UNREVEALED PREFERENCES: UNEXPECTED TRAVELER RESPONSE TO PRICING ON MANAGED LANES

Mark W. Burris
Texas A&M University
3136 TAMU
College Station, Texas 77843
Tel: 979-845-9875
Email: mburris@tamu.edu

John F. Brady
Cintra US
4545 Lyndon B Johnson Fwy
Dallas, TX 75204
Tel: 972-877-5355
Email: jbrady@lbjexpress.com

Submitted for possible presentation and publication at the 2018 TRB Annual Meeting.

Word count: 5,753 words text + 6 tables/figures x 250 words (each) = 7,253 words

Resubmission Date: November 13, 2017
ABSTRACT

This paper addresses Priced Managed Lanes, where travelers may choose to pay a toll to travel on the managed lanes (MLs) to realize generally faster, more reliable travel than on the adjacent, toll-free general purpose lanes (GPLs). These lanes exist in many cities across the United States and are becoming more common as transportation agencies look for innovative ways to increase capacity and regulate demand for their roadways. Commonly, demand for these lanes is modeled assuming travelers choose between the MLs and GPLs primarily based on the cost and time savings of the MLs. While the traffic and revenue forecasts generated by these models have generally succeeded in estimating revenue, newly available empirical data from Katy Freeway and North Tarrant Express shows these models fail to capture how individual drivers make decisions. Most travelers on those freeways were not choosing—they always used the same lane regardless of travel time and toll. Travelers that used both sets of lanes often made choices that appeared counter intuitive based on travel time savings and toll rate. This research provides a preliminary investigation into this issue which calls into question all prior ML travel behavior research.

Keywords: Managed Lanes, Revealed Preference, Value of Time, Pricing, User Choice, Travel Behavior
INTRODUCTION
Priced Managed Lanes (MLs) present travelers with the option to pay a toll or meet certain other requirements to travel on the generally faster MLs. These lanes exist in many cities across the United States and are becoming more common as transportation agencies look for innovative ways to increase capacity and regulate demand for their roadways. The most common form of priced MLs is high occupancy/toll (HOT) lanes, on which high occupancy vehicles (HOVs) can travel for free or a reduced price but single occupancy vehicles (SOVs) must pay a toll—examples include I-15 in San Diego, I-35 in Minnesota, I-85 in Atlanta, I-495 in Northern Virginia, Katy Freeway in Houston, and North Tarrant Express in Dallas-Ft. Worth.

On a number of dimensions managed lanes have been successful. I-495, I-95 in Florida, and NTE have all reported substantial increases in throughput and decreases in corridor congestion following the addition of MLs (1). The revenue generated by priced MLs supports numerous initiatives, usually being reinvested in the corridor upkeep, supporting alternative transportation options, and repaying the cost of construction.

By design, MLs present users of a corridor with a simple choice: choose the generally slower-moving General Purpose Lanes (GPLs) or pay a toll to travel on the generally faster MLs. Understanding how drivers value, compare, and choose between these two alternatives now and in the future is a critical consideration in ML investment decisions, pricing strategies, and policy.

Research into travelers’ use of MLs to date has focused on the individual’s willingness to pay a toll to realize travel time savings. ML choice models focus on the trade-off between price (the toll) and value (usually, reduced travel time). More recently, researchers often include travel time reliability, arguing that all else equal, travelers will pay for a more consistent travel experience. These hypotheses were confirmed by surveys of travelers who would, on paper, pay reasonable toll amounts to save time and improve their travel time reliability.

This basic model is built on logical, sensible assumptions and is workable in a limited data environment where planners need few inputs beyond demographics, speed measurements, and traffic counts. However, there now exist a few ML freeways where trip data is available from both the GPLs and MLs, capturing individual traveler choices over a long time horizon. Surprisingly, these revealed choices do not confirm earlier hypotheses regarding lane choice. This research uses empirical trip data from both Katy Freeway MLs and North Tarrant Express Lanes to investigate lane choice on freeways with MLs. Novel findings include:

• Most travelers were not really choosing between lanes—they always used the same lane regardless of travel time and toll.

• Willingness to pay for travel time savings (expressed as toll paid divided by time saved on the MLs) was consistent across traveler groups when broken down by how frequently they traveled on the MLs.

• Travelers that did use both sets of lanes (termed “choosers”) often made choices that appeared counter intuitive based on travel time savings and toll rate.

This paper first reviews the state of the practice around ML use models, with a particular emphasis on how traveler lane choice is considered. The dataset and analysis is then introduced; a line of inquiry is followed and results noted. The paper concludes with highlights of this research and the authors’ thoughts on how to proceed.

LITERATURE REVIEW
VOT studies have found a strong relationship between the traveler’s hourly wage rate and his or her VOT (5). Various studies have estimated VOTs from 20 percent to 100 percent of the
traveler’s hourly wage rate. However, most literature has suggested that the VOT should be around 50 percent of the hourly wage rate for personal trips (6). For commercial trips, VOT may be as high as 1.7 times the average wage rate (7).

The majority of research efforts in the last 40 years have sought to update VOT using stated-preference (SP) surveys. Travelers being surveyed are generally presented with a set of predetermined, hypothetical travel alternatives and asked to state their preference. For example, would you prefer Option 1, which takes 10 minutes and requires a $2 toll, or Option 2, which takes 15 minutes but has no toll (8). The results of these surveys are used to develop logit equations that predict mode choice and estimate VOT. Carrion and Levinson (8) and Concas and Kolpakov (5) provide good overviews of VOT research.

To emphasize the extent to which Stated Preference VOT studies are relied upon in the practice of travel prediction, the U.S. Department of Transportation recommends values of time of $10.60 per hour for commuter travel and $21.46 per hour for business travel. The latest update to these guidelines (9) suggested a VOT of $12.50 in 2009 dollars for all purposes of travel combined. The US is not alone as many countries have incorporated VOT into their economic evaluation of transportation projects.

There are far fewer studies that have used revealed preference (RP) data, where travelers’ real-world choices are relied upon for all or part of the data used in the VOT analysis. Usually, SP and RP findings tend to differ, with RP studies often finding higher VOT. Researchers in California have examined travelers on SR-91 Express Lanes and the I-15 HOT lanes to determine VOT and value of travel time reliability (VOR) based on real world travel on those lanes. They combine RP data with some SP (survey) data in their analyses. Brownstone and Small (10) use the combined data to find VOT’s in the range of $20/hour. They, and Ghosh (11), note that the SP studies find VOT much lower than in RP studies. For example, Devarasetty et al., (12) found a fairly high ($50/hr) VOT for Katy Freeway ML travelers using combined SP and RP data. One popular hypothesis for the differences between SP and RP VOT is that travelers misperceive their travel times and costs. Devarasetty et al. (13) examined Katy Freeway travelers using both RP and SP data. They found that the responses to the question on how much time they saved by using the MLs overestimated actual travel time savings by a factor of three.

Despite their differences, both SP and RP studies to date examine driver choices as discrete events, decisions disconnected from the driver’s medium-term habits and experiences. Regional transportation models typically model a single day, deriving seasonal and annual results by applying scaling and annualization factors.

**Managed Lanes and VOT**

An operational ML facility provides the perfect opportunity to study driver responses to travel choices: pay to travel on the (generally) faster MLs or travel on the (generally) slower GPLs toll-free. Not surprisingly, considerable research has been undertaken to quantify traveler’s VOT on ML facilities, utilizing both SP and RP-based approaches. This includes a large number of papers by this author that surveyed ML travelers to better understand their VOT (12, 13, 14). These VOT were generally reasonable, although sometimes higher than in the existing literature.

VOT analyses is of particular interest in ML investment decision-making. Many traffic and revenue forecasting firms, along with toll road operators, spend considerable time and resources estimating the potential use of MLs based on VOT. Before construction begins, the modeled revenue stream is instrumental in securing financing for the project. Once operational, these models may be relied upon to inform pricing strategy or design changes.
Some meta-analyses of toll road forecasts (15) have found that traffic and revenues are often overestimated. However, estimates are tending to become better and most are within the range of actual revenues so that the facility can meet its financial obligations. To our knowledge, all of the recent major P3 ML projects that are in operation today have relied heavily on traffic and revenue forecasts modeled using VOT, including the North Tarrant Express (16), the I-495 Capital Beltway (17) and numerous others which have been more recently bid. At the time of writing, each of these projects have seen their debt ratings maintained or raised by rating agencies (18, 19), suggesting that on the whole, this aggregate approach has succeeded in approximating the revenue-generating potential of MLs. Recent theoretical work has begun to take into account some driver behavior that is rational but might not follow traditional model assumptions. For example, Lou et. al (2010) examine ML trips using boundedly rational user equilibrium where travelers may not adjust their trip for small travel time savings (20). This is a logical extension of previous modeling work and brings an important human element to the model.

Therefore, current methods appear to produce reasonable estimates of traffic and revenue in aggregate, and therefore one would assume have estimated a reasonable VOT. However, the data examined in our study finds the standard VOT-based assumptions, and even the advanced analysis concepts, do not hold when examining millions of individual driver choices.

With most of the VOT results derived from SP studies, there is some skepticism on how well those survey responses translate into real world travel choices. However, until now no one was able to look at individual travelers over time and examine how each was choosing between the paid MLs and the toll-free GPLs over time. With the rather unique datasets from Katy MLs and NTE (discussed in the next section) this research examined millions of travelers’ use of the MLs and how much they were willing to pay for the use of the lanes and the time they save. In theory, this would shed additional light on travelers VOT. However, these results were particularly surprising and contradict much of what was expected based on past research.

DATA

Data were obtained from the Katy and NTE Freeways in Texas. For both facilities, the MLs operated at free-flow or near free-flow speeds with rare exception and the GPLs would routinely become congested during typical peak hours.

The following sections describe the facilities and discuss the methods by which each dataset was collected and synthesized. They are quite similar, with a couple key distinctions between the projects:

- Display of travel times - Dynamic message signs display the GPL and ML travel times for key destinations along the Katy Freeway corridor. At NTE, travel times were not displayed during the study period. On both facilities, the ML conditions are easily visible from the GPL.
- Speed limit - Both ML and GPL have the same speed limit on Katy Freeway. At NTE, the MLs have a posted speed limit 10 mph higher than the GPLs. This difference gives the NTE a travel time advantage when both sets of lanes are uncongested.

Katy Freeway Data

The I-10 Katy Freeway connects City of Katy to downtown Houston. This 12-mile section of freeway has up to six GPLs and two variably priced MLs in each direction. The Katy Freeway
MLs generally require less travel time and are usually more reliable than the adjacent GPLs. The MLs are separated from the GPLs by flexible pylons. Drivers are required to pay a toll that varies depending on the time of day and the number of people in the vehicle. HOVs with two or more occupants and motorcycles can use MLs for free during HOV-free hours. HOV-free hours are Monday through Friday from 5 a.m. to 11 a.m. and 2 p.m. to 8 p.m. HOVs and motorcycles pay the same toll as SOVs at all other times. To avoid the toll during the HOV-free hours, HOVs and motorcycles must pass the toll plazas in the HOV lane, the leftmost lane of MLs.

TxDOT operates automatic vehicle identification (AVI) sensors located on both the MLs and GPLs along Katy Freeway. Figure 1 shows the location of the sensors, with each number indicating a specific sensor. These sensors detect vehicles with transponders (or tags) and record the unique transponder ID from the vehicle and time of detection. All vehicles that pay a toll on the MLs are required to use a transponder. Many other vehicles traveling on Katy Freeway also have transponders. The AVI data obtained from TxDOT consists of all sensor detection records from most of 2012, 2013, and 2014. The bulk of the analysis focuses on March, April, and May of 2014 so that it was more readily comparable to the three months of NTE data available.

The Harris County Toll Road Authority (HCTRA) operates the MLs and collects AVI data along the MLs at the three toll plaza locations (see Figure 1 for HCTRA sensors). These data obtained from HCTRA included the unique transponder ID, date and time of record, and toll paid (if applicable) for each vehicle traveling within the MLs for 2012, 2013, and 2014 (only...
through September because the data were obtained in October 2014). Travelers who did not pay to use the ML (including HOVs during rush hours and exempt public vehicles) were not included in the analysis.

To ensure that no transponder owner could be identified using the transponder IDs, each transponder ID was assigned a unique random ID, and the original transponder IDs were deleted. Therefore, the dataset could never be used to identify specific individuals traveling on Katy Freeway. The dataset could still be used to track the trips of vehicles throughout the three years based on the random ID that each vehicle was assigned.

Travel time and distance traveled by freeway travelers were calculated using the time and location of sequential detection of unique IDs. Based on the time of detection and the toll schedule, tolls were assigned to the trips that were detected at toll plazas in the MLs.

To estimate how much travelers value their travel time, a simulated trip on the alternative lane was created for each observed trip. For observed trips on the toll lane, the simulated trip was free on the GPLs, and vice-versa. Simulated trips started and ended at the same point on the freeway as the real trip, just in the opposite lane type. The simulated trip travel times were constructed from observed trips made by other vehicles within the same 15-minute interval on the same day the observed trip was made. For a small percentage of trips (less than 2 percent in the peak and shoulder, and 8 percent in the off-peak), no observed trips were available for the alternate lanes so a historical average was used.

By far the largest source of unusable data came from trips that alternated between lanes since it was impossible to determine their travel time savings. This was approximately 15 percent of trips and these trips were not included in the analysis. Quality control on the data did reveal other minor problems and some trips were unusable. Creation of these trips was a challenging process and more details are available in Sunghoon Lee’s dissertation (21).

The final dataset contained two records for each trip. The two records represented the two choices for the trip: the one that was made and the one on the lanes not chosen. The trip parameters included in the final dataset are the random ID, lane choice, travel time, total toll paid, and several variables not used in this research.

**NTE Data**

The North Tarrant Express (NTE) corridor is an east-west oriented 13-mile stretch of highway that serves as a circumferential road around Ft. Worth, TX and a primary highway route to access the DFW International Airport. Redevelopment of the corridor began in 2011, with works overseen by NTE Mobility Partners, LLC, a private consortium led by Cintra under a comprehensive development agreement with TxDOT. Since construction was completed in 2014, each direction contains two to three general purpose lanes, two tolled managed lanes, and continuous frontage roads. The MLs are concrete barrier-separated from the GPLs, effectively operating as a wholly separate highway-within-a-highway.

Vehicles that choose the MLs are required to pay a toll that varies dynamically in real time. Non-tag equipped vehicles and trucks may use the MLs for a higher toll rate. HOVs with two or more occupants and motorcycles can use the MLs for a 50% discount during rush hours and must pay the same toll as SOVs at all other times. To receive the discount, vehicles must electronically self-declare before their trip using a mobile app.

NTE maintains AVI sensors located on both the MLs and GPLs along the corridor. Figure 2 depicts the arrangement of the sensors, with each circle indicating a specific sensor...
array which includes at least one AVI positioned over each lane of travel. The data obtained from the AVI readers for this study consists of all sensor detection records from August-October 2015, a three-month time period with high data quality.

![AVI sensor locations along North Tarrant Express, westbound shown.](image)

To ensure privacy, the transponder ID records are stored on a secure server and the data anonymized and aggregated before being analyzed. The customer-specific information associated with the tag is maintained by the tag issuer to preclude the possibility of personally identifying customers on the NTE.

At the NTE, detections within a thirty minute time window for a unique tag were matched to create a trip. If both the origin and destination were detected, as was usually the case, the lane choice was recorded and the travel time was calculated. If the trip could have been made using the lanes that were not chosen by the traveler (the alternate lanes), the travel time for the alternative was calculated by taking the average travel time among drivers who chose the alternative lane within a +/- five minute window. Trips that utilized the managed lane had the toll amount assigned to the trip using the toll(s) charged to the vehicle. If a tag was only detected at one location, the “trip” was recorded, along with the lane choice, and toll (where applicable).

In all, the final dataset contained one record for each trip. The trip parameters considered in this study are the random ID, trip start time, lane choice, travel time on the chosen path, toll paid on the chosen path, travel time on the alternative path, and toll on the alternative path. Note that non-tag equipped vehicles, as they are not detected by AVIs, are not included in this dataset. Tag IDs identified as trucks were removed. HOV self-declared trips account for about 2% of rush-hour transactions at the NTE facility.

Both freeways were examined over a three month time period. For Katy Freeway this was March, April and May of 2014. These were the last 3 continuous months of data available.
for this freeway that did not include the lower volume summer months. For NTE this included August, September and October of 2015. This period of time was chosen for the high quality of data available in that window.

RESULTS
The results of this examination of real world travel choices on MLs begins with an examination of the size of the datasets used in the analysis (see Table 1). Previous SP and RP studies generally survey a few hundred to a few thousand travelers at most. Previous RP studies are conducted on datasets approximately that size. This dataset includes nearly 2 million unique travelers (transponders) making over 24 million trips across a three-month period. Therefore, the size of the dataset is orders of magnitude larger than previous studies and includes the vast majority of vehicles who paid to use the MLs. It uniquely considers data from two different roadways in two different cities. If the observed travel behavior is similar on both facilities then observed deviations from long-held assumptions must be, at the very least, not attributable to the unique design, driver sentiment, small sample size, or the specifics of a single urban corridor. Table 1 describes the size of the dataset.
TABLE 1  Size of Datasets

<table>
<thead>
<tr>
<th>Freeway</th>
<th>Number of Transponders</th>
<th>Number of GPL Trips</th>
<th>Number of ML Trips</th>
<th>Total Number of Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katy</td>
<td>1,108,002</td>
<td>9,197,423</td>
<td>800,878</td>
<td>9,998,301</td>
</tr>
<tr>
<td>NTE</td>
<td>884,443</td>
<td>11,414,972</td>
<td>2,624,126</td>
<td>14,039,098</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,992,445</td>
<td>20,612,395</td>
<td>3,425,004</td>
<td>24,037,399</td>
</tr>
</tbody>
</table>

Katy: March, April and May of 2014. NTE: August, September and October of 2015.

In theory, all tag-equipped vehicles on the Katy Freeway and NTE should consider which set of lanes to choose for each trip. The existing literature considers travel time saved, travel time reliability and price among the primary exogenous factors motivating choice. The traveler’s perceived value of these factors, combined with their willingness to pay and individual trip purpose should largely explain their choice. Therefore, it would be reasonable to assume that a frequent user making dozens of trips across a three month time frame would experience a combination of travel time savings, reliability, toll, and trip characteristics (such as trip purpose) would result in the choice to utilize the MLs at least once. However, this is certainly not the case, especially on Katy Freeway.

Table 2 shows how frequently a traveler (a unique tag ID) is observed to use the MLs given how frequently they travel on the freeway (ML and GPL combined). Using the Katy Freeway as an example, the most frequent travelers made over 30 trips per month (90 or more total trips) on the freeway. Approximately 56% of those frequent travelers did not use the MLs at all, 43% used both MLs and GPLs, while just under 1% used the MLs exclusively. Therefore, almost half of this group is clearly considering MLs—but this group represents only 4.4% of the transponders observed on the freeway. Most travelers used the Katy Freeway 1 to 3 times per month (infrequent users) and only 7 percent of those travelers used both sets of lanes during the three month period. For all Katy travelers combined, only 12 percent were “choosers”—those that selected both lane types at least once. At the NTE there were relatively more choosers across all frequency groups, however, a sizable number did not use the ML at all during the study period—we observed that 48% of all travelers and 33% of the most-frequent travelers at NTE exclusively used the GPL.
TABLE 2  Percentage of Travelers Choosing MLs by Frequency of Travel

<table>
<thead>
<tr>
<th>Frequency of Freeway Travel</th>
<th>Roadway</th>
<th>Share of Trips on the MLs</th>
<th>Number of Tags</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0%</td>
<td>1% to 99%</td>
</tr>
<tr>
<td>Infrequent (1-3 trips per month)</td>
<td>Katy</td>
<td>89.3%</td>
<td>6.8%</td>
</tr>
<tr>
<td></td>
<td>NTE</td>
<td>52.9%</td>
<td>26.9%</td>
</tr>
<tr>
<td>Sometimes (4-12 per month)</td>
<td>Katy</td>
<td>68.5%</td>
<td>30.6%</td>
</tr>
<tr>
<td></td>
<td>NTE</td>
<td>35.1%</td>
<td>61.9%</td>
</tr>
<tr>
<td>Commuter Level 1 (13-29 per month)</td>
<td>Katy</td>
<td>51.9%</td>
<td>47.1%</td>
</tr>
<tr>
<td></td>
<td>NTE</td>
<td>28.8%</td>
<td>69.8%</td>
</tr>
<tr>
<td>Commuter Level 2 (30 or more per month)</td>
<td>Katy</td>
<td>55.8%</td>
<td>43.5%</td>
</tr>
<tr>
<td></td>
<td>NTE</td>
<td>33.3%</td>
<td>65.9%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>Katy</td>
<td>84.4%</td>
<td>12.3%</td>
</tr>
<tr>
<td></td>
<td>NTE</td>
<td>47.5%</td>
<td>37.2%</td>
</tr>
</tbody>
</table>

Katy: March, April and May of 2014. NTE: August, September and October of 2015.

The frequency with which the travelers used the freeway did not appear to substantially influence their likelihood of being choosers. With the exception of the infrequent group, travelers tended to exhibit similar likelihood of being choosers at each facility. These data are only transponder reads and there is no information on the users, their trip purposes, trip urgency, or even if it was the same driver (for example, it could be different family members driving on different trips) each time the transponder was identified.

Further insights into the reasons behind a traveler’s choice cannot be derived from this data and so we posit two hypotheses. The first relates to decision aversion. Some travelers do not want to be faced with making a decision on each trip. Possibly even worse would be the feeling you have made a bad decision--taking the MLs when the GPLs were about the same speed or taking the GPLs when the GPLs were heavily congested. A traveler who has decided to always take the GPLs (for example) is no longer faced with a decision and can therefore no longer make a bad decision. A second hypothesis is that infrequent users may not fully understand how to use the lanes, where to enter/exit, or when to get the best value (receive substantial time savings for the toll paid). By contrast, perhaps the more frequent users of the freeway are more likely to be choosers because they have a better understanding of these same concepts. This hypothesis can be examined by looking at the toll paid versus the travel time saved for these individual groups of travelers (see Figure 3).
Figure 3 displays the toll amount paid for each trip on the ML divided by the travel time saved by using the ML. We use this as a surrogate measure for a traveler’s willingness to pay since it shows that the traveler opted to pay at least that much. Additionally, it only represents those travelers who did choose to pay the toll. Other travelers might have been willing to pay a toll, just not quite as much as the toll that was charged at the time of their travel. Finally, it implies that the traveler would know how much travel time they would save. It is likely that the traveler would have a rough idea of their travel time savings (see data section), but probably not the exact amount. Nevertheless, this surrogate willingness to pay was remarkably consistent across traveler groups. Frequent travelers (termed ‘commuters’) ended up getting the same value for their toll dollar as ‘sometimes’ travelers and ‘infrequent’ travelers. This would suggest either that frequency of travel not improve the traveler’s ability to use the MLs to maximum advantage (largest time savings for smallest toll) or that the travelers are not trying to maximize this value proposition discretely on each trip. Anecdotal evidence suggests such an analysis is far more cognitive load than most travelers are willing to spend on planning their trip.

Also, approximately nine percent of ML trips across all groups occurred when the ML took longer and this resulted in a negative willingness to pay. Clearly the traveler did not want to pay to go slower, but chose the MLs for other reasons. When looking at the data in aggregate as in Figure 3 it is difficult to delve any further into this. Therefore, the toll paid and travel time saved was next examined at a disaggregate level.

Figure 4 below summarizes a randomly-selected commuter’s workday PM peak period trip choices observed across a one month period in September 2015 on the NTE. Each mark represents a trip with the choice of lane indicated by the shape.
What is remarkable about this pattern, which we also observed among choosers in aggregate, is that the price and time savings, even across a wide range, offers little help in predicting the individual traveler’s lane preference for a specific trip. This particular driver was presented with prices between $3.75 and $6.10 and time savings between a few minutes and about 10 minutes. If the prevailing normative theory held at the individual level, this driver would have a higher affinity for the ML for trips on the right-hand side of the figure (similar price, higher time saved).

Without additional data we, again, can only posit hypotheses about this observation. One is that the driver’s revealed preference for the MLs--in this specific case, 8 out of 18 trips--is not the result of eighteen discrete choices, carefully informed by trip purpose, price, value of reliability, and travel time, but rather an unobservable change that outweighs the classic VOT assumptions. For example, sometimes there is an event (for example, their turn to cook dinner) so the user must be on time while other days there is flexibility in arrival time. Or, possibly, it could simply be the mood of the traveler. Some days they do not feel like dealing with GPL traffic or they feel like giving themselves the luxury of a free-flow trip home (we assume home based on the regular PM occurrence of this trip).
CONCLUSIONS AND FURTHER RESEARCH

“I call it theory-induced blindness: once you have accepted a theory and used it as a tool in your thinking, it is extraordinarily difficult to notice its flaws. If you come upon an observation that does not seem to fit the model, you assume that there must be a perfectly good explanation that you are somehow missing... Disbelieving is hard work.”
- Daniel Kahneman. Thinking, Fast and Slow (22)

A favorite interview question of one of the authors is “Imagine that a person used the NTE highway yesterday and I want your help guessing if they chose the ML or GPL. You can ask me [the interviewer] or the driver for any information to help you guess. What would you ask?” The reader may not be surprised to learn that the vast majority of students of transportation, without blinking, ask about the level of congestion yesterday and ask the driver how much money they make, if they had a passenger in the car, the purpose of their trip, and how many children they have. These are among the typical inputs to a model of ML use. It is a case of theory-induced blindness. Compared to the depth of information within the student’s grasp, his proposed solution is shallow. He sticks with what he knows and passes up the opportunity to ask the questions that non-transportation students tend to come up with first, like “Do you often use the express lanes?”.

After this preliminary review of this dataset, we have arrived at a few conclusions. First, many travelers on priced ML corridors are not choosing between the lanes. This finding on its own is not inconsistent with the classic VOT model or even more modern bounded rational behavior models, but it is notable that a substantial number of apparently informed, frequent drivers are sticking to one set of lanes across diverse circumstances. Several hypotheses were posited, including lack of understanding of the MLs and decision aversion. Better understanding of how to predict if a traveler is a “chooser” or “non-chooser” would be a significant step forward in predicting the use of MLs.

Second, predicting when a chooser will select MLs versus GPLs is not straightforward. We set aside the question of the price-time savings trade off and observe that frequent drivers of the highway do not exhibit behavior that suggests they are ‘optimizing’ their lane choice any more than the very rare user. Third and finally, individual lane preferences observed over time suggests choosers do not seek to ‘optimize’ each trip, but rather select a mix of lane choices that does not correspond to travel time savings and toll paid. How such decisions are made should be an area of intense future research and would be critical in developing an alternative, cohort-centric approach to understanding and forecasting managed lane use over time.
ACKNOWLEDGMENTS

The authors wish to thank TxDOT, Houston TranStar, and the Harris County Toll Road Authority for providing the data for Katy Freeway. Many Texas A&M University students helped with Katy Freeway data cleaning and database development, including Sunghoon Lee and AKM Abir. These earlier efforts that included data cleaning and database development were funded in part by the Policy Research Center at the Texas A&M Transportation Institute, the Texas Department of Transportation, and the Federal Highway Administration through the University transportation Centers program. The funding from these sources is gratefully acknowledged. The authors also wish to thank the NTE technical team, especially Wei He, whose analytical techniques underpinned the NTE’s analysis. Also Ricardo Sanchez and the Cintra executive team for their foresight to install AVI devices at NTE. Any errors or omissions are the fault of the authors.
REFERENCES


18. Moody's affirms NTE Mobility Partners LLC's Baa2 senior PAB
   https://www.moodys.com/research/Moodys-affirms-NTE-Mobility-Partners-LLCs-Baa2-
   senior-PAB-and--
   PR_350038?WT.mc_id=AM~RmluYW56ZW4ubmV0X1JTQl9SYXRpbmdzX05id3NfTm9f

19. Transurban Primer (2016) https://www.transurban.com/content/dam/investor-

20. Lou, Y., Y. Yin, and S. Lawphongpanich. Robust congestion pricing under boundedly
    rational user equilibrium. Transportation Research Part B: Methodological, Vol. 44, No. 1,

    Department of Civil Engineering, Texas A&M University, College Station, Texas.