-3.81</td>
</tr>
<tr>
<td>Travel Time Variability (minutes)</td>
<td>All</td>
<td>-0.14$^*$</td>
<td>0.06</td>
<td>-2.39</td>
</tr>
<tr>
<td><strong>Nonrandom Parameters in the Utility Functions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toll($)/Wage Rate ($/hr)</td>
<td>All</td>
<td>-15.08</td>
<td>2.24</td>
<td>-6.74</td>
</tr>
<tr>
<td><strong>Derived Standard Deviations of Random Parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASC-CP-GPL</td>
<td>CP-GPL</td>
<td>5.91</td>
<td>0.88</td>
<td>6.73</td>
</tr>
<tr>
<td>ASC-DA-ML</td>
<td>DA-ML</td>
<td>3.44</td>
<td>0.30</td>
<td>11.49</td>
</tr>
<tr>
<td>ASC-CP-ML</td>
<td>CP-ML</td>
<td>5.86</td>
<td>0.56</td>
<td>10.55</td>
</tr>
<tr>
<td>Travel Time$^+$ (minutes)</td>
<td>All</td>
<td>0.17</td>
<td>0.09</td>
<td>1.92</td>
</tr>
<tr>
<td>Travel Time Variability$^+$ (minutes)</td>
<td>All</td>
<td>1.08</td>
<td>0.15</td>
<td>7.36</td>
</tr>
<tr>
<td><strong>Goodness-of-fit</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log-likelihood for Constants Only Model</td>
<td>-2577.79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log-likelihood at Convergence</td>
<td>-1736.38</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.32</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^*$Mean of the random parameter estimate.

$^+$Spread of the distribution (standard deviation = spread/$\sqrt{6}$).

Adjusted $R^2 = 1 - \frac{LL(C) - K}{LL(C) - K_c}$ where, $LL(C) = \text{log-likelihood for the estimated model}$, $K = \text{number of parameters in the estimated model}$, $K_c = \text{number of parameters in the constants only model}$; ASC = alternative specific coefficient.

Since the values estimated from the 2010 survey were similar to those estimated from the 2008 survey, this suggests that travelers’ willingness to pay for travel on MLs was in fact quite
similar to what was predicted in the 2008 survey. Further, the 869 responses from the 2010 survey respondents who also responded to the 2008 survey were analyzed to check their use of MLs (see TABLE 3). 66.3 percent of those respondents had used MLs. This compares favorably to the percentage who, in 2008, predicted that they would (42.9 percent) or might (34.5 percent) use MLs once they opened. Nearly 59 percent of those who used MLs said that they paid for their travel on the lanes (travel on the lanes as an HOV or transit rider is toll-free).

TABLE 3: Managed Lane Usage by the 869 Respondents of the 2008 Survey

<table>
<thead>
<tr>
<th>Managed Lane Use</th>
<th>Category</th>
<th>Percentage of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted Interest in Using Managed Lanes (2008 Survey)</td>
<td>Yes</td>
<td>42.9</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>22.5</td>
</tr>
<tr>
<td></td>
<td>Maybe</td>
<td>34.5</td>
</tr>
<tr>
<td>Ever Used Managed Lanes (2010 Survey)</td>
<td>Yes</td>
<td>66.3</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>33.7</td>
</tr>
<tr>
<td>Paid for Travel on the Managed Lanes (2010 Survey)</td>
<td>Yes</td>
<td>58.7</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>41.3</td>
</tr>
<tr>
<td>Average Toll Paid (2010 Survey)</td>
<td>$1.00 or less</td>
<td>24.0</td>
</tr>
<tr>
<td></td>
<td>$1.01 to $2.00</td>
<td>20.8</td>
</tr>
<tr>
<td></td>
<td>$2.01 to $4.00</td>
<td>30.7</td>
</tr>
<tr>
<td></td>
<td>More than $4.00</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>Do not Remember</td>
<td>19.5</td>
</tr>
<tr>
<td>Average Travel Time Savings (2010 Survey)</td>
<td>None</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>1–2 minutes</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>3–5 minutes</td>
<td>11.3</td>
</tr>
<tr>
<td></td>
<td>6–10 minutes</td>
<td>26.9</td>
</tr>
<tr>
<td></td>
<td>11–15 minutes</td>
<td>22.8</td>
</tr>
<tr>
<td></td>
<td>16–20 minutes</td>
<td>14.2</td>
</tr>
<tr>
<td></td>
<td>21–30 minutes</td>
<td>9.5</td>
</tr>
<tr>
<td></td>
<td>More than 30 minutes</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td>Unsure</td>
<td>5.8</td>
</tr>
</tbody>
</table>

The 869 survey respondents’ reported willingness to pay for travel time savings was estimated by dividing their reported average toll paid by their average perceived travel time savings that they reported in the survey (see FIGURE 4). This ‘reported’ VTTS was estimated to be, on average, $13/hour. The VTTS for those 869 respondents was also estimated from the mixed logit model developed from their SP responses. The SP estimates of VTTS are considerably higher than the travelers’ reported VTTS (see FIGURE 4). The mean of the estimates from the logit model was $28/hour. The SP survey estimates of willingness to pay ($28/hour) were therefore approximately twice as much as those respondents reported they were
paying ($13/hour). First, note that the SP estimates are based on marginal changes (the derivatives that yield the usual ratio of coefficients imply small changes), and are thus indicating the value of one more hour saved. The calculation based on average actual tolls is an average VTTS, thus it is quite possible that the average, spread out over all hours saved, is smaller than the value for a precious additional hour saved at the margin. This difference between the two estimates may also be an indication that:

1. travelers are willing to pay more than they actually currently do,
2. travelers think they are saving more travel time by using the MLs than they actually do, or
3. travelers are also willing to pay for the added reliability of the MLs that is not included in the $13 estimate of their ‘reported’ VTTS which only includes the travel time savings.

In an attempt to determine which of these three potential hypotheses may be correct, travelers’ VTTS was also estimated from actual Katy Freeway ML usage data for the year 2009. This value was obtained by averaging the VTTS from both ML and GPL users, weighted by the corresponding number of users. We included all travelers, not just ML users, since the 869 respondents also included many who did not choose MLs in their survey responses. For ML users the VTTS is obtained by dividing the actual toll paid by their actual travel time savings for all toll paying customers. For GPL users VTTS was assumed to be one-half of the VTTS of the ML users (see 25 for complete description of the estimation procedure). The average VTTS estimated for Katy Freeway travelers in this manner was $51/hour. The combined estimates of VTTS and VOR from the SP survey ($61/hour [VTTS+VOR]) were close to the average VTTS based on actual toll payments and TTS ($51/hour). Therefore, it would appear that travelers are factoring in (consciously or subconsciously) some additional value for the reliability of the managed lanes when actually choosing to pay for and use the lanes. This is consistent with a
positive risk premium for risk averse travelers. However, revealed preference data that uncovers a total willingness to pay cannot easily be decomposed into separate components.

Survey respondents were asked how much travel time they saved by using the MLs. On comparing actual TTS (using sensors on the lanes) to these reported TTS we found survey respondents think they are saving much more than the lanes save travelers on average. For example, from the 2009 actual usage data, the average weekday (excluding holidays) TTS for eastbound ML travelers from 7:00 AM to 9 AM was 4.1 minutes. Survey respondents who traveled at that time in that direction reported saving 14.2 minutes. Some of this difference (14.2 vs. 4.1) is likely due to travelers selecting the most congested days to use the MLs but this does not likely account for the entire difference. It appears travelers are also overestimating their TTS.

CONCLUSIONS

This study examined if Houston Katy Freeway travelers were paying for their ML travel as they indicated that they would in a previous (2008) survey. The multinomial logit models developed from the 2008 survey responses obtained by three design methods—D-efficient, random level generation, and smart adjusting random design—are used to estimate the mean VTTS. We find this to be 55 percent, 52 percent, and 40 percent of the hourly wage rate, respectively. A total of 869 respondents from the 2008 survey were also quite likely to have been participants in the more recent 2010 survey. A mixed logit model for those 869 respondents was developed to estimate their implied mean VTTS and VOR. The implied mean VTTS was estimated as 48 percent of the sample hourly wage rate. The previous survey estimates of VTTS are very close to the current estimates. From this comparison, it can be inferred that travelers’ willingness to pay for MLs did not change much from pre- and post-opening of the MLs. A total of 42.9 percent of 2008 survey respondents indicated that they would use the MLs once they were open, and 34.5 percent indicated that they might use MLs. From the responses from the 869 2010 respondents who also responded to the 2008 survey, it was found that 66.3 percent of them used MLs. From all of the above findings, it can be said that travelers are actually paying for travel as they said they would in the previous 2008 survey.

The VTTS for Katy Freeway travelers based on what they are actually paying to use the Katy Managed Lanes ($51 per hour of travel time saved on average) is close to the estimates we developed from their survey responses of their willingness to pay for travel time savings plus improved reliability (a combined total of $61/hour). Therefore, it appears that travelers are including both their VTTS plus (consciously or subconsciously) some additional value for the reliability of the managed lanes when choosing to pay for and use the lanes. Because of this key result, we argue that when estimating the value (in a benefit cost analysis) or usage (in a traffic and revenue study) of managed lanes, the improved reliability of travel offered by the managed lanes should be included in the estimate.

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Devarasety, Burris, and Shaw

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