DERIVING THE VALUE OF TIME IN A BORDER REGION USING A STATE-OF-THE-ART DYNAMIC MODELING APPROACH

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1. INTRODUCTION

Forecasting the demand for new infrastructure in transportation requires information about user's preferences for the services that do not exist in the current system. The willingness to pay tolls to obtain reductions in travel time is characterized by the value of time (VoT). Stated preference surveys typically ask respondents to choose between different scenarios, which usually involve a reduction in travel time in conjunction with an increase in toll [Richardson]. Stated preference data are commonly used to collect behavioral choice information in hypothetical contexts [Cirillo]. The method is innovative in that it produces individual VoTs and toll road constant (i.e. the amount the driver is prepared to pay to use the toll road at zero time savings, to capture other benefits of using the toll road).

The current practice of forecasting the demand for new tolled roads typically assumes that car users are prepared to pay a higher toll for a shorter journey, and they will keep doing so as long as the toll cost is not higher than their current value of travel time savings [Hensher et al.]. One of the main problems of this approach is how road users perceive their VoT. These are critical elements when evaluating road pricing transportation projects – especially in regions where socio-demographic data (e.g. median income) is lower than the statewide average.

While VoT is a very important notion in transportation planning and infrastructure management, it is a value that cannot be easily quantified or measured. This issue is a barrier to successfully forecasting the impact of tolled roads as well as the demand used in forecasting tools. There are various methods to estimate the VoT: 1) consumer price index (CPI), 2) demographic data, or 3) weighted average. However, many toll roads are not generating revenue as forecasted so a more robust methodology is needed to help improve the forecasted reliability when evaluating toll lanes.

This research analyzes various approaches to derive the VoT in a border region and then compares a simulation-based state-of-the-art dynamic modeling approach using a case study of El Paso, Texas express toll lanes. The goal is to develop a more robust methodology that improves the reliability of forecasted results when evaluating future road pricing projects, managed lanes and road user cost calculations.

The paper reviews literature of existing approaches to calculate the VoT used in travel forecasting .The paper continues with various approaches to derive VoT for traffic forecasting. Section 4 provides an innovative simulation-based modeling approach to derive a VoT based on real-world traffic data from managed express lanes while section 5 provides a summary of the paper and conclusions.

2. LITERATURE REVIEW

This section summarizes the literature on (the different methods and strategies to estimate the VoT for daily commuters. The review has relevant conclusions across several research studies found on journal papers, reports, and research efforts.

2.1. Methodology for the Estimation of VoT Using State-of-the-Art Econometric Models

Constantinos, et al. (2007) analyzed models that estimated VoT using state-of-the-art econometric models, which were applied to a medium-size city in Greece. Researchers developed logit models and mixed effect models to utilize as a comparison with the more widely used binary logit model.

A stated preference (SP) survey was based on personal interviews in the city of Agrinio, Greece, in December 2005 with 289 participants. The survey had 15 questions about socio-economic characteristics and10 hypothetical binary questions based on a seven-point rating scale. The models are of three types:

- A binary logit model to use as a benchmark or, reference model.
- An ordered logit model, in which the ordered response was used directly as a dependent variable.
- A generalized linear mixed effects model, allowing for a random intercept, capturing unobserved heterogeneity among individual respondents.

All coefficients obtained were significant at the 95 percent level, except for the travel time and travel cost coefficients. The binary logit model provided the highest estimate for the VoT. A comparison of the VoT from the three models shows that the ordered logit and generalized linear mixed model offered superior performance

The main contribution of this article is the application of advanced econometric models (ordered logit model, generalized linear mixed effects model) within a methodology for the estimation of VoT. The ordered logit and generalized linear mixed effects model offer superior performance but that does not necessarily translate to a more precise travel forecast on toll lanes.

2.2. Experiment in Megaregional Road Pricing Using Advanced Commuter Behavior Analysis

A study by Mishra et al. (2014) focused on the complexities that go into a congestion-price analysis, including travel demand, infrastructure supply, and commuting patterns. Central to that process is the elasticity of travel demand with respect to congestion and price. One of the key parameters is the estimated VoT. Researchers used an enhanced VoT determination approach that accounts for both income and trip purpose of commuters to determine whether congestion-pricing can be improved and how megaregional pricing-approaches differ in outcome to traditional metropolitan planning organization (MPO) – based approaches.

Three models were developed (aside from the base case) with different methods to apply congestion-pricing on specific links.

- Model 1 where a unique VoT is specified for each income class but does not vary in accordance with trip purpose.
- Model 2 incorporates a VoT that varies depending on the type of trip that is being considered (e.g. commuting to work or for recreational purposes).
- Model 3 builds on the income and purpose classified VoT in Model 2, but adds inverse-demand-based highway assignment. Models 1 and 2 provide a good understanding of shifting routes and modes, however, neither considered the variability of demand due to changes in network conditions as a result of changes in link pricing. In other words, highway users' trip making decisions are not elastic to pricing strategies in the former models.

The models developed were applied to a case study to analyze the commuter behavior for multiple sub-regions in the capital megaregion. The network consisted of over 167,000 links with 20 facility types, including both highway and transit. The case study encompassed a base case (with current highway network travel activity) plus three models that cover different levels of VoT and tolling. This illustrated the user response to road charges with a typical multiclass assignment specification.

The results showed that users are not as elastic to price as previously assumed. However, users in different income-groups and trip purposes widely vary in response. This was partly due to the lack of available substitutes for interstates, but also, the composition of income within trip purposes. The case study results showed that areas of higher density tend to have a higher elasticity of demand towards tolls. The model output revealed that in no-purpose-differentiated VoT models, users in the lowest-income categories were the only group that was elastic to changes in road-pricing. When purpose-differentiated congestion-charging is applied to a megaregion, commuters in the higher-income classes appeared to be more sensitive to charges when the VoT increases. When all commuters face the same charge, the disparity of travel costs between income groups shrank, which in turn reduced the differential impact of tolls on each income group. This research uses a trip-based static model used in long-ranged planning. Trip-based models are not capacity constrained and therefore cannot show volumes on freeways higher than actual capacity.

2.3. When is the Concept of Generalized Transport Costs Useless? The Effects of the Change in the VoT

The research study explains that under an exogenous working time assumption, the VoT for private trips cannot be constant or equal to the wage rate. Instead, it is affected by other factors such as travel time, travel fees, and others. This means that conventional trip demand estimation method, e.g., a four-step method, which adopts the concept of generalized costs could be inadequate for trip demand forecasting. Furthermore, under the exogenous working time assumption, the change in travel time or travel fee influences the endogenous VoT in the opposite sign (i.e. the increase in travel time increases the VoT, whereas the increase in travel fee decreases the VoT).

A behavioral model was constructed by treating the VoT endogenously which helped calculate its change when there was a change in travel time or fees for a hypothetical trip purpose (i.e. shopping trip). The model was applied to carry out various numerical simulations using a wide array of variables including: fundamental exogenous variables (e.g. number of commuting trips, travel fee for a round trip, or staying hours at the destination) as well as the parameters for the utility behavioral model.

Based on the simulation results, the VoT tends to be sensitive to travel time whereas there is no sensitivity for the travel fee. Furthermore, the change in the number of visits through changes in travel time and fees can differ greatly, even if the variation in the travel fee is equivalent to travel time in terms of generalized transportation cost. Results show that the VoT can differ up to 10% depending on reasonable changes in travel time [Kono].

After decades of research, VoT calculations still remain incompletely understood—therefore further theoretical and empirical studies are needed. The three approaches reviewed focused on either deriving the VoT or applying it to a specific modeled area using traditional planning model methods (e.g. trip-based travel demand model). None of the researched approaches take into account the type assignment used in travel forecasting (e.g. static versus dynamic assignment), capacity constraints within planning models, or validate travel forecasts by applying backcasting methods which compare field data to modeled results.

3. METHODOLOGY

This section defines different approaches to calculate the VoT used in travel forecasting for toll analysis. The defined approaches are then compared to a simulation-based modeling approach that uses validated model data (traffic volumes) to backcast and validate simulated results to field data.

3.1. Consumer Price Index

A review of literature from existing practices in Texas was used to derive the VoT for the El Paso region. The Texas Department of Transportation (TxDOT) was using a VoT set at $21.73 for passenger cars and $31.71 per hour for trucks (2014 rates). These values were set by the State of Texas for road user cost calculations used in A+B bidding (method of determining the dollar amount for contract items and the days required to complete the project) and incentive/disincentives milestones, final project completion and lane rentals [Daniels et al.]. However, the TxDOT VoT was an aggregated average across the entire state of Texas and not indicative of the lower median income in El Paso compared to other large urban areas within the state. The median income for the five largest cities in Texas is outlined in Figure 1.

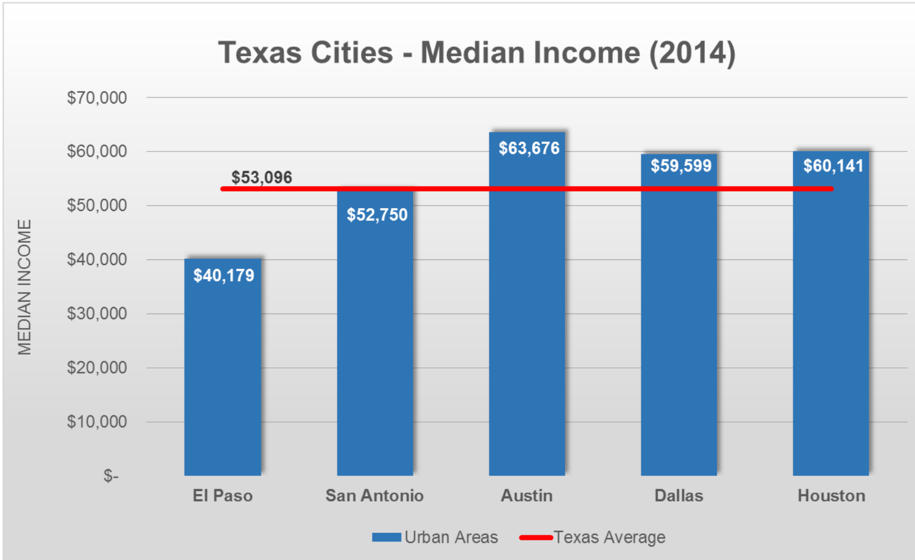

Figure 1: Median Income – Texas Urban Areas

The El Paso median income of $40,179 is approximately 24 percent lower than the aggregated statewide average for Texas, which is $53,096. Therefore, the base 2014 VoT for El Paso was reduced by the same percentage, yielding a monetary value of $16.48 for cars using 2014 dollars. An annual escalation rate was used to determine the base VoT for both cars and trucks. The Consumer Price Index (CPI) from 2001 to 2016 averaged a 2.06 percent increase over the past 15 years. A future value was calculated using the nominal future sum of worth at a given time assuming the calculated annual CPI growth rate:

$$FV = PV(1+i)^n \tag{1}$$

where:

$FV = future\ value$

$PV = present\ value$

$i = interest\ rate\ using\ historical\ CPI$

$n = growth\ period$

Table 1 below compares the VoTs used by TxDOT to the CPI—adjusted value for the past three years.

Table 1: VoT Comparison—TxDOT versus CPI

Year	TxDOT VoT	CPI VoT—Adjusted
2014	$21.73	$16.48
2015	$22.09	$17.17
2016	$22.12	$17.52

3.2. Weighted Average VoT by Trip Purpose

A study by Shao et al showed that various influences such as trip purpose have a direct correlation to VoT. Researchers used the TxDOT 2016 road user cost VoT for cars weighted it based on the El Paso MPO travel demand model diurnal factors to determine percentage of home-work and work-home versus all other trip purposes (e.g. home-home, non-home based, external local, through and non-home based external trips). Trip purposes were weighted based on the percentage of total trips distributed throughout the day.

Figure 2 shows the temporal pattern of home-based work and work-home trips. During the morning peak period, home-work trips account for 68% of all trips made in a 24-hour period while during the afternoon peak, work to home trips account for 63% of all associated trips. The VoT for the region is then calculated:

$$\delta' = \frac{\sum_{i=1}^{n} \omega_i \, \delta_i}{\sum_{i=1}^{n} \omega_i} \qquad (2)$$

where:

$\omega_i = percentage\ of\ trip\ purpose\ i$

$\delta_i = wage\ of\ travelers\ for\ trip\ purpose\ i$

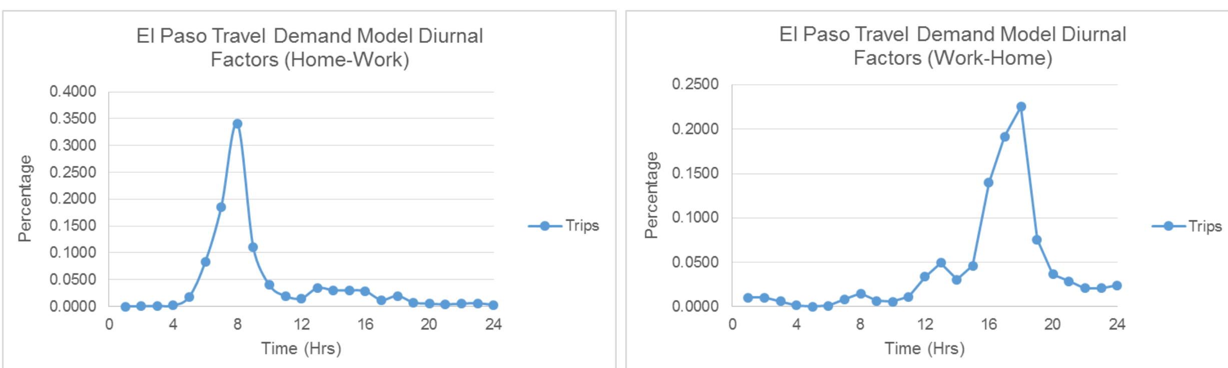

Figure 2: Home-Work Trip Assignment

The VoTs are derived according to the method proposed by Wardman where leisure trips (e.g. non-home based trips) are discounted in half and do not warrant the same VoT. Therefore, a VoT of $22.12 for work-related trips applies, while non-work-related trips are discounted by 50 percent to $11.06. Using a weighted average approach, the home-work and work-home trips account for 23 percent of all trips in the El Paso region. Using equation 2, the VoT for El Paso is $13.61 (2016 dollars).

3.3. Demographics

Travel forecasters use synthesis tools to develop future demographic data for a modeled region to generate forecast year synthetic populations. The tool allows an improved estimation of forecast year marginal totals by transferring a collection of travel demand indicators (median income, employed population, number of households) from the National Household Travel Survey (NHTS) [Auld et al]. The median wage per zone was extracted and weighted against the working age population per zone. The average wage rate per zone was calculated based on a typical 2080 hours of work in a calendar year and then multiplied by the percent of work-related trips. The process is repeated for non-work related trips. Trip purposes were extracted from the NHTS which revealed Texans spend approximately 16 percent of their time on work-related trips. All other trip purposes are combined and discounted by 70 percent.

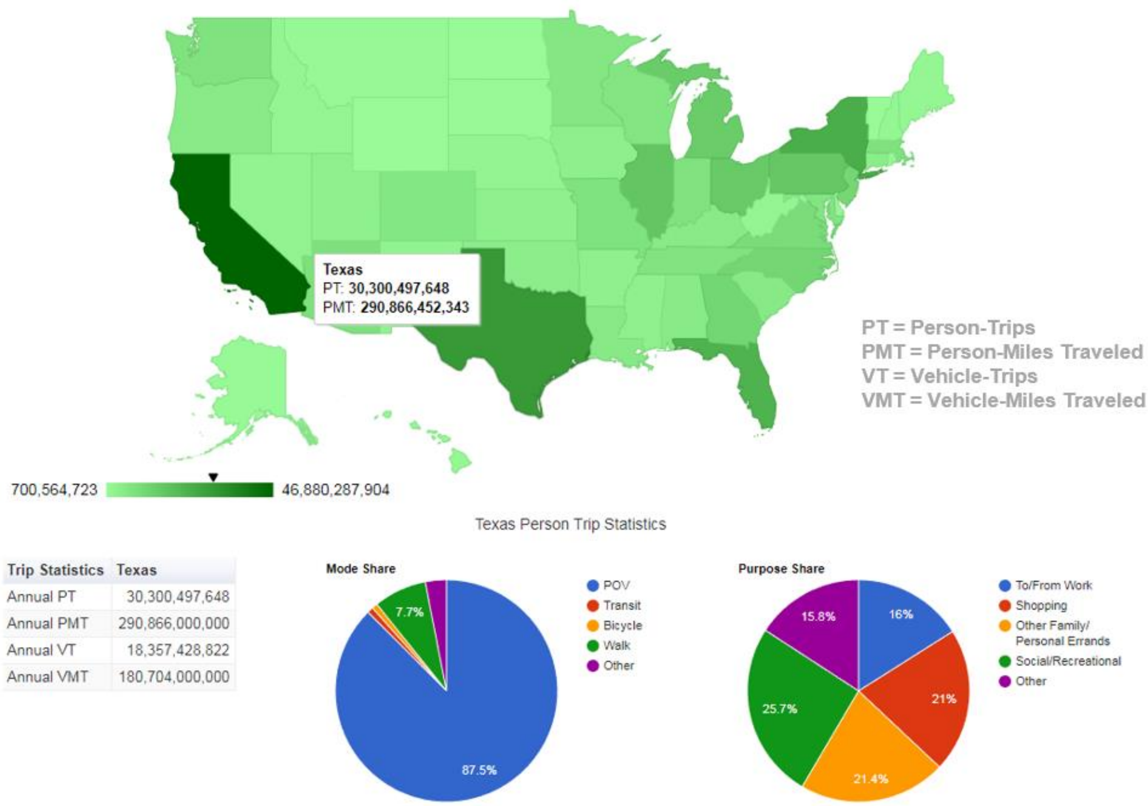

Figure 3: 2009 NHTS Total Annual Person Trips for Texas

The demographics VoT approach used the equation below:

$$\Psi = \sum_{i=1} \varphi_i \left[\left(\frac{\delta_i}{\beta} \right) (\theta_i) \right] + \sum_{i=1} \tau_i \left[\left(\frac{\delta_i}{\beta} \right) (\theta_i) \right] \quad (3)$$

where:

$\Psi = VoT$

$\delta_i = median\ income\ zone\ i$

$\beta = number\ working\ hours\ per\ year$

$\theta_i = working\ age\ population\ (15 - 74)\ zone\ i$

$\varphi_i = percent\ work\ related\ trips\ zone\ i$

$\tau_i = percent\ non - work\ relate\ trips\ zone\ i$

Using 2080 work hours in a year (40 hours in a work week multiplied by 52 weeks), the formulation above yields an averaged VoT of $38.75. Taking the NHTS survey statistics and utilizing 16% for “work” related trips and discounting all other trips by 70 percent, a final weighted VoT was calculated to be $15.97 (2016 dollars).

3.4. VoT Distributions for Mode Choice

Two components used to derive mode choice are time and cost. Implied VoTs from survey data are derived from these coefficient estimates. The time coefficient has units of “utility per minute” and the cost coefficients has units of “utility per dollar”, so the quotient of the time and cost coefficients have units of “dollars per minute” or the implied VoT. The El Paso MPO states that revealed preference data is sometimes insufficient to estimate precise values of these two coefficients due to: (1) relatively low variability in the modes travelers choose, and (2) the high levels of correlation in time and cost variables across modes. Therefore, it is not uncommon to make assumptions about VoT that can be used to constrain the relationships between the time and cost coefficients [Alliance Transportation Group].

The El Paso model employs five different income levels and therefore multiple VoTs were derived across each income group. The approach taken to develop VoTs for El Paso was to relate them to wage rates, which is common practice in the US [Litman]. Home-based-work accounted for 60 percent of trips and 40 percent for all other trips. For wage rates in the El Paso region, the Bureau of Labor Statistics (BLS) report in 2015 had the median wages in the region at $12.70 per hour and the mean wages were $17.78 per hour. From this information, a median and mean VoT of $7.62 and $10.67 per hour were calculated respectively for HBW trips, and $5.08 and $7.11 respectively for all other trips. The assigned upper and lower bounded incomes as well as the mean income for each category are shown in

Table 2. A weighted average (frequency) of the distributed wage income which outlines the share of all households in El Paso as shown in Figure 4.

Table 2: El Paso Income Segments

Income Level	Lower Bound	Upper Bound	Mean Household Income
Low Income	$0.00	$15,000.00	$7,500.00
Modest Income	$15,000.00	$25,000.00	$20,000.00
Middle Income	$25,000.00	$40,000.00	$32,500.00
Upper Income	$40,000.00	$70,000.00	$55,000.00
High Income	$70,000.00	n/a	$110,000.00

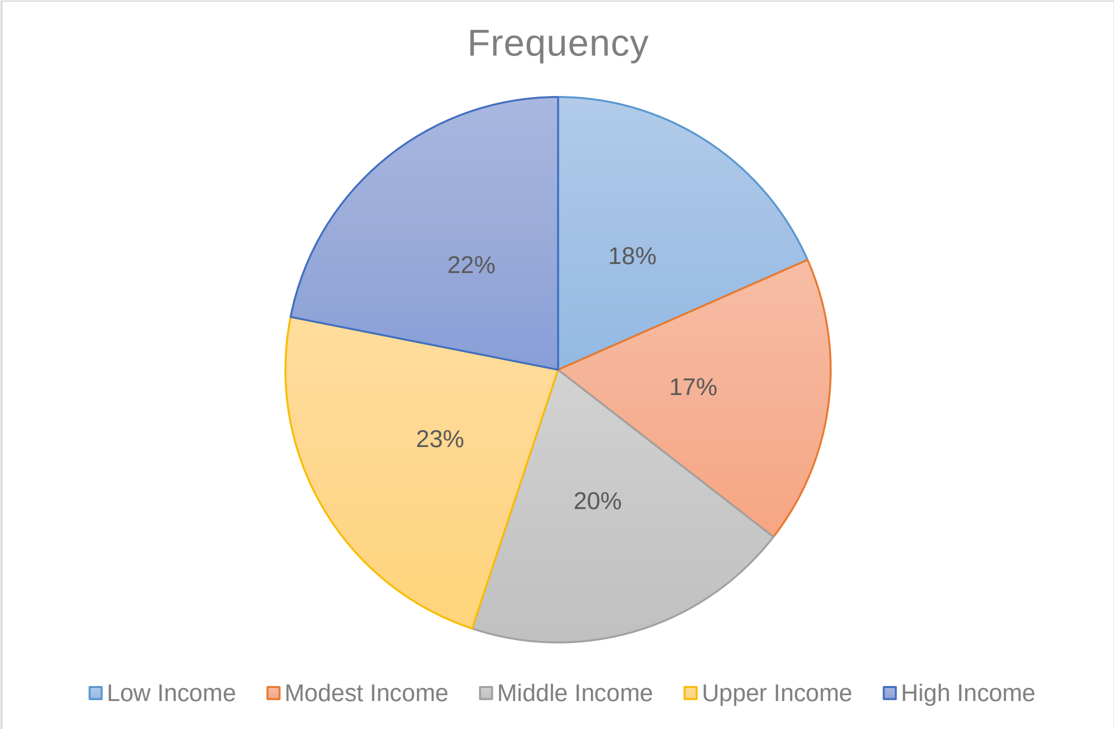

Figure 4: Distribution of Wage Income

A "wage index divisor" which was based on judgment and reflects the relative wage differences across income categories was then derived (

Table 3). The ratio of the wage index to assumed household income is highest for low income households and lower for high income households. It is assumed that while the wage index assigned was based on judgment, it is not used to compute VoT for each category. Relative wage indices were used along with the income category frequency in order to match the calculated overall VoT for the El Paso metropolitan statistical area.

Table 3: Estimated Wage Index Divisor

Income Level	Wage Index Divisor
Low Income	1000
Modest Income	1600
Middle Income	1800
Upper Income	2000
High Income	2000

The mean household income was divided by the wage index divisor to get a wage index for each income category. The wage index was then multiplied by the frequency to derive a "percentage of wage index" which in turn were summed to get a calculated VoT of $25.43. An adjustment factor was derived by dividing the mean hourly wage by the calculated VoT which translated to a value of 0.7[1]. The wage index is multiplied by the adjustment factor and the weighted percentage of trip purpose to get the VoT for each income category. The average of those VoT categories is the actual VoT for the El Paso region per trip purpose and the summation of those two values is the final "Average VoT" for El Paso which equates to $16.88 as shown in Table 4.

Table 4: Income Segment Assumed VoT

Income Level	Lower Bound	Upper Bound	VoT Index	VoT HBW	VoT Non HBW	VoT Total
Low Income	$0.00	$15,000.00	1.00	$3.15	$2.10	$5.25
Modest Income	$15,000.00	$25,000.00	1.67	$5.25	$3.50	$8.75
Middle Income	$25,000.00	$40,000.00	2.41	$7.58	$5.06	$12.64
Upper Income	$40,000.00	$70,000.00	3.67	$11.55	$7.70	$19.25
High Income	$70,000.00	n/a	7.33	$23.10	$15.40	$38.50
Average VoT for El Paso Mode Choice				$10.13	$6.75	**$16.88**

3.5. El Paso MPO—Model Development

The El Paso MPO and TxDOT utilize an official travel demand model which was developed for long-ranged infrastructure improvements and for conformity analysis. The travel demand model for the border region, termed as the "Horizon Model", was developed for the El Paso County in Texas and small portions of Dona Ana and Otero Counties in New Mexico. The model base year was 2007 and included forecast years of 2010, 2020, 2030 and 2040.

The passenger car VoT for the Horizon Model was calculated from the 2009 household travel survey of the El Paso area. For each trip purpose, the average VoT was derived by aggregating individual VoTs for the survey sample and then weighted by the number of trips. The peak periods were identified using the survey data. Based on available literature, 60% of the average hourly wage rate was used as the base VoT. The hourly wage rates in the study area were approximated to be $18.17 by using the median household income of $36,333 divided by an assumed number of 2000 total hours worked in a calendar year and the average workers per household used was 1.16. The average VoT across all trip purposes and income groups was calculated to be $9.43 (in 2007 dollars). Table 5 below shows the passenger VoT for the Horizon Model in 2007 dollars. The VoT for the NXLO trip purpose was assumed to be the

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[1] Factor used to adjust the assumed wage indices to reported BLS hourly wage.

same as the NHB trip purpose VoT. Forecasting those values to 2016 dollars is shown in Table 6 with an average overall VoT of $12.88.

Table 5: Horizon Model Passenger VoT (2007)

	Income Groups 1-3	Income Groups 4-5
HBW	$10.68	$13.62
HBNW	$8.96	$11.66
HNB	$9.46	$12.60
NXLO	$9.46	$12.60
Average VoT = $11.13		

Table 6: Horizon Model Passenger VoT (2016)

	Income Groups 1-3	Income Groups 4-5
HBW	$12.16	$15.51
HBNW	$10.20	$13.27
HNB	$10.77	$14.34
NXLO	$10.77	$14.34
Average VoT = $12.88		

4. CASE STUDY – SIMULATION-BASED MODEL

4.1. Model Development

Researchers developed a simulation- based dynamic traffic assignment (DTA) model derived from the official El Paso MPO travel demand model[2]. DTA is a time-dependent methodology which captures traveler's route choice behavior as they traverse from origin to destination. The objective function (term dynamic user equilibrium or DUE) is based on the idea of drivers choosing their routes through the network according to their generalized travel cost experienced during the simulation. A generalized cost includes both travel time and any monetary costs (e.g. tolls) or other relevant attributes associated with a roadway. An iterative algorithmic procedure attempts to establish DUE conditions by assignment of vehicles departing at the same time between the same OD pair to different paths. At any given point and after much iteration, travelers learn and adapt to the transportation network conditions. Roadway representation is coded at the local street level, and all transit networks are included[3] in the regional travel model.

[2] El Paso 2040 Horizon Model was developed by the Alliance Transportation Group.

[3] The DTA model only runs assignment and does not include mode choice; therefore, transit analysis is not included.

The model is capable of analyzing high-occupancy vehicles, toll lanes, managed lanes, and congestion pricing and incident management. Roadways are defined in terms of functional classification, which is a system of categorizing roadways and highways by their function in the network hierarchy.

The study area for the Horizon model includes El Paso County in Texas and small portions of Dona Ana and Otero Counties in New Mexico. Researchers used the 2010 year to replicate 2016 network conditions (Figure 5) which include the Cesar Chavez toll lanes from the Zaragoza port-of-entry to east of the Bridge of the Americas port-of-entry – approximately 8 miles.

Figure 5: El Paso Horizon Network

In dynamic traffic assignment, there are two major efforts of calibration: 1) traffic flow model calibration and 2) origin-destination (OD) demand calibration. Traffic flow model preparation is related to the supply-side of a DTA network. In order to model the traffic flow properties correctly within the simulation, the traffic flow model – which dictates the behavior of simulated demand in response to various levels of traffic congestion – must be adjusted to replicate existing traffic conditions of the modeled area. The flow model utilized in the simulation is based upon Greenshield's equation (*Eq 4*) which follows the basic traffic engineering principles of speed, density, and flow [Edie]. Separate models for different facility attributes were created. Freeway facilities have greater capacity than arterials and can hold larger densities near free-flow speeds. Arterial–type links (arterial, ramp) are more sensitive to density changes due to interrupted flow (control signals) and less capacity.

$$\boldsymbol{v_i - v_0 = (v_f - v_0)\left(1 - \frac{k_i}{k_{jam}}\right)^{\alpha}} \tag{4}$$

where:

$v_i = current\ speed$

$v_0 = speed\ at\ jam\ density$

$v_f = speed\ at\ free\ flow$

$k = \ density$

$k_{jam} = jam\ density$

For freeway facilities of the network, the traffic flow model parameters used were generated based on data collected on El Paso freeways including speed and volume data. Two arterial models were developed to represent higher-capacity facilities, i.e., 3-4 lane roadways and ramps, while a low-capacity model was created for 1-2 lane roadways. These past arterial flow models demonstrate to be quite stable and provide adequate estimation of arterial behavior.

Roadway networks are defined based on functional classification. This classification defines the roadways in terms of operational and performance characteristics and are based off the current Federal Highway Administration's functional classifications as shown in Table 7Table 7. For the DTA model development, functional classes 3 – 7 were aggregated into one "arterial" classification.

Table 7: Horizon 2040 Model Functional Classifications

Functional Class Number	Functional Class Name	DTA Link Type
1	Interstate	Freeway
2	Other Freeways or Expressways	Toll Lane
3	Other Principle Arterials	Arterial
4	Minor Arterials	Arterial
5	Major Collectors	Arterial
6	Minor Collectors	Arterial
7	Local Streets	Arterial
20	Ramps	Ramps

The Origin-Destination (OD) demand tables are based from the static regional planning model created and maintained by the MPO of the region. However, these tables are based from a static traffic assignment model which does not take into account the dimension of time which is essential for modeling time-varying traffic dynamics. Therefore, the time-dependent OD demand tables were calibrated to resemble observed traffic flows.

Each traffic analysis zone has socioeconomic and demographic data tied to the transportation system using centroid connectors. The data associated with each TAZ represents the number of trips originating or terminating each zone based upon trip purpose (e.g. home-based work, work-based home, non-home-based, external local, truck and non-external local). The demand matrices were disaggregated based on trip purpose and then multiplied each matrix with its corresponding diurnal factor. Matrices and then summed for each time interval to generate 24 - one matrices which provides a temporal departure time profile for the El Paso network.

The formulation for matrix conversion is expressed as:

$$\sum \left(\varphi_k^j\right)\left(\delta^j\right) \qquad \forall\, k \in i \qquad 0 \le \varphi_k^j \le 1 \tag{5}$$

$where$:

φ_i^j $= hourly\ factor\ for\ time\ period\ i\ within\ trip\ purpose\ j$

δ^j $= matrix\ for\ trip\ purpose\ j$

k $= all\ one\ hour\ time\ periods\ within\ a\ 24\ hour\ day$

j $\in \{HBW, HBNW, NHB, TRTX, NHB-V, EXLO\}$

- *HBW = Home-based to work*
- *HBNW = Home-based to non-work*
- *NHB = Non-home based*
- *TRTX = Truck/taxi*
- *NHB-V = Non-resident trips made by external local travelers*
- *EXLO = External local*

4.2. Data Collection

Several data sources are used to calibrate the simulation based DTA model including speed profiles, signal timing inventories and traffic counts. Speed profiles are used to help calibrate the traffic flow model algorithms in the DTA model which govern how traffic flows on various roadway types. Signal timings were provided by the City of El Paso –where major arterials and diamond interchanges were coded to actual conditions. Remote areas of the city or areas with lower traffic volumes had default 2 or 3-phase signal settings. Traffic counts were used to help calibrate the demand to existing conditions. The demand matrices must be updated to reflect traffic counts throughout the region. Researchers used a combination of RHiNo[4] data provided by TxDOT and actual counts collected in the field to calibrate the final demand tables. Demand

[4] Roadway Highway Inventory Network annual report published by TxDOT.

tables were calibrated without toll lanes in place to reflect “before” conditions. Once the matrices were calibrated to existing conditions, the toll lanes were activated to determine how many vehicles would switch their route from the general purpose lanes to the express lanes.

Traffic counts of vehicles using the tolls lanes over a 24-hour period were obtained from the Camino Real Regional Mobility Authority (CRRMA). The Cesar Chavez toll lanes have two toll plazas in each direction where toll fees are imposed on vehicle with egress/ingress access points throughout the corridor as shown in Figure 6.

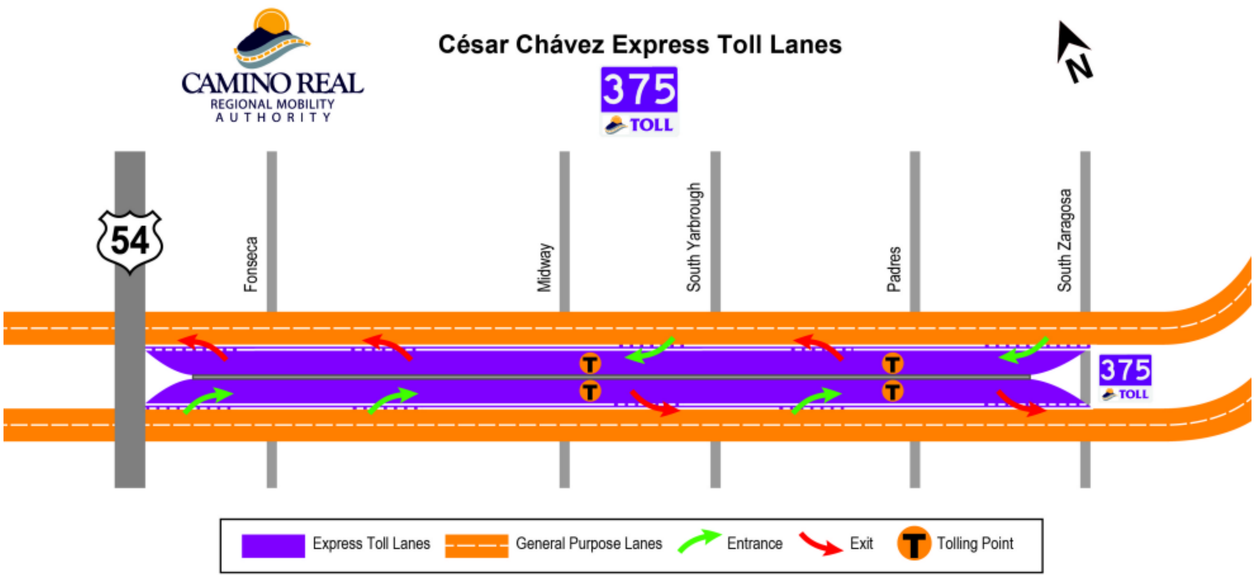

Figure 6: Cesar Chavez Express Toll Lanes

From the data provided by the General Engineering Consultant[5] to the CRRMA, traffic counts and toll revenue were obtained for vehicles utilizing the express lanes for a typical workday. Traffic counts are taken at each toll plaza where vehicles are charged a “distance-based” toll fee. Toll rates during 2016 were $0.10/mile for the entire 8.9-mile corridor so the maximum toll fee imposed per directional trips was $0.89. Figure 7 show the eastbound directional volume for the express lanes while Figure 8 show the westbound direction. Toll revenue generated during that day equated to $661.08 eastbound and $2,848.83 in the westbound direction.

[5] Atkins Global Engineering

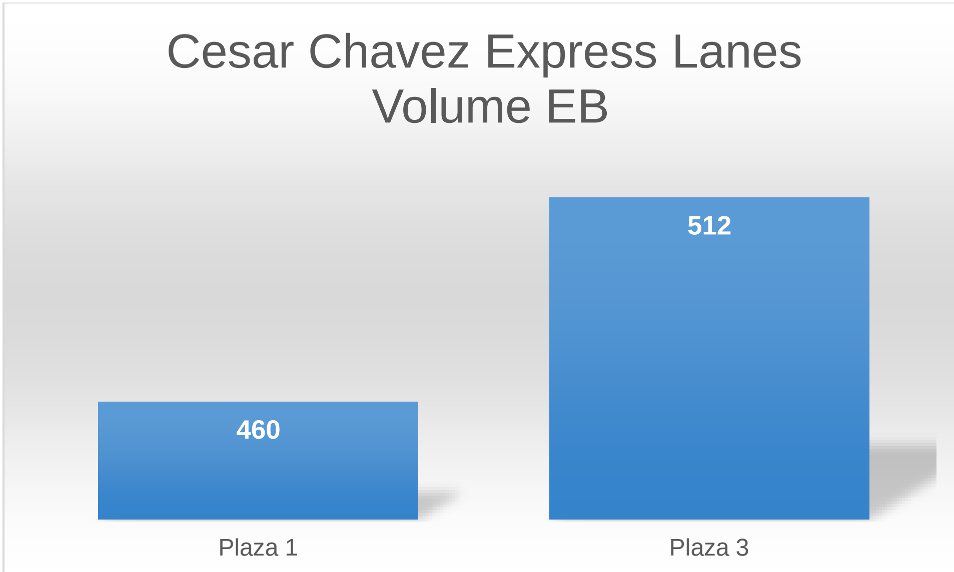

Figure 7: Express Lanes Daily Volume – Eastbound

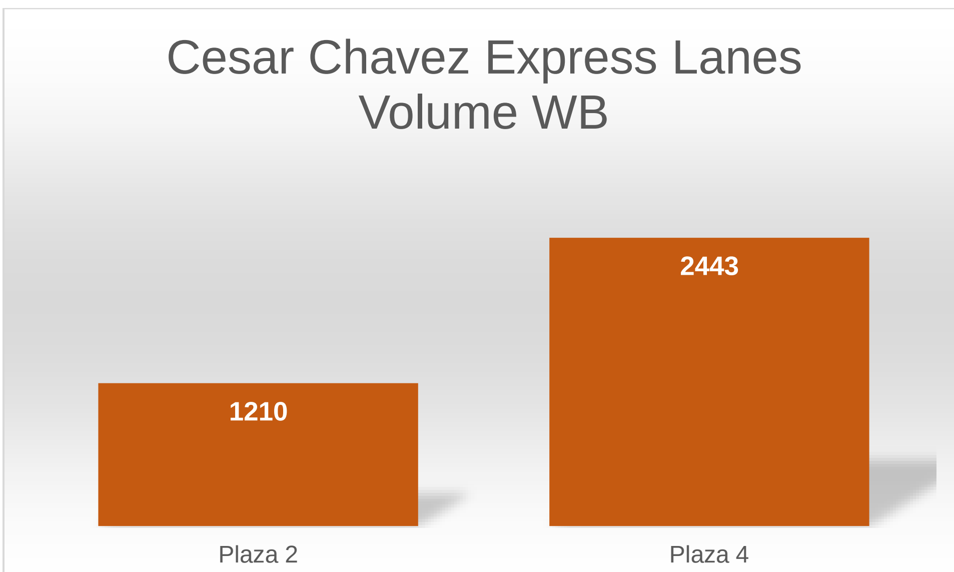

Figure 8: Express Lanes Daily Volume – Westbound

4.3. VoT Calculation – Simulation- Based Approach

The DTA model was run for a 24-hour time period using the 2016 VoTs from the TxDOT road user cost approach utilizing the CPI adjusted values ($17.52 for cars) and compared to the actual counts provided by the CRRMA general engineering consultant. An iterative process was used to vary the VoT for passenger cars (trucks are restricted from the express lanes) and compared volume results. It must be noted that the CRRMA express lanes have two toll gantries in each direction and the tolled facility is not barrier separated so vehicles have the freedom to merge in and out of the express lanes at will and therefore an average volume of 1827 vehicles was used.

Given that the highest directional volume on the express lanes occur during the morning peak period for HBW trips, the westbound numerical values were used as a basis for comparison. After multiple iterations, the VoT closest to actual field counts were converging with values lower than base line. Simulation results showed a VoT that most represents actual field counts provided by the CRRMA is $15.77 which is approximately $1.75 lower than the base line VoT value used from the TxDOT road user cost adjusted using CPI approach as show in Table 8.

Table 8: Simulation VoT Results

Percentage Δ	VoT	WB Volumes
70%	$12.26	1685
80%	$14.02	1742
90%	$15.77	1877
100% - Base	**$17.52**	**1965**
110%	$19.27	2088
120%	$21.02	2411
130%	$22.78	2831

5. CONCLUSIONS

Various approaches were used to calculate a quantitative value that would be representative of the City of El Paso VoT and then compared those varied approaches to a simulation-based approach using the Cesar Chavez express lanes as a case study. TxDOT road user cost VoT used in A+B bidding had the highest value at $22.12 while the El Paso MPO household surveys used in the development of the regional TDM had the lowest VoT for the border region at $12.67. The weighted trip purposed approach was also lower than the value generated by the DTA model while the CPI, demographics and CS approaches all had VoT values higher than the DTA model.

The simulation-based approach provides the highest degree of accuracy when compared to the alternate approaches given that the DTA model uses real-world traffic volumes on the express lanes and through an iterative process, adjusts the VoT to match simulated volumes to real data. Therefore the modeled approach used to calculate the VoT can be considered to have the highest confidence level of all approaches taken. Figure 9 outlines the various VoTs calculated and compared to the simulation-based modeling approach.

Further research is needed to analyze the impacts from zonal-based VoTs assessment. In additional, the impacts of mobility-as-a-service and the introduction of autonomous vehicles also play a critical role in the way VoT is calculated in the future.

Figure 9: Final Calculated VoT per Approach

6. BIBLIOGRAPHY

Cirillo, C. R Xu, The acceptability and driver's willingness to pay and departure time choice model for HOT lanes on I-495 in Maryland, Center for Integrated Transportation Systems Management, Department of Civil and Environmental Engineering.

Constantinos, A., E. Matsoukis, P. Roussi, A Methodology for the Estimation of Value-of-Time Using State-of-the-Art Econometric Models, Journal of Public Transportation, Vol 10 (3): pp 1-19, 2007. DOI: http://dx.doi.org/10.5038/2375-0901.10.3.1

Daniels, G., W. Stockton, R. Hundley, Estimating Road User Costs Associated with Highway Construction Projects: Simplified Method, Transportation Research Record, Journal of the Transportation Research Board, 2000. 1732: P 70-79.

El Paso Metropolitan Planning Organization: El Paso 2040 Horizon Model Development Report, Alliance Transportation Group, 2013. [Cited February 10, 2017]. http://www.elpasompo.org/scroll_bar_area/mtp/default.htm

Hensher, D., C. Ho, W. Liu, How much is too much for tolled users: toll saturation and the implications for car commuting value of travel time savings, Transportation Research Part A: Policy and Practice, Volume 94, December 2016, pp 604-621. https://doi.org/10.1016/j.tra.2016.10.012

Kono, T., H. Morisugi, A. Kishi, When is the concept of generalized transport costs useless? The effect of the change in value of time. Urban Transport and the Environment in the 21st Century, Wessex Institute of Technology, Vol. XIV 629, ISSN 1743-3509, doi:10.2495/UT080611.

Litman, T., Transportation Cost and Benefit Analysis II – Travel Time Costs Guidebook, Victoria Transport Policy Institute 2013. http://www.vtpi.org/tca/tac0502.pdf.

Mishra, S. T. Welch, A. Chakraborty, Experiment in Megaregional Road Pricing Using Advanced Commuter Behavior Analysis, Journal of Urban Planning and Development, Vol 140 (1), 2014. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000175.

Perez, B., T. Batac, P. Vovsha, Assessing Highway Tolling and Pricing Options and Impacts, National Cooperative Highway Research Program Report No. 722, Volume 1: Decision-Making Framework, Washington, DC. ISBN 978-0-309-25828-9, DOI 10.17226/22701.

Richardson, T., Estimating individual values of time in stated preference surveys, Road and Transport Research, Vol 15, Issue 1 pp 44-53, March 2006.

Santos, A, N. McGuckin, H. Nakamoto, D. Gray, S. Liss, Summary of Travel Trends: 2009 National Household Travel Survey, US Department of Transportation, Federal Highway Administration, Report No. FHWA-PL-11-022.

Shao, C-Q, Y. Liu, X-M, Lui, Valuation of Travel Time Savings in Viewpoint of WTA, Computational Intelligence and Neuroscience, Volume 2014, Article 305285, pp 5, 2014. http://dx.doi.org/10.1155/2014/305285

Wardman, M., A review of British evidence on time and service quality valuations, Transportation Research Part E: Logistics and Transportation Review, Volume 37, Issues 2-3, April-July 2001, Pages 107-128, ISSN 1366-5545, DOI: 10.1016/S1366- 5545(00)00012-0.

United States Department of Labor. Bureau of Labor Statistics. Consumer Price Index. [Online] [Cited: August 16, 2016.] http://www.bls.gov/cpi/