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Online Appendix for

The Value of Urgency: Evidence from Congestion Pricing Experiments

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(for reference only; not for publication)

This appendix provides details on the construction of the data, the tabular results for robustness tests using alternate specifications, and descriptive figures. In Appendix A, we provide further details on the data, including the rationale for the choice of the I-10W, background information on the I-10W, and details regarding matching of the aggregate PeMS flow and speed data to repeat transaction-level transponder data. Appendix B provides the full derivation of the conceptual framework presented in section III.A of the paper. Appendix C provides proofs of the identification of marginal willingness-to-pay for travel time savings from the ExpressLanes toll under continuous and discrete segment length. Appendix D includes details comparing our core results to some key prior literature. Appendix E includes descriptive figures related to each of the datasets and the ExpressLanes policy. Appendix D presents additional tables outlining descriptive statistics of our data and alternate specifications as robustness checks.

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Appendix A. Additional Data Discussion

This appendix provides further details on the datasets discussed in Section II.

Corridor Selection.—Of the two ExpressLanes roadways, the I-10 corridor near downtown LA was selected for our central analysis for several reasons. The I-10 had a later start date than the I-110 ExpressLanes, which resulted in a higher rate of adoption of transponders at program start on the I-10. In addition, the I-110 ExpressLanes started just before the Thanksgiving holiday when traffic patterns would be expected to deviate from regular commuting, and there was a blackout of transponders along the I-110 corridor right after the program start.

Of the two directions of travel along the I-10, the westbound direction was selected for the following reasons. First, the I-10 W corridor travels east of Downtown Los Angeles (running from El Monte to Downtown) and is the predominant morning commuting direction as it connects a major residential center to a major employment center. As a result, it is one of the most congested morning weekday commuting corridors in the country. Second, data was available for the I-210 W, a competing route 5 miles north of the I-10. Travel times for this alternate route allow us to test the robustness of our assumptions about the commuting patterns on the I-10 W as shown in Appendix Table E.8. Third, while the I-10, in general, has one of the highest detector concentrations of any freeway in general, the detector coverage in the westbound direction is particularly high (3.5 per mile in the mainline lanes, 2.73 per mile in the HOV lanes) as shown in Appendix Figure E.8. This density ensures that the travel times reported by PeMS are not overly dependent upon a small set of detectors.

Background on the I-10 and the ExpressLanes Program.—The 10.5-mile section of the I-10 W analyzed is shown in Appendix Figure E.8. It runs between the suburb of El Monte and downtown LA. With the exception of the 3+ occupant requirement during peak travel times, this route is fairly representative in terms of size and design for the LA region. The road generally has barriers on both sides with a shoulder for stopped vehicles on the right.

On February 23rd, 2013, Los Angeles converted the High Occupancy Vehicle (HOV) lanes on the I-10 into a High Occupancy Toll (HOT) facility, as part of the ExpressLanes program. This was the second of such conversion in Los Angeles, the first being the I-110 ExpressLanes, which opened on November 10th, 2012. For our main results we consider the initial period of the policy between February 25th, 2013 to December 31st, 2013. By starting on February 25th, we have allowed sufficient time for drivers in Los Angeles to learn how to use the ExpressLanes.

The program opened the lanes to Single Occupant Vehicles (SOV) who were charged a per-mile toll ranging from $0.10 to $15.00, debited from a FasTrak account linked to a required transponder in the vehicle. The ExpressLanes function such that once the maximum price is reached the lane is closed to further SOV traffic. The lane was never closed during the period considered on the I-10 W.

The goal of the program was to increase the total throughput of these roads and to raise funds to maintain the corridors. Maximum throughput is maintained along the ExpressLanes through a level-of-service system that adjusts prices every five minutes. The policy is designed to minimize costs to pre-existent carpoolers, who are ensured free-flow conditions by the mandated minimum speed of 45 mph and the continued ability to use the ExpressLanes free of charge. Carpools are required to use a transponder but are not charged when it is set to HOV-3+ during peak times (5-9 AM and 4-8 PM), and HOV-2+ during off-peak hours.

Compared with fixed- or peak-toll lanes, the Los Angeles ExpressLanes program has two features that present a unique opportunity for individuals to make a last-minute choice that offers the potential for on-time arrival in the face of a schedule constraint. First, the ExpressLanes adjust prices to maintain a minimum 45 mph speed. While other toll lanes may, generally, provide faster travel than an untolled alternative, the ExpressLanes can guarantee close to congestion-free driving. Second the ExpressLanes allow drivers multiple points of entry and exit. Drivers may enter or exit the ExpressLanes at 6 separately-priced locations along the I-10 W. These exit and entry points represent sub-markets of the ExpressLanes and are indicated by arrows in Appendix Figure E.8. This allows them flexibility to change their decisions based on traffic conditions and consume exactly the amount of distance desired. This is often only a few miles—considerably shorter distances than other toll roads where drivers must commit to a decision and are unable to opt out of the lane if conditions improve. Varied subsegment use by drivers is substantial, with a large proportion of observed trips exiting either at mid-way points along the corridor or at the end as documented in Appendix Table F.26.

At these entry points drivers see posted toll rates, ranging between $0.55 and $14.70, with a mean toll on the longest corridor of $5.23 in our sample, and once a vehicle enters the lane the corresponding toll rate is locked in for the duration of its trip even if the price for subsequent vehicles changes. Between entry points the ExpressLanes are separated from the mainline lanes by a solid double white lane marker that drivers may not cross. Crossing this marker is a moving violation. The program funds cameras at entry and exit points that read license plates to toll vehicles without transponders and additional California Highway Patrol officers that patrol the road segment.

Entry into the ExpressLanes from the mainline is limited access at noted points, with a fine of $481 for occupancy violations or for crossing the double-yellow buffer between the ExpressLanes and mainline lanes. Several park-and-ride lots exist along the I-10 to encourage carpool formation, and vanpool availability was expanded in conjunction with the opening of the ExpressLanes. The Metrolink San Bernardino Line, a regional commuter rail option, tracks a significant portion of the route. The I-10 was selected as one of the targeted corridors for the ExpressLanes project based on its heavy morning congestion and the pre-existence of one HOV lane. As part of this program, the HOV lane was expanded to two lanes to allow for greater capacity.

Table 1 of the paper presents average weekday travel time differences between the ExpressLanes and the mainline lanes. During the morning peak, travel times are between zero and forty-five minutes lower in the ExpressLanes than the mainline lanes, with the average at about 4 minutes.

A subtle design element to the I-10 Westbound ExpressLanes is the HOV policy. Prior to the ExpressLanes program, HOV lane access on this road required three or more people per vehicle during the morning peak (5-9 AM) and afternoon peak (4-8 PM) times, and two or more people per vehicle otherwise. Nearly all other HOV lanes in CA require two or more occupants during peak hours. Because this policy allows toll-paying ExpressLanes drivers to avoid the cost of carpool formation, the 3+ regulation may affect the decision of drivers to break their carpool, forgo the carpool formation cost and pay to drive in the I-10 as a SOV driver. For those not carpooling before the policy, the 3+ versus 2+ regulation only has an impact in so far as it creates a larger initial travel time differential between the HOV and mainline lanes.

This differential, however, should not vary greatly across freeways, as regulators have set these occupancy requirements to keep congestion in HOV lanes similar across all roads, implying that despite the 3+ regulation on the I-10 we may expect to observe similar effects of the ExpressLanes policy on HOV lanes on other freeways. Moreover, we find that the share of trips with the transponder switched to HOV-2+ mode is relatively small (11.3 percent), both the result of the fact that the toll is the same for SOV and HOV-2+ vehicles during the morning peak, so that it would need to be the case that the savings from shared vehicle use outweighed the carpool formation cost for HOV-2+ driving to be preferable to SOV driving in the ExpressLanes. Second, because drivers are tolled the same amount during the morning peak regardless of whether the transponder is set to SOV or HOV-2+, it seems possible that a non-trivial share of tolled drivers might be occupied by two persons where the driver has simply left the transponder in the SOV position because the toll to be paid is no different.

Calculation of Travel Time Savings.—We calculate mainline travel time from road segment average speeds reported by detectors in the I-10 W mainline lanes from the California Department of Transportation's Freeway Performance Measurement System (PeMS). PeMS generates real-time 5-minute speed and flow data for HOV and mainline lanes from loop-detectors embedded in all major California divided highways based on calibrated flow and occupancy observations taken every 30 seconds. The five-minute data used for our analysis is aggregated by PeMS from the 30 second observations but provides a more accurate picture of average speeds because of additional calibration. This is done by matching each ExpressLanes trip observed in our transponder data to the average speeds observed in the mainline lanes from PeMS for the same starting time. Trip-level travel time savings in our analysis is then the difference between the realized travel times in the ExpressLanes and that for the same distance trip taken at the same time along a parallel stretch of the mainline lanes of the I-10 W.

Travel time in the mainline lanes is calculated as the distance traveled in the ExpressLanes divided by the average speed from PeMS speed detectors on a parallel stretch of the mainline lanes during the same 5-minute interval as the start of the trip. That individuals would infer travel times in the mainline based on contemporaneous speeds is consistent with the fact that the speed data from PeMS as well as other sources is widely available from news outlets, and mobile technology like Waze that tracks the speed of users provides extremely accurate travel time predictions based on contemporaneous travel conditions.

The choice of the mainline lane as the relevant counterfactual travel time is motivated by the fact that sorting of individuals across roads and freeways implies that the travel time in the mainline lane of the I-10 can serve as a close approximation of the travel time it would take in any other travel option. This is the appropriate comparison to make because during the peak commuting period, the Nash Equilibrium in routing serves to equalize average travel times between substitute commuting routes, so travel times in the mainline of the I-10 W are consistent with the lowest possible travel time commutes for any untolled route in the transportation system. We focus our analysis on accounts registered to private individuals for whom travel time savings likely correspond to trips to work. In most figures and regressions, we omit the 6.2% of trips where the mainline speed implies negative time savings but include these observations in robustness checks. Trips with negative travel time savings appear to occur when mainline speeds are abnormally high, suggesting passing is possible and our measure of counterfactual mainline speed is subject to error. Median mainline speeds are in excess of 65 mph for these negative trips, while those with positive time savings have a median mainline speed less than 45 mph. We test the robustness of our results to this assumption in Appendix Table F.24.

Construction of Reliability.—The value of reliability is the willingness-to-pay for reduced uncertainty in travel time when choosing between routes, and empirical evidence suggests that drivers particularly dislike longer delays (Brownstone and Small, 2005). When arriving at the entrance to the ExpressLanes, the driver already perceives differences in travel conditions suggesting there is limited uncertainty at that point in the trip. If this is truly the case, individuals' willingness to pay to enter the ExpressLanes is unlikely to reflect insurance or an option value in case conditions deteriorate, given that by entering the ExpressLanes a minimum level of speed is secured. To the extent that some uncertainty remains, this will be the most onerous in the right tail of the travel time distribution, reflecting the potential deterioration of conditions in the mainline lanes.

To capture this uncertainty, Brownstone and Small (2005) and Small, Winston and Yan (2005) construct a measure called reliability. This variable measures the difference in the spread between the 80^{th} and 50^{th} quantile of travel time savings between the mainline lanes and the ExpressLanes. This measure varies by time of day and is calculated based on a random sample of weekdays during the year when their study was conducted. This means that the measure of reliability constructed in this way does not vary from one day to the next and is based on a sample of drivers making choices at one point in time rather than repeatedly.

We note two important differences between the approach just described and with the way we calculate reliability—important differences that are only possible given the uniqueness of our dataset. First, given the institutional features of the program, our measure of reliability varies by road segment, reflecting portions of the roadway where slowdowns in mainline lanes may be more likely. Second, unlike prior studies, we observe individuals making repeated choices over the course of a year and therefore construct reliability measures that reflect changing realizations of the travel time distribution. Therefore, we calculate this measure for each hour and day of the week, using a moving average of the same weekday hour for the preceding 30 days and segment of trips, reflecting the fact that expectations of travel time savings are likely formed based on recent performance.

To remove the influence of infrequent occasions when travel times are longer in the ExpressLanes (times with fewer cars when driver discretion results in slower speeds), we restrict the sample for constructing reliability to positive travel time differences. We also set reliability differences less than 0.01 hour (36 seconds) to zero under the assumption that differences in the spread that are this small are imperceptible to drivers. We test the sensitivity of our results to this assumption, as discussed in Appendix Table F.24, and find no meaningful impact on our estimates of the value of urgency. An important advantage of our measure is that it is less sensitive to potential sampling error that is a result of measuring choices at a single point in time, as it has been the practice in the literature. Equally important, in our approach, unlike prior literature, there is considerable variation across observations in reliability by hour, date and segment where the trip is taken as shown in Appendix Figure E.4.

Weather.—In Appendix Table F.22, we differentiate our results based on local weather patterns as a robustness check to the main results. To match weather measures to the travel time data from PeMS, we follow the algorithm used in Auffhammer and Kellogg (2011). First, the Vincenty distance of each airport weather station to each PeMS detector is calculated using their geographical coordinates. The closest station to roughly two-thirds of the detectors is Hawthorne and Fullerton for the remainder. The weather data from these stations are matched to the travel time data for the I-10 W. After these records have been matched, 0.07% of the travel time records are not matched to a full set of weather measures. These missing weather measures are imputed by regressing the observations where the closest station (Fullerton or Hawthorne) was active, for the relevant variable, onto the same variable for the remaining eight stations. The predicted values from that regression were used to replace the missing values. No weather measures were subsequently missing.

Vehicle Prices—In Appendix Table F.25, we examine the relationship between account-level estimates of the value of urgency and value of time and the value of vehicles registered to these accounts. Account-level vehicle make, model and year come from Metro transponder account information, which we match to data on vehicle Manufacturer's Suggested Retail Price (MSRP) from Ward's Automotive Yearbooks (1945-2013). Vehicle prices are in 2000 dollars and are depreciated by an annual rate of 20%. Of the 31,331 vehicle-account observations, 6,727 do not match based on these criteria for various reasons. For the unmatched observations, we attempt to match them to the nearest (in time) Wards MSRP for which there is data, within a five-year window. Of the 6,727 observations that do not initially match, 3,127 account-vehicles remain unmatched after attempting to match within a 5-year window. These are matched by year and make to an average make-level MSRP.

Appendix B. Conceptual Framework for Recovering Drivers' Preferences for Travel Time Savings

In the classical bottleneck model (Vickrey, 1969), individuals choose departure times, given a desired time of arrival. Because of its deterministic nature, there is no uncertainty in travel time. As a result, individuals can always adjust departure times to meet any underlying schedule constraint. The framework developed in Noland and Small (1995) defines a general commuting cost function also incorporating a discrete penalty for late arrival in the context of assessing optimal departure time.

A driver forms expectations about congestion levels that determine the expected arrival time, $E[T^A(\sigma)]$ relative to their desired arrival time, T^*. In reality, people may not have a precise desired arrival time, per se, but rather an acceptable arrival window, i.e., $T^* \pm \varepsilon$, where ε denotes the window length. We will abstract from this concern in the analysis below under the assumption that ε is sufficiently small relative to travel times, expected schedule delay early or schedule delay late sizes. If ε is comparable to these windows, then we may consider the windows themselves to be negligible, that is zero.

The expected arrival time depends on the level of congestion on the roadway, σ, a random variable about which the driver forms expectations. The driver then decides on a departure time, T^D, to minimize the opportunity cost of time associated with commuting by car:

$$\text{(A.1)} \qquad \min_{T^D} Cost = \theta \cdot \underbrace{(E[T^A(\sigma)] - T^D)}_{TT} + \beta \cdot \underbrace{\min(T^* - E[T^A(\sigma)], 0)}_{SDE} + \gamma \cdot \underbrace{\min(E[T^A(\sigma)] - T^*, 0)}_{SDL} + \delta \cdot \underbrace{1\{E[T^A(\sigma)] > T^*\}}_{DL}.$$

These costs have four components, all of which depend upon the uncertain time of arrival, $E[T^A(\sigma)]$, affected by congestion levels: the time spent commuting itself, TT, the cost associated with arriving early, SDE, the cost associated with arriving late, SDL, and a discrete cost of arriving late that does not scale with how late the individual is: DL. $E[T^A(\sigma)] = TT(\sigma, T^D) + T^D$, where uncertain congestion and the departure time determines TT, and where each $E[T^A(\sigma)]$ term is determined by the choice of T^D.[1] θ is the cost per hour of time spent commuting, β is the cost per hour of arriving early, γ is the cost per hour of arriving late, and δ is a discrete lateness penalty that does not scale with time.[2] DL equals one when SDL is greater than zero. While we do not denote *SDE*, *SDL*, and *DL* with an expectation operator, they all depend on expected arrival times and therefore congestion and so are themselves random variables.

When faced with uncertainty in travel time, drivers consider earlier departures, which can be seen by totally differentiating the identity for departure time, $T^D = T^* - TT(\sigma, T^D)$:

$$\frac{dT^D}{d\sigma} = -\frac{dTT}{d\sigma} - \frac{dTT}{d\sigma} \cdot \frac{\partial T^D}{\partial \sigma}.$$

This equation provides intuition for how the commuter adjusts their departure time in response to an increase in congestion, where the first term on the right-hand side reflects earlier departure time that comes directly from adjusting to longer travel times from higher congestion, while the second term reflects the additional adjustment the commuter must make to account for the fact that higher congestion puts them in traffic during a later period. If congestion is expected to get worse, then this term is negative and induces the commuter to leave the house even earlier.

Once on the road, departure time is no longer a choice variable. In addition, the commuter can update their priors about travel time expectations.[3] Finally, the driver is assured that the toll displayed is the one they will pay. Presented with the option

[1] The acronym *SDL* stands for schedule delay late, *SDE*, schedule delay early and *DL*, delay late.
[2] Units of time are specified here per hour as they can be made comparable to hourly wage equivalents in the context of the value of time.
[3] While theoretically there may still be some uncertainty left, in practice, for ExpressLanes programs with a varying toll system that guarantee a minimum speed and where drivers obtain information via signage uncertainty is dramatically reduced.

of purchasing the time needed to avoid late arrival, the driver decides whether or not to enter the ExpressLanes, where there is no uncertainty about travel time.[4]

A driver's utility in lane $\ell = E, R$ can be represented as:

(A.2) $u\left(TT^{\ell}(\sigma)\right) =$

$$\begin{cases} R_{OT} - \theta TT^{\ell} - toll \cdot 1\{\ell = E\} & \text{if on time} \\ R_{OT} - \theta TT^{\ell} - \beta\left(SDE^{\ell}\right) - toll \cdot 1\{\ell = E\} & \text{if early} \\ R_{OT} - \theta TT^{\ell} - \gamma\left(SDL^{\ell}\right) - \delta\left(DL^{\ell}\right) - toll \cdot 1\{\ell = E\} & \text{if late,} \end{cases}$$

where R_{OT} is the gross benefits of arriving on time. (A.2) can be rewritten using the identities for each component:

(A.2') $u\left(TT^{\ell}(\sigma)\right) =$

$$\begin{cases} R_{OT} - \theta\left(E\left[T^{A,\ell}(\sigma)\right] - T^{D}\right) - toll \cdot 1\{\ell = E\} & \text{if on time} \\ R_{OT} - \theta\left(E\left[T^{A,\ell}(\sigma)\right] - T^{D}\right) - \beta\left(T^{*} - E\left[T^{A,\ell}(\sigma)\right]\right) - toll \cdot 1\{\ell = E\} & \text{if early} \\ R_{OT} - \theta\left(E\left[T^{A,\ell}(\sigma)\right] - T^{D}\right) - \gamma\left(E\left[T^{A,\ell}(\sigma)\right] - T^{*}\right) - \delta - toll \cdot 1\{\ell = E\} & \text{if late.} \end{cases}$$

Let $P_E^{\ell}(\sigma)$ and $P_L^{\ell}(\sigma)$ denote the probability of arriving on early or late in lane ℓ, which depend on the level of congestion itself, since as congestion grows, $P_L^{\ell}(\sigma)$ rises and $P_E^{\ell}(\sigma)$ falls.

Given uncertainty in travel time, the driver's expected utility in lane ℓ can be represented as:

[4] In principle, it would be possible for the driver to leave the house early in order to lower the probability of late arrival. This then reflects the trade-off between this benefit and the cost of potentially arriving at work earlier than desired. In practice, drivers may find themselves running late for a variety of reasons. The most straightforward case is where an individual faces an idiosyncratic shock (e.g., left briefcase at home) and now has to re-evaluate commuting decisions without the ability to leave the house earlier.

(A.3) $E\left[u\left(TT^{\ell}(\sigma)\right)\right] = \left(1 - P_E^{\ell}(\sigma) - P_L^{\ell}(\sigma)\right)\left[R_{OT} - \theta \cdot E\left(TT^{\ell}\right)\right] + P_E^{\ell}(\sigma)\left[R_{OT} - \theta \cdot E\left(TT^{\ell}\right) - \beta\left(SDE^{\ell}\right)\right] + P_L^{\ell}(\sigma)\left[R_{OT} - \theta \cdot E\left(TT^{\ell}\right) - \beta\left(SDL^{\ell}\right) - \delta\right] - toll \cdot 1\{\ell = E\}.$

Therefore, the lane choice decision can be written as:

(A.4) $\max\left\{E\left[u\left(TT^{E}(\sigma)\right)\right] - toll, E\left[u\left(TT^{R}(\sigma)\right)\right]\right\}.$

We now state a few assumptions that reflect the general features of the ExpressLanes program. The goal of this exposition is not to explain the general features of a hypothetical ExpressLane, which has been done in Hall (2018), but rather to write a model that follows the pattern of behavior and design of the ExpressLanes that we observe in practice in our sample along the I-10W in Los Angeles.

Assumption 1. There is no uncertain congestion once vehicles exit the ExpressLanes.

Assumption 1 is a simplifying assumption that allows us to ignore uncertainty that occurs outside of the corridor in question. It may be that there are slowdowns on downtown arterial roads once cars are off the highway, although in practice these slowdowns tend to be less substantial than on highways. If drivers using the ExpressLanes expect to be late, this could be because of certain congestion once the vehicle exits the ExpressLanes (either past the end of the ExpressLanes on the highway or on downtown arterial roads.

Assumption 2. There is no uncertainty in travel times in the ExpressLanes, so $T^{A,E}(\sigma) = T^{A,E}$ is known to the commuter.

Note that assumption 2 is reflected in the summary statistics in Table 1 and after October 20th in our sample, drivers can see the expected travel time in the ExpressLanes at lane entry points. Assumption 2 also relies on Assumption 1 so that uncertain congestion does not affect certainty about on-time arrival using the ExpressLanes.

Lemma 1. Under Assumptions 1 and 2, the probability of late and early arrival in the ExpressLanes is known to the commuter at the point of lane choice decision in (A.4), so that using the ExpressLanes the commuter will either be on time for sure $P_E^E(\sigma) = P_L^E(\sigma) = 0$, late for sure, $P_L^E(\sigma) = 1, P_E^E(\sigma) = 0$, or early for sure, $P_E^E(\sigma) = 1, P_L^E(\sigma) = 0$.

Proof: Under Assumptions 1 and 2, $T^{A,E}$ is known with certainty. So, if $T^{A,E} > T^*$, $P_L^E(\sigma) = 1$ and the commuter will be late for certain. If $T^{A,E} < T^*$, $P_E^E(\sigma) = 1$, and the commuter will be early for certain. And, if $T^{A,E} = T^*$, $P_E^E(\sigma) = P_L^E(\sigma) = 0$, the commuter will be on-time for certain. ■

Lemma 1 allows us to write a general form of equation (3), the lane choice decision rule as (A.5) below. This is done by re-writing (A.4) as an inequality. A driver approaching the entry point to the ExpressLanes will enter them if the expected utility of its use is greater than or equal to the mainline lanes:

(A.5) $$E\left[u\left(TT^E(\sigma)\right)\right] - toll \geq E\left[u\left(TT^R(\sigma)\right)\right]$$

$$\begin{aligned}\Rightarrow (1 - P_E^E(\sigma) - P_L^E(\sigma))[R_{OT} - \theta \cdot E(TT^E)] \\ + P_E^E(\sigma)[R_{OT} - \theta \cdot E(TT^E) - \beta(SDE^E)] \\ + P_L^E(\sigma)[R_{OT} - \theta \cdot E(TT^E) - \gamma(SDL^E) - \delta] - toll \\ \geq E\left[u\left(TT^R(\sigma)\right)\right]\end{aligned}$$

$$\Rightarrow E\left[u\left(TT^R(\sigma)\right)\right] + toll \leq \begin{cases} R_{OT} - \theta \cdot TT^E & \text{if on-time in ExpressLanes} \\ R_{OT} - \theta \cdot TT^E - \beta(SDE^E) & \text{if early in ExpressLanes} \\ R_{OT} - \theta \cdot TT^E - \gamma(SDL^E) - \delta & \text{if late in ExpressLanes,} \end{cases}$$

where the first arrow comes from substitution of (A.3) and the second from Lemma 1. This piecewise inequality shows the expected utility from mainline lane use relative to certain utility from the ExpressLanes. It also shows the relationship between expected utility for an uncertain outcome relative to a certain one net of a payment. This makes clear that the toll can act as a certainty equivalent in the case in which the utility of using the two lanes is the same. It also highlights the role of risk preferences since if the certain ExpressLanes utility under any of the three scenarios is equal to the expected utility on the mainline lanes, the driver may still strictly prefer the ExpressLanes before the toll if they are risk averse.

The following assumption allows for clearer analysis of (A.5) and introduces a key characteristic of the observed pattern of traffic in the ExpressLanes

Assumption 3. ExpressLanes travel times are always equal or less than those in the mainline lanes, so that $TT^E \geq TT^R$. Drivers also perceive this difference in forming expectations so that $TT^E \geq E[TT^R(\sigma)]$.

Assumption 3 is almost exclusively borne out in the data in Table 1 and is always the case in our main results as we exclude observations where this is not the case. Also, we do not observe conditions consistent with accidents or capacity disruptions in the ExpressLanes but do in the mainline lanes so Assumption 3 is likely to hold in almost all cases in our data. It may be that some drivers in the ExpressLanes (e.g., carpoolers) choose to drive slower than their mainline lane counterparts, but this pattern would not violate Assumption 3.

To understand the derivation of equation (3) in the text of the paper and its implications for recovering preferences for travel time savings, it is helpful to consider the lane choice problem from (A.4) under Assumptions 1-3 under three possible cases: when ExpressLanes use will make you early, when ExpressLanes use will make you late, but less late, and when ExpressLanes use will make you arrive on-time. In any of the cases, we leave open, for the moment, the possibility of late, on-time or early arrival in the mainline lanes except where Assumption 3 precludes it (i.e., you cannot be early in the mainline lanes but late in the ExpressLanes).

Case 1. Early in the ExpressLanes

From (A.5):

$$
\begin{aligned}
R_{OT} - \theta \cdot TT^E - \beta(SDE^E) - toll \quad &\geq \quad E\big[u\big(TT^R(\sigma)\big)\big] \\
&\geq \quad (1 - P_E^R(\sigma) - P_L^R(\sigma))[R_{OT} - \theta \cdot E(TT^R)] \\
&\qquad + P_E^R(\sigma)[R_{OT} - \theta \cdot E(TT^R) - \beta(SDE^R)] \\
&\qquad + P_L^R(\sigma)[R_{OT} - \theta \cdot E(TT^R) - \gamma(SDL^R) - \delta]
\end{aligned}
$$

(A.6)
$$
\begin{aligned}
\Rightarrow toll \quad &\leq \quad \theta \cdot (E(TT^R) - TT^E) - \beta(SDE^E - P_E^R(\sigma)SDE^R) \\
&+ \quad P_L^R(\sigma)(\gamma(SDL^R) + \delta).
\end{aligned}
$$

When a driver knows that they will be early in the ExpressLanes, they will choose to use them if the toll is less than or equal to the value of time savings and the expected value of saved lateness penalties net of early arrival costs.

Case 2. Late in the ExpressLanes

From (A.5) and noting from Assumption 3, that if a driver is late in the ExpressLanes, they must be late in the mainline lanes, so $P_L^R(\sigma) = 1$:

(A.7)
$$
\begin{aligned}
R_{OT} - \theta \cdot TT^E - \beta(SDL^E) - \delta - toll \quad &\geq \quad R_{OT} - \theta \cdot E(TT^R) - \gamma(SDL^R) - \delta \\
\Rightarrow toll \quad &\leq \quad \theta \cdot (E(TT^R) - TT^E) + \gamma(SDL^R - SDL^E).
\end{aligned}
$$

If a driver is going to be late using the ExpressLanes, then only savings in travel time and a reduction in lateness penalties can explain ExpressLanes use relative to the toll. Note that the discrete lateness penalty, δ, has canceled out because the driver will be late in either lanes. This leads to Remark 1.

Remark 1. In a model of lane choice during AM Peak commuting following the scheduling model of (A.1), if all drivers in the ExpressLanes are always late, then the value of urgency, corresponding to discreteness penalties in (A.1), is always zero.

Remark 1 provides an empirical basis for a test of the value of urgency, if the constant in a regression is statistically different from zero, then a sufficient mass of drivers using the ExpressLanes must not expect to be late using the ExpressLanes.

Equation (A.7) can also be re-written as $toll \leq \theta \cdot (E(TT^R) - TT^E) + \gamma \cdot (T^{A,R} - T^*) + \delta$ for a driver expecting to be late in the untolled, mainline lanes. Note that if the drive expects to be on-time in the mainline lanes, then $SDL^R = DL^R = 0$ and the toll is only rationalized by the value of travel time savings themselves.

Case 3. On-time in the ExpressLanes

Lastly, if a driver is on-time in the ExpressLanes, then they are either on-time or late in the mainline lanes:

$$\begin{aligned} R_{OT} - \theta \cdot TT^E - toll \quad &\geq \quad (1 - P_L^R(\sigma))[R_{OT} - \theta \cdot E(TT^R)] \\ &\qquad +P_L^R(\sigma)[R_{OT} - \theta \cdot E(TT^R) - \gamma(SDL^R) - \delta] \end{aligned}$$

$$\text{(A.8)} \qquad \Rightarrow toll \quad \leq \quad \theta \cdot (E(TT^R) - TT^E) + P_L^R(\sigma)(\gamma(SDL^R) + \delta).$$

Here, if a driver expects to be on-time in the ExpressLanes, then, following Assumption 3, they will either be on-time or late in the mainline lanes. Thus the decision rule relates the toll to the value of travel time savings and possible lateness penalties from the mainline lanes.

Together (A.6) - (A.8) create a basis for understanding identification of preference parameters in (3). Putting each together yields:

$$\text{(A.9)} \qquad toll \leq \theta \cdot (E(TT^R) - TT^E) + \begin{cases} P_L^R(\sigma)(\gamma(SDL^R) + \delta) & \text{if on-time in ExpressLanes} \\ P_L^R(\sigma)(\gamma(SDL^R) + \delta) - \beta(SDE^E - P_E^R(\sigma)SDE^R) & \text{if early in ExpressLanes} \\ \gamma(P_L^R(\sigma) \cdot SDL^R - SDL^E) & \text{if late in ExpressLanes.} \end{cases}$$

It is instructive to make one qualification to (A.9) before proceeding which has to do with early arrival penalties, β. The transportation literature has found that the value of these penalties are typically small compared to late arrival penalties and the value of time. In the current context, however, early arrival penalties in the ExpressLanes make less sense given sufficient intended segment use since if a driver expects to face early arrival penalties when using the ExpressLanes, they could simply use a shorter subsegment of the ExpressLanes and save money by paying a correspondingly lower value of the toll. This is articulated below in Lemma 2.

Lemma 2. If trips are sufficiently long and segments sufficiently short, early arrival penalties from ExpressLanes use will be sufficiently small to be negligible: $\beta(SDE^E - P_E^R(\sigma)SDE^R) \lll toll$.

Proof. When facing toll for segment use, s, of $toll(s)$, a driver expecting to arrive early in the ExpressLanes will face early arrival penalty in the ExpressLanes of $\beta \cdot SDE^E$ and expected early arrival penalty in the mainline lanes of $\beta \cdot P_E^R(\sigma) \cdot SDE^R$. The driver can thus avoid the relative early arrival penalty difference of $\beta(SDE^E - P_E^R(\sigma)SDE^R)$ by driving fewer ExpressLanes segments, $s' < s$ for a lower toll of $toll(s') < toll(s)$. Such a driver is thus incentivized by the toll to mitigate relative early arrival penalties up until $\beta(SDE^E - P_E^R(\sigma)SDE^R)$ approaches zero. ■

Equation (A.9) makes clear why many previous studies in the transportation literature have included discrete lateness penalties, δ, in their definition of reliability. This term, $P_L^R(\sigma)\delta$, does not scale with the number of minutes late like SDL^R, it is multiplied by the probability of late arrival in the mainline lanes, $P_L^R(\sigma)$, which depends on the level of congestion in those lanes and therefore the expectation of its product with δ should scale up with the amount time saved. In plain English, this term is not constant with respect to changes in the amount time saved from the ExpressLanes: the slower the mainline lanes, the more likely late arrival is (i.e., the bigger $P_L^R(\sigma)$ is) and consequently the larger $P_L^R(\sigma)\delta$. As long as there is uncertainty in how slow the mainline lanes might be, then this term will not be constant.

If i is the case is there no value of urgency or is it not identified from our empirical results in Section IV? To understand the answer to this question, consider the effect of variation in travel time savings: $\Delta TT = E(TT^R) - TT^E$ on $P_L^R(\sigma)$. Since $TT = E[T^A(\sigma)] - T^D$, then $\Delta TT = E[T^{A,R}(\sigma)] - T^{A,E}$, the difference in arrival times between the mainline and ExpressLanes, where the former remains affected by congestion. Here mainline lane arrival times get later with congestion $\frac{dT^{A,R}(\sigma)}{d\sigma} > 0$, but ExpressLanes travel times do not, so the travel time savings must grow with congestion, $\frac{d\Delta TT}{d\sigma} > 0$. As stated earlier, the probability of late arrival in the mainline lanes also rises with congestion, $\frac{dP_L^R(\sigma)}{d\sigma} > 0$. Thus, a regression of the toll on travel time savings, even including reliability, may pickup perceptions of the value of discrete lateness penalties in the coefficient on travel time savings since the probability of facing these penalties would be expected to rise with travel time savings: $\frac{d\gamma P_L^R(\sigma)\delta}{d\Delta TT} > 0$.

However, this suggests that as ΔTT approaches zero, as in Figure 1, we would expect $P_L^R(\sigma)\delta$ to similarly approach zero. Yet, as that figure makes clear, this is not the case for the ExpressLanes. We now describe two assumptions, the first strong, the second less so, which provide conditions under which some portion of discrete lateness penalties persist even when travel time savings between the lanes get small.

Assumption 4A [Strong]. All uncertainty about mainline travel times has been resolved by the time that drivers face the decision to use the ExpressLanes from (A.4).

Assumption 4A is the analogue of Assumption 2 but for the mainline lanes. Assumption 4A is defensible to the extent that once drivers are on the highway, they have a lot more information than when they left the house: they can observe real-time traffic conditions whether on the road, on a GPS devise using Google Maps, Waze or a similar application, or after October 22nd, 2013 can see the real time travel time savings prediction on roadway signs. Thus, it may be the case that deviations from travel time predictions in the mainline lanes are unlikely to occur once they are on the roadway.

However, this assumption may be less credible to the extent that traffic conditions at one moment in time can change dramatically because of an accident, a change in weather conditions or an unexpected surge in vehicle volumes in the mainline lanes. To the extent that one believes that reliability differences between the mainline and ExpressLanes are pertinent to drivers at the point of lane choice, then this assumption may be unlikely to hold. Indeed, our main results find a statistically significant value of reliability differences, however relatively small: 4% of the total toll in column III of Table 2 once drivers have full information about travel time savings from signs after October 22nd, 2013. As discussed in the text, however, the transportation literature has provided evidence that drivers experience psychological distress from uncertain traffic conditions independent of their probability of occurring at a particular moment in time. To the extent that drivers simply dislike that uncertainty, in general, then Assumption 4A may be valid. We proceed to lay out a proposition now that results in the expression for equation (3) in the text under Assumptions 1-4A.

Proposition 1. Under Assumptions 1-4A, Remark 1 and Lemmas 1 and 2, the commuter's lane choice rule in (A.4) becomes simplified to relating the toll to the value of travel time savings plus lateness penalties (discrete and time-varying) from the mainline lanes.

(A.10) $$toll \leq \theta \cdot (TT^R - TT^E) + \gamma \cdot SDL^R + \delta \cdot DL^R.$$

Proof. Under Lemma 2, ExpressLanes drivers are never meaningfully early, and under Remark 1, they are also unlikely to be late in the ExpressLanes. Following Assumption 4A, $P_L^R(\sigma) = 0{,}1$ and $E(TT^R) = TT^R$. Thus (A.9) simplifies to (A.10). If drivers will be late in the mainline lanes, $DL^R = 1$ and $SDL^R > 0$ if the will not be late in the ExpressLanes, then they are simply trading off the toll for travel time savings and $toll \leq \theta \cdot (TT^R - TT^E)$. ■

As noted earlier, Assumption 4A may be overly strong. There may remain some uncertainty about mainline travel times. Nevertheless, the persistence of the value of urgency in our empirical results suggests that discrete lateness penalties have to be likely for a non-trivial mass of drivers in our sample. Moreover, $P_L^R(\sigma) = Pr[T^A(\sigma) > T^*]$, may vary by individual for drivers choosing whether to enter the ExpressLanes at the same time. This difference in lateness probability in the mainline lanes may be because they have different values of T^*, may have different exact destinations, or may have different subjective perceptions of their arrival times in the mainline lanes.

Assumption 4B. A sufficiently large mass of commuters facing lane choice decision (A.4) experiences certain lateness ($P_L^R(\sigma) = 1$) *in the mainline lanes or does not perceive that the probability of late arrival depends on mainline travel times (i.e., they perceive that Corr(*$\Delta TT, P_L^R(\sigma)) = 0$*),*

Simply, Assumption 4B simply requires that a sufficiently large mass of commuters to be measurable in our hedonic regressions act as though Assumption 4A holds. They do not need to behave this way because they have full certainty about mainline travel times, but rather that given whatever uncertainty there is in the mainline lanes, they still expect to be late with certainty. This allows us to write a proposition allowing for a more general form of equation (A.10).

Proposition 2. Under Assumptions 1, 2, 3, 4B, Remark 1 and Lemmas 1 and 2, the commuter's lane choice rule in (A.4) becomes simplified to relating the toll to the value of travel time savings plus lateness penalties (discrete and time-varying) from the mainline lanes, accounting for lateness probabilities for those who are not certain to be late:

(A.11)
$$toll \leq \theta \cdot (E(TT^R) - TT^E) + \begin{cases} \gamma \cdot SDL^R + \delta & \text{if late for sure in mainline lanes} \\ 0 & \text{if on-time for sure in mainline lanes} \\ P_L^R(\sigma)(\gamma \cdot SDL^R + \delta). & \text{otherwise.} \end{cases}$$

Proof. As with the proof for Proposition 1, the only relevant case from (A.9) is where ExpressLanes users expect to be on-time. Also, as in Proposition 1, some have certainty over mainline lane lateness, but in the last case, others do not, which reduces to the first case from equation (A.9). ∎

Appendix C. Identification of Marginal Willingness-to-Pay from Toll Hedonic

We assume the value of urgency and travel time savings to be non-negative and ignore the role of reliability in subsequent analysis.

1. Continuous ExpressLanes Use

For illustrative purposes, suppose vehicle transponders tracked the distance traveled in the ExpressLanes and charged a dynamic, throughput maximizing toll that varied by meter. Therefore, the travel time saved would be at least a weakly monotonic function of trip length, ℓ_{it}: $\Delta TT_{it} = f(\ell_{it})$, where f is continuous, differentiable, nondecreasing and concave.

The WTP function for an individual driver would then be

$$WTP_{it} = \delta + \theta \Delta TT(\ell)_{it}$$

These assumptions would yield the WTP function shown below in Figure X. In this instance, longer trips along the ExpressLanes would correspond to greater travel time savings. Thus willingness to pay would increase accordingly.

For illustrative purposes, suppose for the moment vehicle transponders tracked the distance traveled in the ExpressLanes and charged a dynamic, throughput maximizing toll that varied by meter:

$$C_{it} = g(\ell),$$

where, where g is continuous, differentiable, nondecreasing and convex. The last assumption of convexity is helpful to establish the following result for illustrative, but is not strictly necessary for our argument. Therefore, longer trips would also incur higher total tolls as indicated by the line labeled Total Toll.

Therefore, the hedonic price function is defined in equilibrium by the tangency between the WTP curve and the price function. Point identification of the hedonic price function requires us to identify MWTP from the tangency between trips along the price function and WTP as in Panel A of Figure D.8.

2. Discrete Segments

Now we will relax the assumption that drivers can consume distance in the ExpressLanes continuously, but rather we will account for the fact that they are restricted to discrete number of subsegments. For illustrative purposes, we use the example of a lane with four subsegments, although our logic still holds with more subsegments. Indeed, one can, in principle, bound the estimates more precisely with more subsegments as will be shown.

Just as in the continuous case, traveling along more sub-segments of the ExpressLanes ensures greater travel time savings although the savings scale both with the distance traveled and the amount of mainline congestion. As such, the total toll paid increases in a strictly monotonic way as more subsegments are used since the total toll paid is the sum of individual tolls along subsegments.

With segments, there is non-linearity in the price function so tangency is no longer guaranteed as in Panel B of Figure D.8. This provides an additional reason that the toll reflects a lower bound on WTP in our model, beyond the argument explored earlier about inframarginal drivers. To understand how preferences are bounded, it is important to understand that a driver will choose to drive in as much of the ExpressLanes to guarantee that $WTP - TotalToll \geq 0$. In Panel B, this corresponds to the driver choosing to drive segments 1 and 2 for a total toll of C_2 and a travel time savings of ΔTT_2. This revealed choice provides four conditions allowing us to bound δ and θ:

1. $\delta + \theta\Delta TT_2 > C_2$ - For chosen segments, $WTP > TotalToll$.
2. $\delta + \theta\Delta TT_2 - C_2 > \delta + \theta\Delta TT_3 - C_3$ - For chosen segments, $WTP - TotalToll$ is bigger than that for using one more segment (segment 3).
3. $\delta + \theta\Delta TT_2 - C_2 > \delta + \theta\Delta TT_4 - C_4$ - For chosen segments, $WTP - TotalToll$ is bigger than that for using two more segments (segments 3 and 4)
4. $\delta + \theta\Delta TT_2 - C_2 > \delta + \theta\Delta TT_1 - C_1$ - For chosen segments, $WTP - TotalToll$ is bigger than that for using one less segment (segment 2).

Conditons 2 and 3 can be rearranged to derive bounds on the value of time, θ:

$$\theta < \min\{\frac{C_3 - C_2}{\Delta TT_3 - \Delta TT_2}, \frac{C_4 - C_2}{\Delta TT_4 - \Delta TT_2}\}.$$

Note that a precise bound on θ can be written if we know whether the price function with sub-segments is convex (the first term in the min) or concave (the second term). This would then identify which of the expressions to the right of the inequality is smaller.

(1) can be substituted into condition 4 to provide a bound on δ:

$$\begin{aligned} \delta \quad & > C_2 - C_1 - \theta(\Delta TT_2 - \Delta TT_1) \\ & > C_2 - C_1 - \min\{\frac{C_3 - C_2}{\Delta TT_3 - \Delta TT_2}, \frac{C_4 - C_2}{\Delta TT_4 - \Delta TT_2}\}(\Delta TT_2 - \Delta TT_1)^{\cdot} \end{aligned}$$

As with θ, a more precise bound can be written based on the above inequality when convexity of the price function is known.

We have therefore derived an upper bound on the value of travel time savings and a lower bound on the value of urgency that helps to demonstrate identification of marginal willingness-to-pay from the ExpressLanes toll with discrete segment use.

Appendix D. Relation to Prior Literature

In Appendix Table F.13, we present models that approximate the findings of previous studies to illustrate why we are able to recover preferences for urgency while others have not. Because the mean estimates from the heterogenous model are identical to the point estimates from the homogeneous model, for simplicity, here we rely on the homogeneous model. And, to perform comparisons with the literature, we estimate models with and without the constant. We also run separate models, broken down by different minimum threshold values of time savings. Further sample restrictions to travel time savings are considered in Appendix Table F.17, which demonstrate only moderate variation in the point estimates of the value of urgency, and indistinguishable from one another.

A direct comparison with Small, Winston and Yan (2005) can be made by contrasting the estimates in column III for the model without the constant with their estimates based exclusively on the revealed preference model.[5] In this case, our model yields estimates of the value of time and the value of reliability of $21.56 and $23.36 respectively, which are not statistically different than those reported in Small, Winston and Yan (2005). One should note, however, that the estimate of the value of time is substantially higher than half the local wage (roughly $10), the estimate generally found in the literature (Small, 2012). When we add back the constant in column III of Table 3 Panel A, we recover estimates for the value of time ranging from $8.02 to $4.58 per hour, slightly lower than those in Small (2012) but perhaps more realistic than the estimate of $21.56.

Given that the structure of tolls is fundamentally different across studies, a closer comparison with earlier studies is not possible. Nonetheless, two points are worth noting. First, removing the constant from the model decreases the fit of the model, as measured by AIC and BIC criteria.

Second, one should be concerned whether respondents of stated preference surveys are able to precisely reveal valuations for rather small travel time savings, as those reported in Panel A of Figure 1. Given this concern and the institutional features of previous ExpressLanes programs, travel time savings presented to respondents in prior studies were typically capped at a minimum of 10 minutes. Based on Panel A of Figure 1, one can appreciate that visually it appears as if that

[5] Small, Winston and Yan (2005) estimate a joint revealed and stated preference model. Median estimates from the former are $21.46 per hour for value of time and $19.56 per hour for the value of reliability. Stated preference estimates for the value of time are lower $11.92 per hour and for reliability are not comparable because of survey phrasing.

part of the curve is relatively flatter. However, by contrasting Column III in Appendix Table F.13 with and without the constant, we provide suggestive evidence that prior estimates of the value of time and reliability may be severely overestimated, since even at portions of the curve in Panel A, Figure 1 where time savings are greater than 10 minutes, drivers still exhibit preferences for urgency.

APPENDIX REFERENCES

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Appendix E. Additional Figures

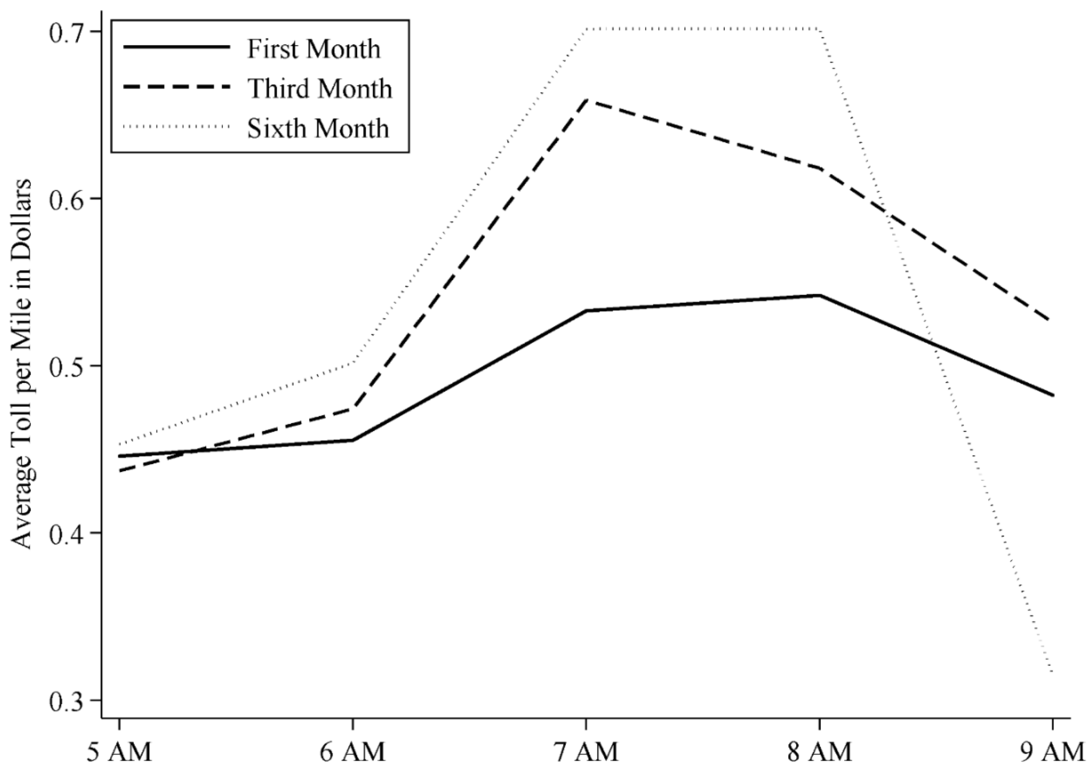


FIGURE E.1. EVOLUTION OVER TIME OF TOLL PER MILE BY HOUR

Notes: The figure displays the average hourly toll per mile in dollars paid during the morning peak (5-9 AM) for drivers on the I-10W ExpressLanes during the first month, (February 25th, 2013 – March 31st, 2013), the third month (May 2013) and the sixth month (August 2013) of the program. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped.

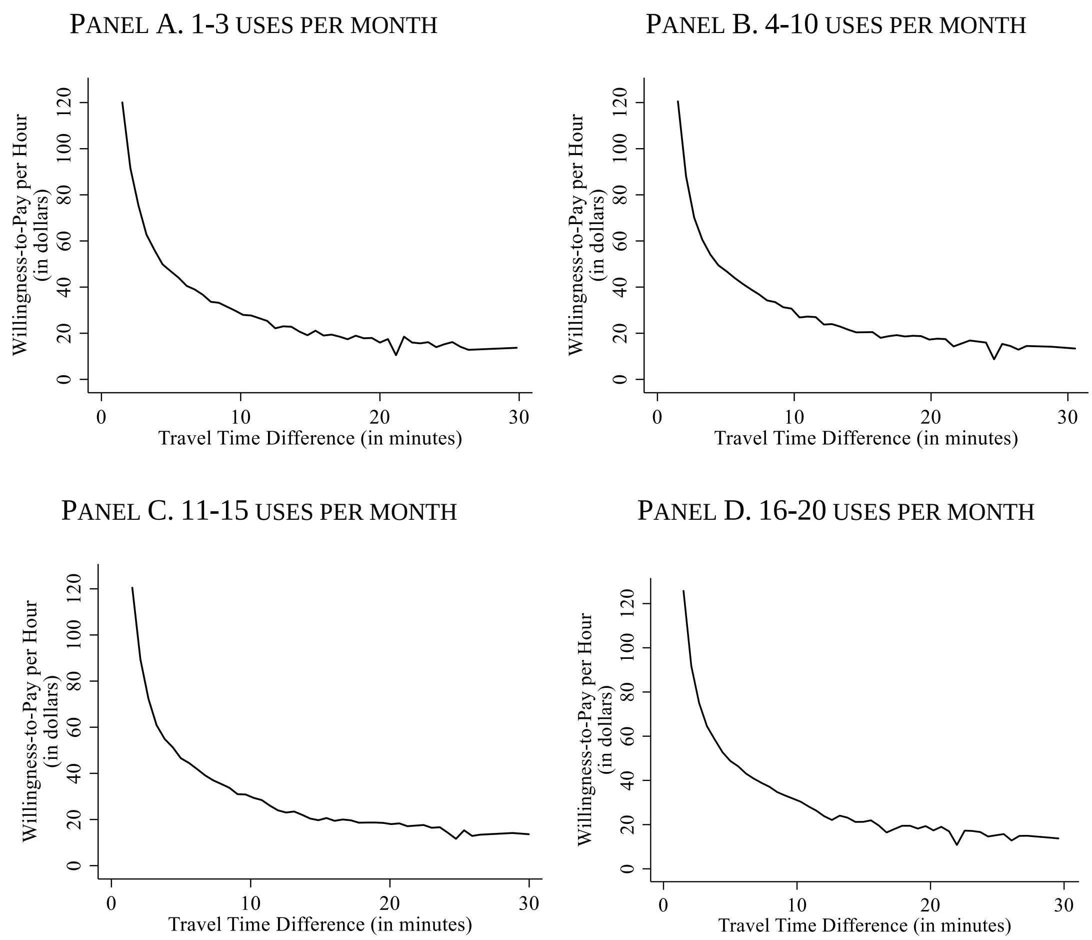
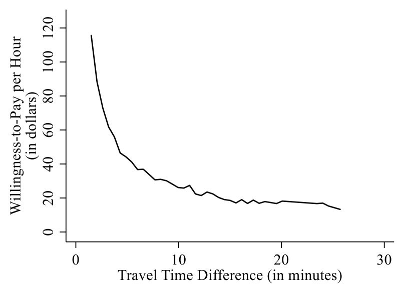


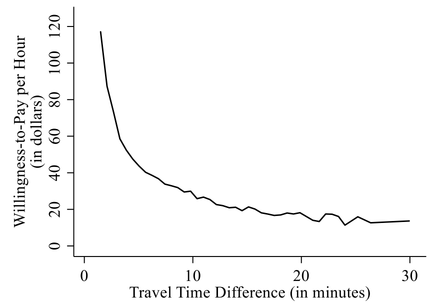
FIGURE E.2. AVERAGE WILLINGNESS-TO-PAY PER HOUR OF TRIPS IN THE EXPRESSLANES BY MONTHLY AM PEAK TRIP FREQUENCY

Notes: This figure displays the average willingness-to-pay (WTP) per hour for travel time savings while assessing the ExpressLanes as in Figure 1, but for subsamples of the trips in our data. Each panel considers a subset of trips taken by accounts that appear in the ExpressLanes during the AM peak for the indicated number of during the same month. Panel A includes 65,526 trips, panel B 132,885, panel C 93,529 and panel D 59,316. The WTP per hour is calculated using a kernel-weighted local polynomial smoothing for the ratio of the total toll paid for each trip over the travel time difference between the mainline lanes and the ExpressLanes. The vertical axis is truncated at $120, although the actual values are much higher (See Table Panel A). The smoother for all panels is an Epanechnikov kernel with a bandwidth of 0.05. Travel times are calculated based on mainline speeds from PeMS and ExpressLanes time stamps and the actual distance traveled for each trip in the ExpressLanes. Both panels are generated using trip-level transponder data for the morning peak hours (5-9AM) of workdays in the first 10 months of the program, excluding holidays. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped.

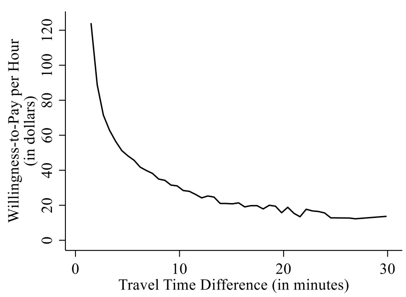
PANEL A. 1ST APPEARANCE



PANEL B. 2ND-5TH APPEARANCE



PANEL C. 30TH-50TH APPEARANCE



PANEL D. ≥100TH APPEARANCE

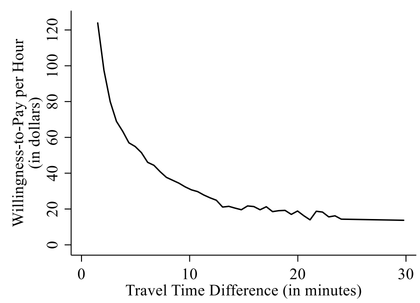
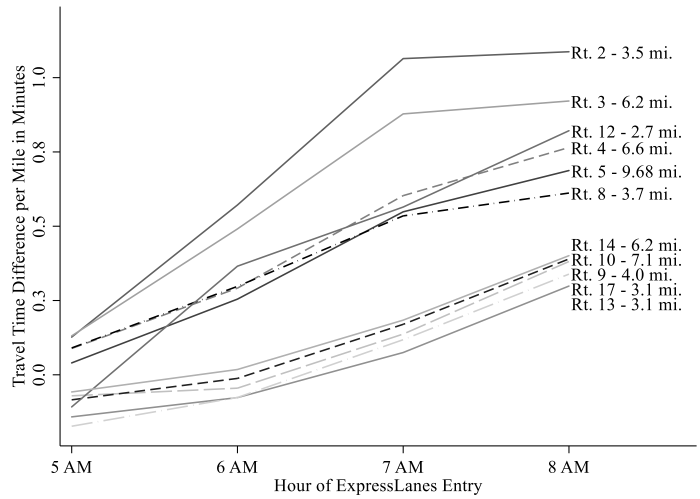


FIGURE E.3. AVERAGE WILLINGNESS-TO-PAY PER HOUR OF TRIPS IN THE EXPRESSLANES BY NUMBER OF PREVIOUS AM PEAK EXPRESSLANES APPEARANCES

Notes: This figure displays the average willingness-to-pay (WTP) per hour for travel time savings while assessing the ExpressLanes as in Figure 1, but for subsamples of the trips in our data. Each panel considers a subset of trips taken by accounts that have previously appeared in the ExpressLanes during the AM peak for the indicated number of trips since the start of the program. Panel A reflects 20,912 trips, panel B 51,063, panel C 143,248 and panel D 15,683. The WTP per hour is calculated using a kernel-weighted local polynomial smoothing for the ratio of the total toll paid for each trip over the travel time difference between the mainline lanes and the ExpressLanes. The vertical axis is truncated at $120, although the actual values are much higher (See Table 1, Panel A). The smoother for all panels is an Epanechnikov kernel with a bandwidth of 0.05. Travel times are calculated based on mainline speeds from PeMS and ExpressLanes time stamps and the actual distance traveled for each trip in the ExpressLanes. Both panels are generated using trip-level transponder data for the morning peak hours (5-9AM) of workdays in the first 10 months of the program, excluding holidays. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped.

PANEL A: TRAVEL TIME SAVINGS



PANEL B: RELIABILITY

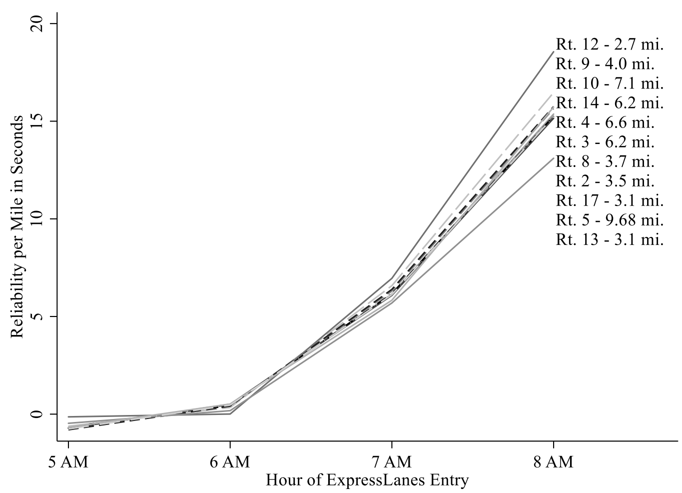
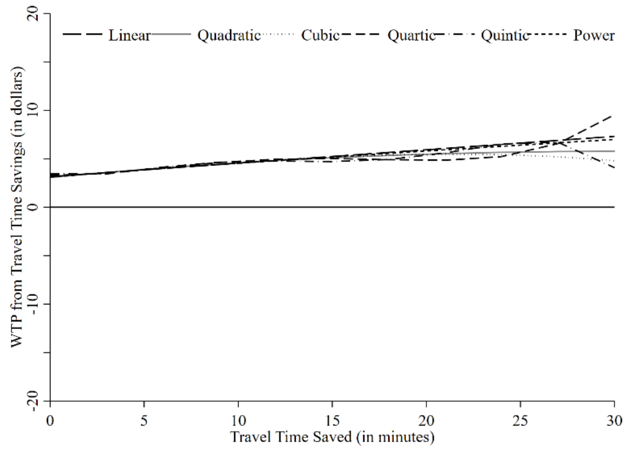


FIGURE E.4. SEGMENT-LEVEL VARIATION IN TIME SAVINGS AND RELIABILITY BY HOUR

Notes: The figures plot the considerable variation in average travel time savings and reliability by route and hour of entry to the ExpressLanes on workdays. Segment names and distances are indicated to the right of each line. Travel time difference, measured in hours per mile, is the time saved by taking the ExpressLanes compared with Mainline Lanes, from Mainline speeds reported by PeMS, divided by the trip distance. Reliability is the difference between lanes in the spread of travel times between the 50th and 80th quantiles divided by the trip distance. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped.

PANEL A: MODELS WITH A CONSTANT



PANEL B: MODELS WITHOUT A CONSTANT

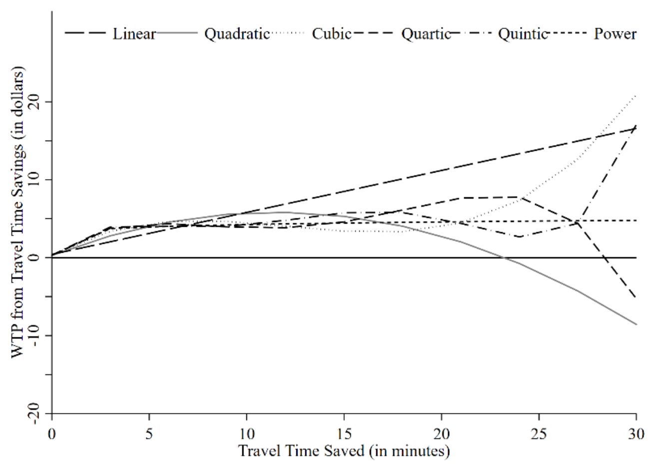


FIGURE E.5. MODEL PREDICTED WTP FROM ALTERNATIVE FUNCTIONAL FORMS

Notes: The figure plots predicted WTP for variation in time savings between 0 and 30 minutes based on estimates from 12 different regressions in a homogeneous agent model during the morning peak (5-9 AM) on workdays of the toll paid on travel time savings, reliability and a constant. These correspond to the models estimated in Appendix Tables D.15 and D.16. Models vary by the polynomial order (1st through 5th) or as a power function, where all other terms enter linearly, but travel time savings include a multiplicative parameter and an exponent: $\beta_1(Travel\ Time)^{\beta_2}$. The regressions in Panel A include a constant while those in Panel B do not. Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability, measured in hours, is the difference between lanes in the spread of travel times between the 80th and 50th quantiles. Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped.

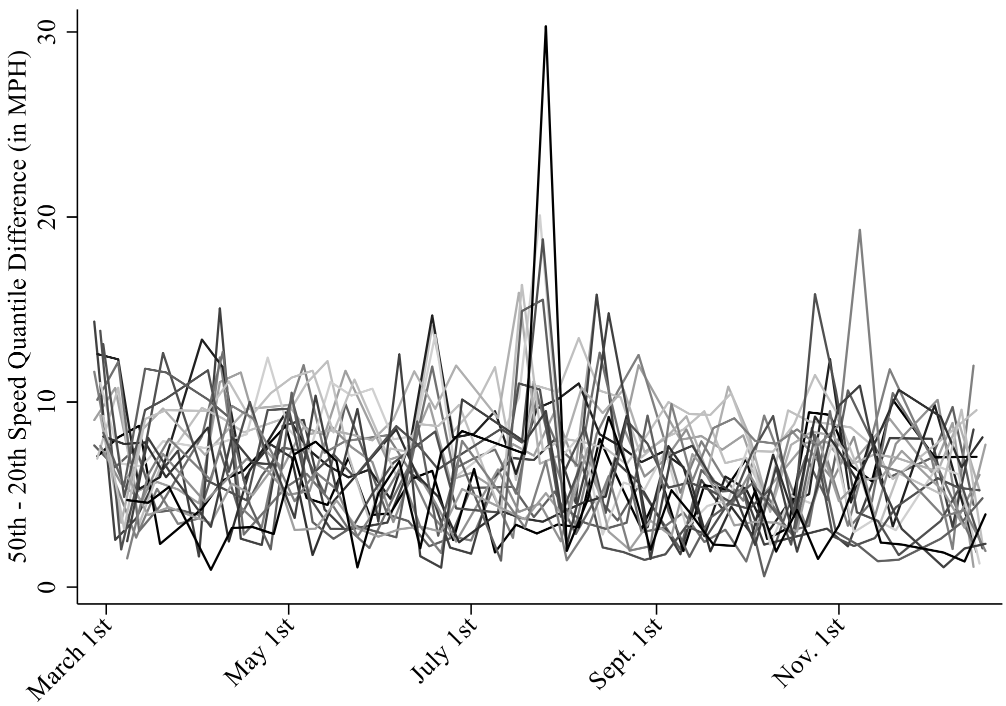


FIGURE E.6. VARIATION IN MAINLINE SPEED DISTRIBUTION BY HOUR AND DAY-OF-WEEK

Notes: This figure plots 20 time series of the difference between the 50th and 20th quantiles of speed. Each line corresponds to this value for an AM peak hour (5, 6, 7, 8 AM) and weekday (Monday-Friday), illustrating substantial variation in the distribution of 5 minute speeds within a weekday-hour from one week to the next. Speed for mainline speeds are those reported by PeMS. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped.

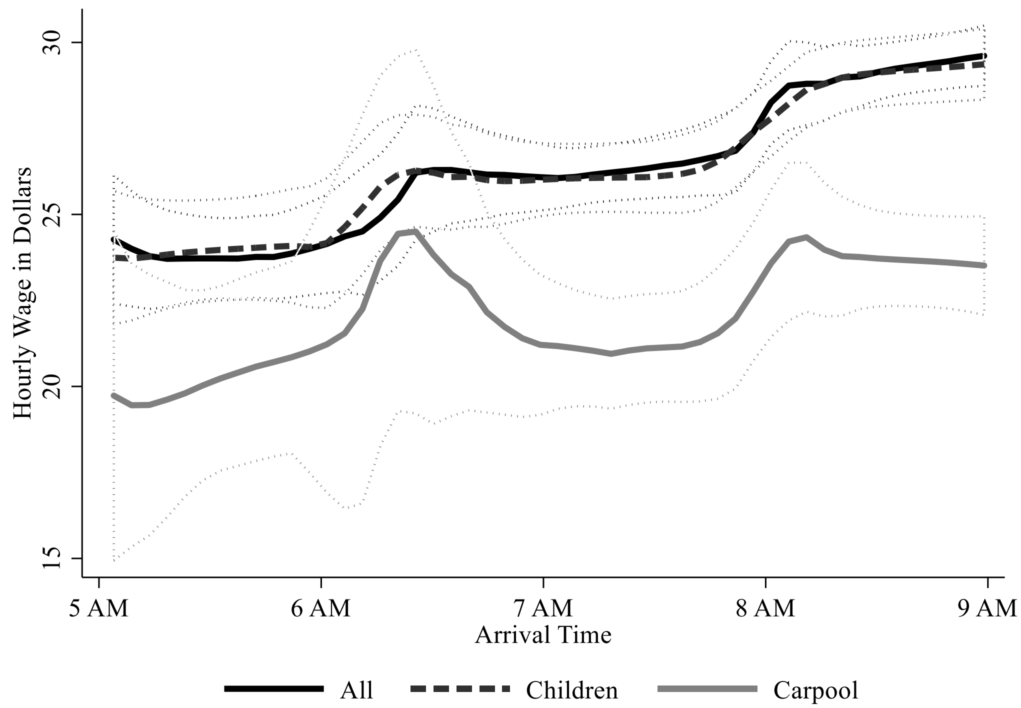


FIGURE E.7. AVERAGE INCOMES BY USUAL ARRIVAL TIME TO WORK IN LOS ANGELES

Notes: This figure plots the kernel-weighted locally smoothed estimate of hourly wages for commuters by the reported usual arrival time over the AM peak at work from the 2013 5-year ACS estimates for employed Los Angeles County residents earning more than $20,000 per year and driving to work. Hourly wages are based on reported annual wage income and assume 2,040 hours worked per year. The solid black line corresponds to all commuters in the sample, the dashed black line to those in households with any children, and the solid grey line for commuters that drive or are driven to work in a vehicle with one or more passengers. Faint dotted curves show the 95% confidence intervals around each set of estimates.

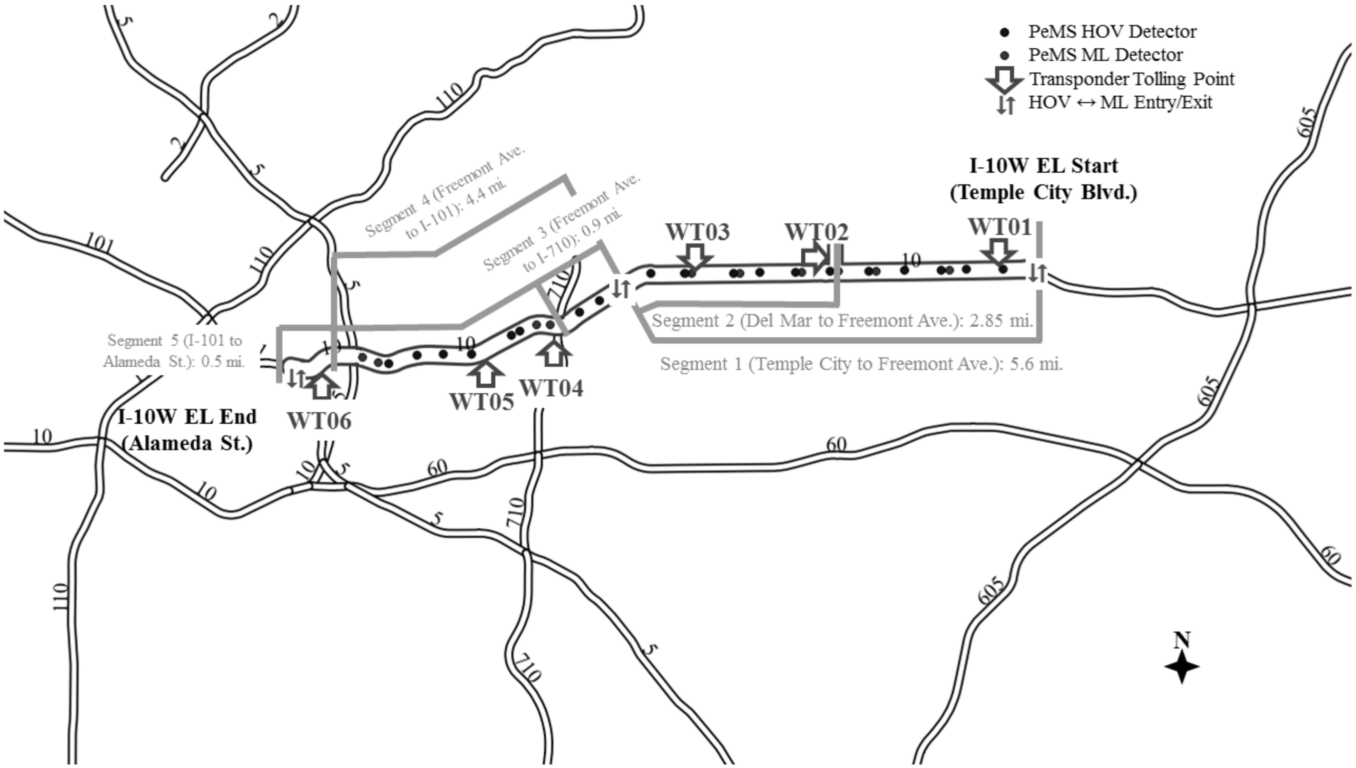


FIGURE E.8. I-10 W EXPRESSLANES DESIGN

Notes: The figure displays the I-10 W ExpressLanes design, which includes 5 separately tolled segments along its 10.5 mile stretch West of Downtown Los Angeles (indicted by the light grey lines). The beginning and end of each segment is defined by a transponder detector and license plate scanner at each tolling plaza (indicated in the map with an arrow) that identifies vehicles entering and exiting the ExpressLanes. This corridor has one of the highest densities of PeMS flow and speed detectors in California as indicated by the small circles.

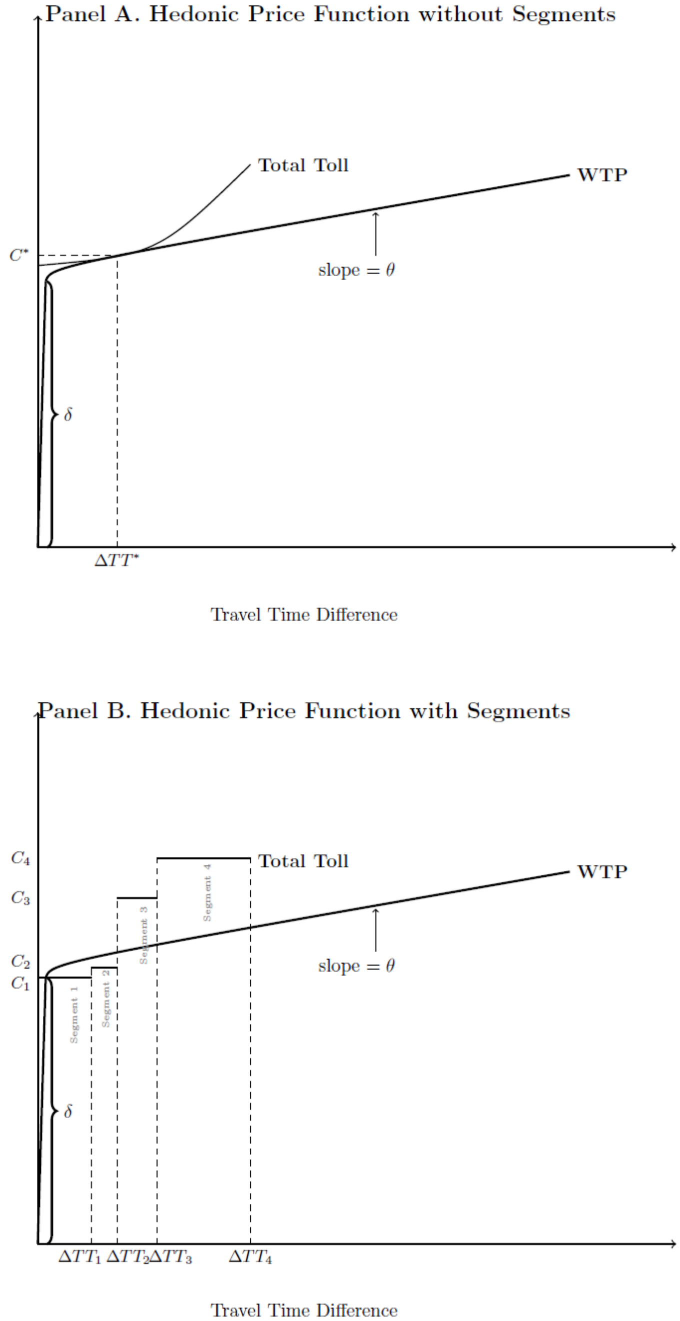


FIGURE E.9. IDENTIFICATION OF WTP FROM TOLL HEDONIC

Notes: The figure displays the willingness-to-pay for travel time savings given value of urgency δ and value of time θ in the ExpressLanes with continuous segment length (Panel A) and discrete segment length (Panel B). Tangency between WTP and the price function reveals MWTP in the continuous case, while the differences between cumulative segment prices provide bounds on these parameters.

Appendix F. Additional Tables

TABLE F.1—TRIP- & ACCOUNT-LEVEL WILLINGNESS-TO-PAY ESTIMATES BY DECILE OF TRAVEL TIME SAVINGS

II	III	IV	V	VI	VII	VIII
Panel A. Trip-Level Characteristics						
Time Savings			Average WTP per Hour			
in Hours	in Minutes	Average Toll Paid	Full Time Period	February & March	June	September
0.01	0.39	$3.20	$1,977	$1,730	$1,910	$1,220
0.02	1.01	$3.10	$190	$147	$242	$134
0.03	1.66	$3.12	$115	$94	$158	$86
0.04	2.37	$3.17	$81	$72	$116	$66
0.05	3.11	$3.29	$64	$55	$85	$55
0.06	3.88	$3.57	$55	$45	$70	$48
0.08	4.69	$3.81	$49	$39	$62	$44
0.09	5.64	$4.15	$44	$34	$56	$41
0.12	6.95	$4.49	$39	$29	$46	$38
0.18	11.04	$4.95	$28	$25	$40	$28
0.07	4.08	$3.69	$264	$227	$278	$176
Panel B. Account-Level Characteristics						
Time Savings (decile)	Average Uses per Month	Average Hourly Wage in Zip Code	Average Toll Paid	Modal Vehicle Registered to Account		Average Vehicle Value
1	8.8	$19.35	$3.20	Honda Accord		$9,543
2	9.5	$19.40	$3.10	Honda Accord		$9,512
3	9.8	$19.47	$3.12	Honda Accord		$9,553
4	9.9	$19.47	$3.17	Honda Accord		$9,443
5	9.8	$19.65	$3.29	Toyota Camry		$9,477
6	9.9	$19.71	$3.57	Honda Accord		$9,476
7	9.8	$19.73	$3.81	Honda Accord		$9,523
8	9.8	$19.76	$4.15	Honda Accord		$9,607
9	9.8	$19.79	$4.49	Honda Accord		$9,793
10	9.6	$20.00	$4.95	Honda Accord		$9,943
Average	9.7	$19.63	$3.69	Honda Accord		$9,587

Notes: The table calculates the average time savings, toll paid and implied WTP for travel time saved by decile of travel time saved during the morning peak (5-9 AM) on workdays. Columns II-V cover the period from February 25th, 2013 until December 30th, 2013 while VI-VIII cover the indicated subsamples. "Time Savings" is the travel time saved by driving in the ExpressLanes over the mainline lanes, calculated from Metro transponder information on vehicle distance traveled and speed compared with the speed recorded by PeMS in the mainline lanes. "Average Hourly Wage in Zip Code" is based on annual wage income 2013 ACS data for Los Angeles assuming 2,040 hours worked per year. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Each decile for the full time period contains 46,624 trips, for February and March contains 3,261 trips, for June contains 4,615 trips and for September contains 7,001 trips.

TABLE F.2—MOST COMMON VEHICLES BY DECILE OF TRAVEL TIME SAVINGS

I	II	III	IV
Time Savings (decile)		Top 3 Cars	
1	Honda – Accord	Honda – Civic	Toyota – Camry
2	Honda – Accord	Honda – Civic	Toyota – Camry
3	Honda – Accord	Honda – Civic	Toyota – Camry
4	Honda – Accord	Toyota – Camry	Honda – Civic
5	Toyota – Camry	Honda – Accord	Honda – Civic
6	Honda – Accord	Toyota – Camry	Honda – Civic
7	Honda – Accord	Honda – Civic	Toyota – Camry
8	Honda – Accord	Toyota – Camry	Honda – Civic
9	Honda – Accord	Toyota – Camry	Honda – Civic
10	Honda – Accord	Toyota – Camry	Honda – Civic
Whole Sample	Honda – Accord	Toyota – Camry	Honda – Civic

Notes: The table displays the most common three vehicle models by decile of time saved during the morning peak (5-9 AM) on workdays. We report the vehicle make and model registered to accounts most commonly for each decile. Time savings are calculated from transponder information on vehicle distance traveled and speed compared with PeMS mainline speed data. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Each decile for the full time period contains 46,624 trips.

TABLE F.3—MONTHLY FREQUENCY BY TRAVEL TIME SAVINGS DECILE

I	II	III	IV	V	VI	VII
Time Savings (decile)	One Month of Use	1x per Month	2-5x per Month	6-10x per Month	11-20x per Month	>20x per Month
1	5.20%	3.87%	31.61%	34.12%	24.33%	0.69%
2	5.99%	2.98%	26.98%	33.40%	29.38%	1.12%
3	6.26%	2.68%	24.53%	33.00%	32.19%	1.18%
4	6.73%	2.61%	23.12%	33.13%	33.20%	1.04%
5	6.66%	2.62%	23.56%	32.74%	33.33%	0.92%
6	6.29%	2.51%	23.17%	32.96%	33.93%	0.98%
7	6.32%	2.62%	23.35%	32.89%	33.83%	0.81%
8	6.09%	2.83%	23.55%	32.36%	34.08%	0.92%
9	6.08%	2.97%	23.68%	31.86%	34.31%	0.91%
10	6.08%	3.06%	24.73%	32.06%	33.08%	0.80%

Notes: The table presents the usage patterns of individuals by decile of travel time savings during the morning peak (5-9 AM) on workdays. First, we categorize accounts according to average number of trips (in any decile) per month. Then values given are the number of trips in that decile by agents with frequency of the listed column, implying that rows sum to 100%. Because the first month the agent adopts a transponder may not by typical, we construct average monthly use excluding the initial observed month. Agents who only use the lane for one month of data are given in the first column. Monthly use numbers are rounded up to the nearest integer. Data cover workdays during the morning peak (5-9 AM) from February 25th, 2013 until December 30th, 2013. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Each decile for the full time period contains 46,624 trips.

TABLE F.4—REGRESSION OF DISTANCE ON EXIT TIME

	I	II	III	IV	V
Exit Time	0.27***	0.27***	0.27***	0.26***	0.12***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Exit Time^2				0.06***	
				(0.02)	
Toll in Dollars per Mile	-3.59***	-3.13***	-3.13***	-3.58***	-2.62***
	(0.07)	(0.09)	(0.07)	(0.07)	(0.05)
Constant	8.61***	8.33***	8.33***	8.59***	6.67***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.03)
Limitations		Acct FE	Transponder FE		Removing Full Segment
R^2	0.103	0.659	0.675	0.103	0.198
Observations	334,127	334,127	334,127	334,127	232,053

Notes: The table provides additional evidence for the influence of schedule constraints by considering how drivers' consumption of distance along the ExpressLanes responds to variation in average exit time during the AM Peak (5-9AM). Values shown are the coefficients of 5 separate regressions of the total distance traveled by commuters in the ExpressLanes on the regressands. Exit time, measured in hours, is the difference for each trip between the time exiting the lanes and the average for each transponder account. Column V reports the same model as column I but with trips travelling the full ExpressLanes corridor removed. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.5—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: RELIABILITY MOMENTS AND WINDOW ROBUSTNESS

Panel A. Reliability Moments	I	II	III	IV
Constant	2.85***	2.84***	2.76***	2.87***
	(0.48)	(0.48)	(0.47)	(0.47)
Travel Time	8.11**	8.02**	8.63**	10.99***
	(3.02)	(3.00)	(2.90)	(3.09)
Reliability – 75-50 Quantile	31.51***			
	(6.66)			
Reliability – 80-50 Quantile		24.76***		
		(5.24)		
Reliability – 90-50 Quantile			12.03***	
			(1.82)	
Reliability – Standard Deviation				0.06
				(0.03)
Observations	433,623	433,623	433,623	433,623
R^2	0.22	0.22	0.24	0.16
AIC	1,512,162	1,510,246	1,496,897	1,543,628
BIC	1,512,195	1,510,279	1,496,930	1,543,661

Panel B. Reliability Window	15 Days	30 Days	60 Days	90 Days
Constant	2.87***	2.84***	2.83***	2.82***
	(0.49)	(0.48)	(0.49)	(0.49)
Travel Time	9.28**	8.02**	7.31**	6.30**
	(3.06)	(3.00)	(2.91)	(2.67)
Reliability	9.98***	24.76***	30.63***	36.71***
	(2.16)	(5.24)	(6.34)	(7.30)
Observations	451,878	433,623	398,136	346,915
R^2	0.19	0.22	0.24	0.27
AIC	1,580,000	1,510,000	1,380,000	1,190,000
BIC	1,580,000	1,510,000	1,380,000	1,190,000

Notes: The table examines the robustness of the central specification to the inclusion of reliability measures. Values shown are the coefficients of 8 separate regressions of the toll paid on the regressands. Panel A reports coefficients for models where we vary the moments differenced between mainline lanes and ExpressLanes, and we use a 30 day moving window by day of week and hour to construct each measure. Panel B reports reliability constructed as the 80^{th}-50^{th} quantile spread in time savings calculated using a moving window using different sizes: 15-90 days by day of week and hour. AIC and BIC are Akaike and Bayesian Information Criteria. Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability, measured in hours, is the difference between lanes in the spread of travel times between the 80^{th} and 50^{th} quantiles. Data cover workdays during the morning peak (5-9AM). Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.6—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: STANDARD ERROR CLUSTERING

	I	II	III	IV	V	VI
	Robust	Day	Week	Month	Account	Week-Segment
Constant	2.89***	2.89***	2.89***	2.89***	2.89***	2.89***
	(0.00)	(0.03)	(0.05)	(0.08)	(0.01)	(0.47)
Travel Time	8.30***	8.30***	8.30***	8.30***	8.30***	8.30***
	(0.04)	(0.63)	(0.77)	(0.65)	(0.10)	(2.81)
Reliability	22.67***	22.67***	22.67***	22.67***	22.67***	22.67***
	(0.12)	(2.11)	(3.39)	(4.24)	(0.27)	(5.00)
R^2	0.22	0.22	0.22	0.22	0.22	0.22
Observations	433,623	433,623	433,623	433,623	433,623	433,623

Notes: The table examines the effects of differing levels of clustering on the standard errors. Values shown are the coefficients of 6 separate regressions of the toll paid on the regressands. Standard errors are in parentheses. Column I reports heteroskedastic robust standard errors, while columns II-VI cluster by the indicated variable. Column VI calculates two-way clustered standard errors following Cameron, Gelbach and Miller (2011). Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability, measured in hours, is the difference between lanes in the spread of travel times between the 80th and 50th quantiles. Data cover workdays during the morning peak (5-9AM). Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.7—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: POTENTIAL MEASUREMENT ERRORS

	I	II	III	IV
Panel A. Measurement Error Models				
Constant	2.94***	2.97***	1.66***	0.36
	(0.50)	(0.50)	(0.47)	(0.67)
Travel Time in Hours	5.53***	9.70***	11.05***	11.05***
	(1.51)	(2.85)	(3.03)	(3.03)
R^2	0.15	0.13	0.15	0.15
Observations	466,232	466,232	466,232	466,232
	Multiply time saved by 2	Each segment is 0.5 miles longer than measured	Add 7 minutes to ALL time savings	Add 14 minutes to ALL time savings
Panel B. Alternative Measurements of Travel Time Difference				
Constant	2.78***	2.38***	2.84***	2.39***
	(0.479)	(0.44)	(0.53)	(0.44)
Travel Time (Max. 1)	11.84***			
	(3.22)			
Travel Time (Max. 2)		13.50***		
		(2.64)		
Travel Time (Max. 3)			11.39***	
			(1.40)	
Travel Time (Max. 4)				12.24***
				(1.26)
R^2	0.180	0.284	0.255	0.366
Observations	466,232	433,623	433,623	433,623
Avg. Travel Time Diff. in Min.	4.60	5.98	4.68	6.59

Notes: This table explores the robustness of our main results to variations in the construction of the travel time difference variable to understand how various types of measurement error would influence the estimates, reflecting alternative driver perceptions than those assumed in our main results. Values shown are the coefficients from 8 separate regressions of the total toll on the regressands. In Panel A, Column I, we replace the travel time saved with twice its realized value to reflect the fact that underestimating the time saved inflates the value of time. Column II assumes that each segment is half a mile longer than recorded, possibly because of transition zones. Columns III and IV add 7 and 14 minutes of time saved to all trips suggesting that only by uniformly adding travel time will the constant go to zero. Panel B examines the robustness of the central specification to variation in the calculation of travel times in the parallel mainline segment. "Max. 1" compares the maximum speed in the ExpressLanes within a 5-minute interval that a transponder is recorded in the lane to the average speed recorded by PeMS detectors in the mainline lanes for a comparable segment at the same time. "Max. 2" compares the maximum speed in the ExpressLanes for the preceding month by hour and day of week to the average speed recorded by PeMS detectors in the mainline lanes for a comparable segment at the same time. "Max. 3" compares the travel time recorded by the transponder receiver for each vehicle to the minimum speed in the mainline lanes from PeMS detectors for the preceding month by hour and day of week. "Max 4" compares the maximum speed in the ExpressLanes for the preceding month by hour and day of week to the minimum speed in the mainline lanes from PeMS detectors for the preceding month by hour and day of week. These results also serve as a robustness check to recording errors with individual PeMS detectors in mainline lanes.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.8—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: I-210W AS A SUBSTITUTE ROUTE

	I	II	III
	Whole Sample	I-210W Below Mean Speed	I-210W Above Mean Speed
Constant	3.15***	2.94***	2.79***
	(0.57)	(0.52)	(0.42)
Travel Time I-210W	8.31***		
	(0.93)		
Travel Time I-10W		8.66**	5.00
		(2.81)	(3.92)
Reliability I-10W	19.47***	19.98***	35.93***
	(2.79)	(4.87)	(6.20)
R^2	0.20	0.21	0.21
Observations	433,623	237,839	195,784

Notes: The table examines the robustness of the result to the extent that the approximately parallel, untolled I-210W acts as substitute for the mainline I-10W lanes. Values shown are the coefficients of 3 separate regressions of the toll paid during the AM peak period (5 – 9 AM) on the regressands. Column I uses counterfactual travel time savings of the ExpressLanes relative to the I-210W instead of the I-10W. Column II uses counterfactual travel time savings from the I-10W mainlines as in our central specifications, but restricts the sample to times when speeds along the I-210W are below average. Column III uses the same travel time savings variable, but restricts the sample to times when speeds along the I-210W are above average. Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes on the I-10W or I-210W, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability, measured in hours, is the difference between lanes in the spread of travel times between the 80th and 50th quantiles. Data cover workdays during the morning peak (5-9AM). Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses.
*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

Table F.9—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: ACCOUNT FIXED EFFECTS

	I	II	III	IV
Constant	2.887***	3.055***	2.733***	2.693***
	(0.481)	(0.005)	(0.016)	(0.018)
Travel Time	8.345**	7.849***	7.393***	7.627***
	(2.868)	(0.061)	(0.058)	(0.061)
Reliability	22.742***	11.664***	15.929***	16.101***
	(4.624)	(0.195)	(0.207)	(0.205)
R^2	0.22	0.17	0.22	0.23
Observations	426,761	426,761	426,761	426,761
Implied Value of Urgency from Account Fixed Effects in $ per Trip				
25th Quantile		2.13	1.80	1.76
Mean		3.06	2.73	2.69
75th Quantile		3.98	3.68	3.65
sd(Account FEs)			0.99	0.99
sd(Time FEs)			0.38	0.16
Account FE		X	X	X
Hour FE			X	X
Hour-DOW FE				X

Notes: This table is based on a model that assumes a common value of time and reliability across the sample, but an account-specific value of urgency, using within variation to explain the latter and between to explain the former. Time-fixed effects (by hour or hour-by-day-of-week) also control for time-specific urgency across trip appearances in the sample. Values shown are the coefficients of 4 separate regressions of the toll paid during the AM peak period (5 – 9 AM) on the regressands. Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability, measured in hours, is the difference between lanes in the spread of travel times between the 80th and 50th quantiles. Three rows report the mean, 25th and 75th quantiles of the account-level fixed effects corresponding to varying estimates of the value of urgency across accounts in our sample. Data cover workdays during the morning peak (5-9AM). Sd(.) reports the standard deviation of account and time fixed effects. Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Robust standard errors are in parentheses.
*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.10—ACCOUNT-LEVEL HEDONIC PRICE FUNCTION ESTIMATES: TIME-VARYING VALUE OF TIME

	I Whole Sample	II Whole Sample	III After Oct. 20, 2013
Constant	2.823***	2.724***	2.716***
	(0.501)	(0.423)	(0.450)
1(6AM)		-0.157	-0.020
		(0.124)	(0.375)
1(7AM)		0.458	0.872
		(0.315)	(0.499)
1(8AM)		-0.033	-0.197
		(0.348)	(0.456)
Travel Time	-13.405	-8.042	-6.984
	(18.481)	(8.914)	(7.613)
Travel Time*1(6AM)	21.763	20.048*	23.907
	(16.108)	(9.565)	(14.143)
Travel Time*1(7AM)	26.477	17.881	13.618
	(18.007)	(10.439)	(11.130)
Travel Time*1(8AM)	15.920	11.507	4.872
	(18.836)	(10.659)	(9.364)
Reliability	33.193***	33.415***	37.537***
	(6.774)	(7.454)	(7.189)
R^2	0.28	0.29	0.33
Observations	426,761	426,761	8,1023

Notes: Values shown are the coefficients of three regressions of the toll paid on the regressands. Data cover workdays during the morning peak (5-9AM). 1(.) is an indicator variable equal to one during the indicated hour. Column III reports estimates for the period during which signs displaying travel time differences were installed at ExpressLanes entrances. Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability, measured in hours, is the difference between lanes in the spread of travel times between the 80th and 50th quantiles. Only accounts with 10 or more ExpressLanes uses are included. Reliability less than 0.01 hours (36 seconds) is set to zero in account-specific regressions. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors in all regressions are clustered by road segment and are presented in parentheses.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.11—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: EXPECTED VS. REALIZED TRAVEL TIMES

	I	II	III	IV
	Whole Sample	Whole Sample	After Oct. 22, 2013	After Oct. 22, 2013
Constant	2.84***	2.68***	3.15***	3.03***
	(0.48)	(0.38)	(0.43)	(0.44)
Travel Time	8.02**		7.98	
	(3.00)		(4.42)	
E[Travel Time]		12.05		13.11*
		(7.58)		(6.99)
Reliability	24.76***	20.14**	15.68***	8.74
	(5.24)	(8.04)	(4.26)	(7.59)
Observations	433,623	433,623	82,657	82,657
R^2	0.22	0.21	0.14	0.16
Mean Travel Time Savings in Minutes	4.08	4.02	4.42	3.80

Notes: This table explores the impact of using of expected rather than realized travel times in hedonic price regressions to reflect different driver perceptions. Values shown are the coefficients of 4 separate regressions of the toll paid during the AM peak period (5 – 9 AM) on the regressands. "E[Travel Time]" is the sample average by day-of-week, segment and five-minute interval of the time saved, measured in hours, by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability, measured in hours, is the difference between lanes in the spread of travel times between the 80th and 50th quantiles. Data cover workdays during the morning peak (5-9AM). Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses. Standard errors, clustered by road segment, are in parentheses.
*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.12— HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: TABLE 2 AS HOMOGENEOUS AGENT MODEL

	I	II	III	IV	V
	OLS	OLS	OLS	Instrumental Variables	OLS
Constant	2.89***	3.10***	3.61***	2.59	2.88***
	(0.48)	(0.54)	(0.50)	(0.47)	(0.49)
Travel Time	8.30**	7.99**	5.62	17.52	8.48**
	(2.88)	(2.83)	(4.48)	(5.13)	(2.85)
Reliability	22.67***	20.79***	12.54**	42.90	23.10***
	(4.61)	(5.69)	(5.32)	(8.29)	(4.67)
5 or more uses of ExpressLanes		X	X	X	
10 or more uses of ExpressLanes					X
After Oct. 20th, 2013			X		
Mean Toll Paid	$3.73	$3.98	$4.36	$3.97	$3.73
Urgency's Share of WTP	77%	78%	83%	65%	77%
Mean Time Savings in Minutes	4.20	4.20	4.80	3.60	4.20
Mean Reliability in Minutes	0.60	0.60	1.20	0.60	0.60
Number of Accounts	26,833	9,054	2,286	4,891	9,870

Notes: This table explores the impact of sample selection on estimates in Table 2 from restricting regression to accounts appearing 5 or more times in the I-10W ExpressLanes. Values shown are the coefficients of 5 regressions of the toll paid on the regressands. Instrumental variables used in column IV are 1 hour, 1 week and 2 week leads of time savings by hour, day of week and segment. Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability, measured in hours, is the difference between lanes in the spread of travel times between the 80th and 50th quantiles. Data cover workdays during the morning peak (5-9AM). Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses. *** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.13—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: COMPARISON WITH PRIOR LITERATURE

Panel A: Model with Constant			
	I	II	III
Constant	2.84***	3.21***	3.87**
	(0.48)	(0.98)	(1.36)
Travel Time	8.02**	6.90***	4.58*
	(3.00)	(1.88)	(2.08)
Reliability	24.76***	17.70**	9.81
	(5.24)	(5.66)	(8.74)
Trip Restriction	> 0 minutes	> 4 minutes	> 8 minutes
Observations	433,623	188,369	42,277
AIC	1,510,246	695,318	153,230
BIC	1,510,279	695,349	153,255

Panel B: Model without Constant			
Travel Time	30.18***	28.43***	21.56***
	(3.149)	(2.915)	(2.907)
Reliability	44.18***	29.55***	23.36***
	(8.305)	(2.829)	(1.585)
Trip Restriction	> 0 minutes	> 4 minutes	> 8 minutes
Observations	433,623	188,369	42,277
AIC	1,923,834	792,574	171,281
BIC	1,923,856	792,594	171,298

Notes: Values shown are the coefficients of six regressions of the toll paid on the regressands. Data cover workdays during the morning peak (5-9AM). Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability, measured in hours, is the difference between lanes in the spread of travel times between the 80th and 50th quantiles. AIC and BIC are Akaike and Bayesian Information Criteria. Reliability less than 0.01 hours (36 seconds) is set to zero in account-specific regressions. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors in all regressions are clustered by road segment and are presented in parentheses. Standard errors, clustered by road segment, are in parentheses.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.14—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: MODEL WITHOUT RELIABILITY

	I	II
Constant	2.887***	2.960***
	(0.481)	(0.513)
Travel Time	8.345**	11.330***
	(2.868)	(3.014)
Reliability	22.742***	
	(4.624)	
R^2	0.22	0.15
Observations	426,761	426,761
Chow Test Constant p-value	0.08	
Chow Test Travel Time p-value	0.00	

Notes: Values shown are the coefficients of two regressions of the toll paid on the regressands. Data cover workdays during the morning peak (5-9AM). Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability, measured in hours, is the difference between lanes in the spread of travel times between the 80^{th} and 50^{th} quantiles. Reliability less than 0.01 hours (36 seconds) is set to zero in account-specific regressions. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors in all regressions are clustered by road segment and are presented in parentheses. Standard errors, clustered by road segment, are in parentheses.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level

TABLE F.15—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: OTHER CORRIDORS

	I	II	III	IV	V	VI
	I-10 East		I-110 North		I-110 South	
	AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
Constant	1.98**	1.55**	3.71***	2.40***	2.19***	2.58***
	(0.66)	(0.57)	(0.33)	(0.20)	(0.26)	(0.26)
Travel Time	6.21	12.70	17.40***	7.28***	10.10	4.92
	(5.26)	(7.65)	(3.32)	(1.58)	(5.80)	(4.47)
Reliability	71.03	30.20**	75.94***	33.32***	87.36***	55.52***
	(55.01)	(10.19)	(17.67)	(10.15)	(15.25)	(16.77)
R^2	0.08	0.43	0.10	0.19	0.12	0.06
Observations	19,007	285,147	433,800	211,131	213,806	555,460
Average Toll	2.36	2.5	4.48	2.71	2.44	2.84
Urgency's Share of WTP	0.84	0.62	0.83	0.89	0.9	0.91
Average Time Savings in Hours	0.06	0.01	0.04	0.02	0.02	0.04
Average Time Savings in Minutes	3.63	0.44	2.48	1.39	1.29	2.18
Average Reliability in Hours	0.01	0.03	0.01	0.01	0.01	0.01
Average Reliability in Minutes	0.01	1.69	0.04	0.26	0.02	0.09

Notes: The table examines the central specification using trips from other ExpressLanes corridors in Los Angeles: the other direction of the I-10 and trips on the I-110. Values shown are the coefficients of 6 separate regressions of the total toll paid on the regressands. Morning Peak periods occur during non-holiday weekdays between 5-9 AM and afternoon peak periods are 4-8 PM. Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability is the difference in the spread of the 80th and 50th quantiles of travel time savings between the mainline and ExpressLanes. Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.16—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: SEGMENT ROBUSTNESS

	I	II	III	IV	V	VI
Segment number	2	3	4	5	7	8
Entry Plaza	WT01	WT01	WT01	WT01	WT02	WT02
Exit Plaza	WT03	WT04	WT05	WT06	WT03	WT04
Constant	1.99***	2.24***	3.97***	4.47***	—	1.37***
	(0.06)	(0.05)	(0.08)	(0.14)	—	(0.05)
Travel Time	7.57***	6.83***	12.95***	9.51***	—	11.09***
	(0.60)	(0.57)	(1.28)	(1.07)	—	(1.25)
Reliability	-7.76*	-2.40	11.50**	4.39		1.51
	(3.38)	(2.27)	(4.83)	(2.68)		(2.87)
R^2	0.16	0.31	0.34	0.3	—	0.2
Number of Observations	111,446	126,106	16,533	146,939	0	11,030
Segment number	9	10	12	13	14	17
Entry Plaza	WT02	WT02	WT03	WT03	WT03	WT05
Exit Plaza	WT05	WT06	WT04	WT05	WT06	WT06
Constant	4.22***	4.51***	1.74***	4.51***	4.42***	3.39***
	(0.14)	(0.13)	(0.11)	(0.10)	(0.11)	(0.08)
Travel Time	4.23*	3.02**	8.82***	-0.33	5.42**	3.19*
	(1.82)	(0.71)	(1.67)	(2.39)	(1.52)	(1.28)
Reliability	-4.71	-2.75	-0.26	-6.91**	-0.08	13.39
	(5.08)	(2.20)	(5.01)	(2.91)	(3.37)	(10.25)
R^2	0.03	0.04	0.15	0.00	0.04	0.00
Observations	1,079	24,033	333	286	8,145	20,302

Notes: The table examines the robustness of the central specification to a restriction on the trips entering the regression that take place on the listed road segment. Values shown are the coefficients from 11 separate regressions of total toll on the regressands for the indicated road segment. Data cover workdays during the morning peak (5-9AM). Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability is the difference in the spread of the 80th and 50th quantiles of travel time savings between the mainline and ExpressLanes. Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses. Standard errors, clustered by month, are in parentheses.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.17—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: RESTRICTED TIME WINDOWS

	I	II
Constant	2.29***	3.04***
	(0.25)	(0.30)
Travel Time	15.99*	-3.14
	(7.41)	(8.01)
Reliability	25.57***	35.15***
	(2.19)	(4.13)
R^2	0.10	0.12
Observations	108,942	188,911
Limit on Trip Differential	3-5 min	<3 min

Notes: The table tests the robustness of the central specification to restrictions on the trip time saved that enter the regression. Values shown are the coefficients from 2 regressions of the toll paid on the regressands. Data cover workdays during the morning peak (5-9AM). Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability is the difference in the spread of the 80th and 50th quantiles of travel time savings between the mainline and ExpressLanes. Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.18—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: OTHER FUNCTIONAL FORM

	I	II	III	IV	V	VI	VII
	Higher Order Terms					Non-Linear Power Model	
Constant	2.89***	2.84***	3.00***	3.19***	β_0	2.83***	
	(0.48)	(0.31)	(0.30)	(0.30)		(0.32)	
Travel Time	8.30**	9.27	-1.68	-18.61			
	(2.88)	(13.63)	(15.64)	(13.55)			
Travel Time^2		3.89	162.27	514.40***	β_1	7.29	4.87**
		(74.65)	(121.56)	(124.99)		(4.61)	(1.64)
Travel Time^3		-31.31	-752.22*	-3,405.54***	β_2	0.90	0.12*
		(110.98)	(372.86)	(610.69)		(0.67)	(0.06)
Travel Time^4			969.18**	8,898.96***			
			(389.22)	(1383.62)			
Travel Time^5				-7,973.01***			
				(1147.69)			
Reliability	22.67***	22.19***	21.78***	21.59***	β_3	22.57***	24.79***
	(4.61)	(5.34)	(5.22)	(5.34)		(5.27)	(6.20)
Observations		433,623	433,623	433,623		433,623	433,623
AIC		1,511,412	1,509,235	1,506,824		1,512,370	1,526,171
BIC		1,511,467	1,509,301	1,506,901		1,512,414	1,526,204
% of WTP from VOT	0.16	0.17	0.12	0.07		0.17	0.95

Notes: The table examines the robustness of models with urgency to functional form assumptions. Given the functional forms of models in columns I and III, the WTP implied by the estimates becomes negative when travel time savings exceed 43.4 and 31.7 minutes, respectively. "Non-Linear Power Model" in columns VI and VII estimates a power model using maximum likelihood of: $Toll = \beta_0 + \beta_1(Travel\,Time)^{\beta_2} + \beta_3 Reliability + \varepsilon$. Column VII excludes the constant term β_0.Values shown are the coefficients of five regressions of the toll paid on the regressands. Data cover workdays during the morning peak (5-9AM). Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability is the difference in the spread of the 80th and 50th quantiles of travel time savings between the mainline and ExpressLanes. Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.19—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: MODELS WITHOUT A CONSTANT

	I	II	III	IV	V
Travel Time	32.32***	57.80***	84.00***	114.07***	147.65***
	(2.98)	(8.81)	(12.46)	(16.26)	(19.21)
Travel Time^2		-151.04***	-487.51***	-1082.42***	-2037.42***
		(15.49)	(56.91)	(149.36)	(313.89)
Travel Time^3			803.97***	3891.95***	12133.72***
			(114.73)	(658.20)	(2448.81)
Travel Time^4				-4456.12***	-30954.77***
				(904.12)	(7511.27)
Travel Time^5					27847.87***
					(7646.72)
Reliability	34.84***	24.16**	25.42**	26.42***	26.08***
	(6.90)	(8.70)	(8.52)	(7.68)	(6.80)
Observations	433,623	433,623	433,623	433,623	433,623
AIC	1,938,562	1,801,141	1,729,194	1,686,791	1,659,345
BIC	1938,584	1,801,174	1,729,238	1,686,846	1,659,411

Notes: The table examines the robustness of models without urgency to functional form assumptions. Values shown are the coefficients of five regressions of the toll paid on the regressands. Data cover workdays during the morning peak (5-9AM). Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability is the difference in the spread of the 80th and 50th quantiles of travel time savings between the mainline and ExpressLanes. Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses.
*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.20—HEDONIC PRICE FUNCTION ESTIMATES: TWO-STAGE LEAST SQUARES FIRST-STAGE

	I	II	III	IV	V
Instrument:	Leads	Mean I-10W Travel Time Savings	Mean I-10W Travel Time Savings after Oct. 20	I-210W Inverse Speeds	I-10E Travel Time Savings
Travel Time (1 hour lead)	0.456***				
	(0.027)				
Travel Time (1 week lead)	0.220***				
	(0.024)				
Travel Time (2 week lead)	0.107*				
	(0.051)				
Reliability	0.605***	0.643***	0.817***	0.581***	0.543***
	(0.099)	(0.143)	(0.111)	(0.141)	(0.146)
Travel Time (Hourly-DOW Mean)		0.804***	0.745***		
		(0.192)	(0.140)		
Inverse Contemporaneous I-210W Speed				2.673***	
				(0.635)	
Travel Time I-10E					0.944***
					(0.212)
Constant	-0.002	0.006	0.001	-0.002	0.011
	(0.002)	(0.006)	(0.005)	(0.008)	(0.007)
R^2	0.589	0.265	0.267	0.255	0.523
Observations	221,127	411,053	411,053	302,504	329,111
Kleiberg-Paap F-Statistic	2,342	18	28	18	20

Notes: The table shows the coefficients from five regressions of the realized travel time saved on the regressands. Each column reports first-stage IV estimates from a different set of instruments. Column I corresponds to the first-stage of the split sample instrumental variable heterogeneous estimates reported in column IV of Table 2 as well as homogeneous IV estimates reported in Appendix Table E.18. Data cover workdays during the morning peak (5-9AM). The dependent variable, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Travel Time leads are constructed for the same 5-minute time window 1 hour, 1 week and 2 weeks in the future. Travel Time (Hourly-DOW Mean) is the average travel time savings for the corresponding hour and day of the week, while in column III, the same variable is constructed from the subsample of our data during which travel time savings signs were posted. I-210W Inverse Speeds are the inverse of contemporaneous average hourly speeds along the I-210W, a parallel commuting corridor to the I-10W that does not have ExpressLanes. Travel Time I-10E is the contemporaneous travel time savings from the I-10 ExpressLanes in the opposite direction on average by hour and day of week. Reliability is the difference in the spread of the 80^{th} and 50^{th} quantiles of travel time savings between the mainline and ExpressLanes. Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.21—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: TWO-STAGE LEAST SQUARES SECOND-STAGE

	I	II	III	IV	V
Instrument:	Leads	Mean I-10W Travel Time Savings	Mean I-10W Travel Time Savings after Oct. 20	I-210W Inverse Speeds	I-10E Travel Time Savings
Constant	2.409***	2.760***	2.562***	2.856***	3.202***
	(0.377)	(0.477)	(0.424)	(0.518)	(0.597)
Travel Time	17.231***	10.646**	14.277***	8.045*	4.995***
	(5.755)	(5.071)	(4.488)	(4.157)	(1.422)
Reliability	47.180***	20.456**	16.439*	24.146***	23.469***
	(7.275)	(9.483)	(8.633)	(8.238)	(6.501)
R^2	0.286	0.214	0.184	0.232	0.175
Observations	221127	411053	411053	302504	329111

Notes: The table shows the coefficients from five regressions of the total toll paid on the regressands. Each column reports second-stage two-stage least squares estimates from a different set of instruments. Column I corresponds to a homogenous agent model for the account-level estimates reported in column IV of Table 2. Data cover workdays during the morning peak (5-9AM). Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance, and is instrumented for by the indicated instrument sets. Travel Time leads are constructed for the same 5-minute time window 1 hour, 1 week and 2 weeks in the future. Travel Time (Hourly-DOW Mean) is the average travel time savings for the corresponding hour and day of the week, while in column III, the same variable is constructed from the subsample of our data during which travel time savings signs were posted. I-210W Inverse Speeds are the inverse of contemporaneous average hourly speeds along the I-210W, a parallel commuting corridor to the I-10W that does not have ExpressLanes. Travel Time I-10E is the contemporaneous travel time savings from the I-10 ExpressLanes in the opposite direction on average by hour and day of week. Reliability is the difference in the spread of the 80th and 50th quantiles of travel time savings between the mainline and ExpressLanes. Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.22—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: GAS PRICE AND WEATHER ROBUSTNESS

	I	II	III	IV
	Gas Price < $4	Gas Price > $4	Dry	Rainy
Constant	3.01***	2.77***	2.89***	2.84***
	(0.51)	(0.43)	(0.48)	(0.34)
Travel Time	8.61**	6.23*	8.29**	9.42
	(2.73)	(3.08)	(2.82)	(6.73)
Reliability	17.78***	34.09***	22.52***	24.55***
	(4.14)	(5.39)	(4.63)	(5.18)
R^2	0.194	0.247	0.217	0.193
Observations	253,671	179,952	408,720	24,903

Notes: The table examines the robustness of the result to the periods of time where gas prices were above and below $4 and with and without rainfall based on nearby weather stations describe in Appendix A. Values shown are the coefficients of 4 separate regressions of the toll paid on the regressands. The gas price is the lagged weekly regular reformulated price of gasoline for the Los Angeles area as reported by the Energy Information Administration. The sample is partitioned for observations where weekly regular reformulated gasoline price for Los Angeles is below $4 (column I) and above $4 (column II), where hours on a given date with zero precipitation ("Dry" – column III) and otherwise ("Rainy" – column IV). Data cover workdays during the morning peak (5-9AM). Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability is the difference in the spread of the 80th and 50th quantiles of travel time savings between the mainline and ExpressLanes. Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.23—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: SEASONALITY

	I	II	III	IV	V	VI
Constant	2.94***	2.39***	2.38***	2.67***	2.20***	2.33***
	(0.50)	(0.41)	(0.44)	(0.45)	(0.32)	(0.45)
Travel Time	11.05***	10.64***	10.52***	11.51***	11.22***	11.54**
	(3.03)	(3.14)	(3.20)	(3.31)	(3.48)	(3.76)
Reliability	22.67***	22.74***	23.77***	22.52***	22.55***	23.03***
	(4.61)	(4.60)	(4.53)	(4.66)	(4.71)	(4.79)
R^2	0.22	0.22	0.23	0.22	0.23	0.24
Observations	433,623	433,623	433,623	433,623	433,623	433,623
Quarter Fixed Effects		X				
Month Fixed Effects			X			
Day-of-Week Fixed Effects				X		
Quarter x Day-of-Week Fixed Effects					X	
Month x Day-of-Week Fixed Effects						X

Notes: The table examines the robustness of models with urgency to variation due to seasonal conditions by using a series of fixed effects models. Values are the coefficients of six regressions of the toll paid on the regressands. Column I reports baseline estimates from column I of Table 2 in the main text. Data cover workdays during the morning peak (5-9AM). Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability is the difference in the spread of the 80th and 50th quantiles of travel time savings between the mainline and ExpressLanes. Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.24—HOMOGENEOUS AGENT HEDONIC PRICE FUNCTION ESTIMATES: INCLUDING NEGATIVE TRAVEL TIME DIFFERENCE & NEGATIVE RELIABILITY

	I	II	III	IV
Constant	2.84***	2.911***	2.86***	2.93***
	(0.48)	(0.42)	(0.48)	(0.42)
Travel Time	8.021**	7.21*	8.04**	7.23*
	(3.00)	(3.590)	(3.02)	(3.61)
Reliability	24.76***	25.48***	24.12***	24.82***
	(5.24)	(5.70)	(5.03)	(5.52)
R^2	0.220	0.208	0.218	0.206
Observations	433,623	462,537	433,623	462,537
Travel Time Savings > 0 dropped	Yes	No	Yes	No
Reliability < 0 zeroed	No	No	Yes	Yes

Notes: The table examines the robustness of the central specification to the zeroing of negative reliability and the inclusion of trips with negative time savings. Values shown are the coefficients of 4 separate regressions of the toll paid on the regressands. Data cover workdays during the morning peak (5-9AM). Travel Time, measured in hours, is the time saved by taking the ExpressLanes compared with mainline lanes, from mainline speeds reported by PeMS, for the chosen trip distance. Reliability is the difference in the spread of the 80th and 50th quantiles of travel time savings between the mainline and ExpressLanes. Reliability less than 0.01 hours (36 seconds) is set to zero. Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses.

*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.25—REGRESSION OF ACCOUNT-LEVEL ESTIMATES ON VEHICLE PRICES

	I	II	III
Dependent Variable:	Urgency ($/trip)	Value of Time ($/hour)	Value of Reliability ($/hour)
Vehicle Price in 1,000s of 2013 Dollars (MSRP)	0.006***	-0.102***	-1.290***
	(0.001)	(0.008)	(0.046)
Constant	2.138***	7.688***	44.764***
	(0.008)	(0.085)	(0.596)
R^2	0.002	0.008	0.038
Observations	22,979	22,979	20,155
Correlation coefficient of dependent variable with VOT	-0.59	1.00	-0.09

Notes: This table examines the effect of vehicle value on estimates of the value of urgency and the value of time. Values shown are the coefficients of 3 regressions of account-level estimates from Table 2, column II of urgency, value of time or value of reliability on the regressands. Vehicles reported to Metro in transponder registration are matched to Wards Auto Database MSRPs by vehicle make, model and year. Vehicle prices are depreciated by an annual rate of 20%. Regressions are weighted by inverse of account-level regression standard error of dependent variable from account-level regressions reported in Table 2. Data cover workdays during the morning peak (5-9AM). Trips with zero distance traveled and the 6.2% of observations with negative time saving are removed. Transponders registered to public sector, corporate or unknown accounts (2% of the entire sample) are dropped. Untolled HOV-3 trips (33% of sample) are removed. Observations from PeMS where any of the 30 second observations are missing are also dropped. Standard errors, clustered by road segment, are in parentheses.
*** Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.

TABLE F.26—ENTRY-EXIT FREQUENCY MATRIX

I	II	III	IV	V
	Exit Plaza			
Entry Plaza	WT03	WT04	WT05	WT06
WT01	111,446	126,106	16,533	146,939
WT02	0	11,030	1,079	24,033
WT03	—	333	286	8,145
WT05	—	—	—	20,302

Notes: This table reports the frequency of observations by entry and exit toll plaza for the morning peak (5-9 AM) on workdays from February 25th, 2013 until December 30th, 2013 in the Metro transponder data. Trips with zero distance traveled and the 6.2% of observations with negative time saving, are removed. WT01 and WT02 are entry only. WT04 and WT06 are exit only.