# Toll Roads: What We Know About Forecasting Usage and the Characteristics of Texas Users

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# TOLL ROADS: WHAT WE KNOW ABOUT FORECASTING USAGE AND THE CHARACTERISTICS OF TEXAS USERS

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*TxDOT Project 0-6044: Estimated and Actual Usage of Toll Facilities*

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## Contents

# Toll Roads: What We Know About Forecasting Usage and the Characteristics of Texas Users

## Introduction/Background

Road infrastructure is a key component of any region's transportation system. It allows unprecedented levels of mobility, accessibility, and economic growth. In the U.S., the largest revenue source for the funding of transportation infrastructure is the federal and state fuel taxes. These taxes were conceived in the 1950s as an indirect charge to recover the costs of vehicle travel on the U.S. highway system. However, fuel taxes have not increased with the inflation rate, and are anticipated to decline as fleet fuel efficiency increases. Inadequate funding from fuel taxes, increased demand for transportation, and increasing maintenance needs due to an aging highway system, have resulted in significant deficits along with renewed interest in toll road development, both to finance new roads or add capacity to existing roads. A number of U.S. State Departments of Transportation, including Texas, are actively pursuing tolling as a means to provide much needed capacity sooner.

As tolling is considered, reliable traffic and revenue (T&R) forecasts informed by a robust understanding of potential users becomes increasingly important to toll road owners, developers, financiers, and investors, in addition to the consultants who perform these studies. The objectives of this TxDOT research study were to (a) expand upon the analysis conducted by the bond rating agencies that alluded to the existence of an optimism bias in T&R forecasts, and (b) characterize the users and non-users of Texas toll roads in an effort to conceptualize incentives that can be used to encourage the use of toll roads (see Figure 1 for the study approach).

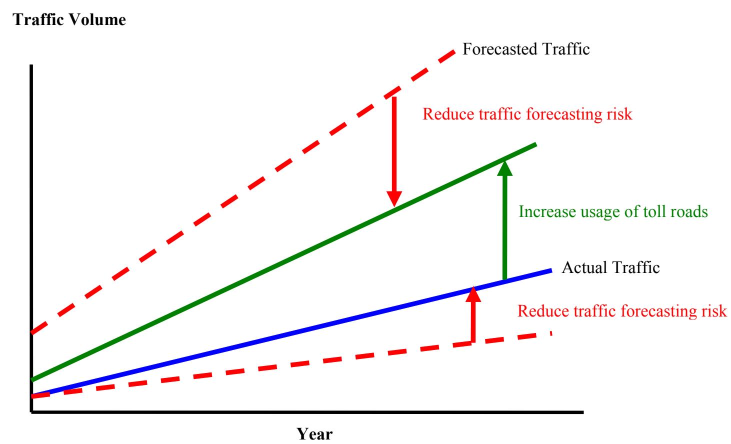


*Figure 1. Study approach*

## Reducing Forecasting Uncertainty

Reliable T&R forecasts are critical to the success of toll road development. However, a number of studies by bond rating agencies—in particular Standard & Poor's (S&P)—have shown that a majority of toll roads failed to meet traffic projections in their first full year of operation. These projections were compared to non-tolled roads, and also considered whether the region had a history of tolling. These studies alluded to the existence of an optimism bias in T&R forecasts, with an over-estimation of traffic by 20-30% in the first 5 years of operation, which is commonly known as ramp-up. For the toll road developer, this uncertainty contributes to increased risks about the feasibility of toll roads, resulting in higher interest rates and more financial safeguards for investors such as escrow accounts of up to 30% of the amount borrowed. Ultimately, increased uncertainty could lead to higher tolls. Unreliable toll T&R forecasts can also impact a public agency—even if they are not the developer—as such toll T&R forecasts might skew public decision-making and (a) result in over or under compensation for risk, (b) prevent investments in feasible projects that had underestimated forecasted traffic and revenues, and finally (c) result in costly renegotiations.

This study expanded upon the analysis conducted by the bond rating agencies by summarizing the general approach followed by T&R consultants used to forecast toll T&R and by evaluating toll road case studies that have been operational for varying lengths of time in areas with similar demographic and transportation characteristics as central Texas. Special care was taken to ensure the inclusion of more mature systems that have been in operation beyond the ramp up period.

### The Role of the Metropolitan Planning Organization's Traffic Demand Model

When forecasting toll road usage, T&R consultants usually begin with the local Metropolitan Planning Organization's (MPO) traffic demand model. Most MPOs use the four-step travel demand model, but MPO travel demand models vary greatly in terms of level of sophistication, data used, and output. The steps of the four-step travel demand model are:

1. Trip Generation—Total number of trips originating in and destined to a particular zone is calculated based on the different land uses of each zone[1].
2. Trip Distribution—Matches trip travelers' origins and destinations to form a trip matrix, which identifies how many trips are going from each origin to each destination zone. This step commonly assumes that the amount of activity between two locations decreases with increasing distance, time, and cost.
3. Modal Split—Trips are allocated to one of several travel modes. This step typically takes into account travel time, out of pocket cost, comfort, number of stops, etc. associated with different modes of travel.

[1] When applying the travel demand model, the first step is to divide the MPO area into homogenous zones—called Traffic Analysis Zones (TAZ)—based on land use. Developing population and employment values by TAZ for a base and forecasted model years require data, for example, about current employment locations by sector, household locations by income quartile, land use inventories, travel time matrices, number of workers per household, district level household change, acres of vacant land, density of future residential development, proximity to transportation infrastructure, etc. MPOs typically use a demographic model to develop the population and employment estimates by TAZ.

4. Network Assignment—All trips are loaded onto the traffic network. All vehicles are typically assigned to the route that minimizes travel time and iterates to account for changes in travel time as the network is loaded.

Typically, the T&R consultants obtain the following information from the MPOs:

- socio-economic information by TAZ for the base and forecasted model years,
- trip tables (e.g., peak and off-peak trip tables) for the base and forecasted model years, and
- TAZ network structure and highway network characteristics for the base and forecasted years.

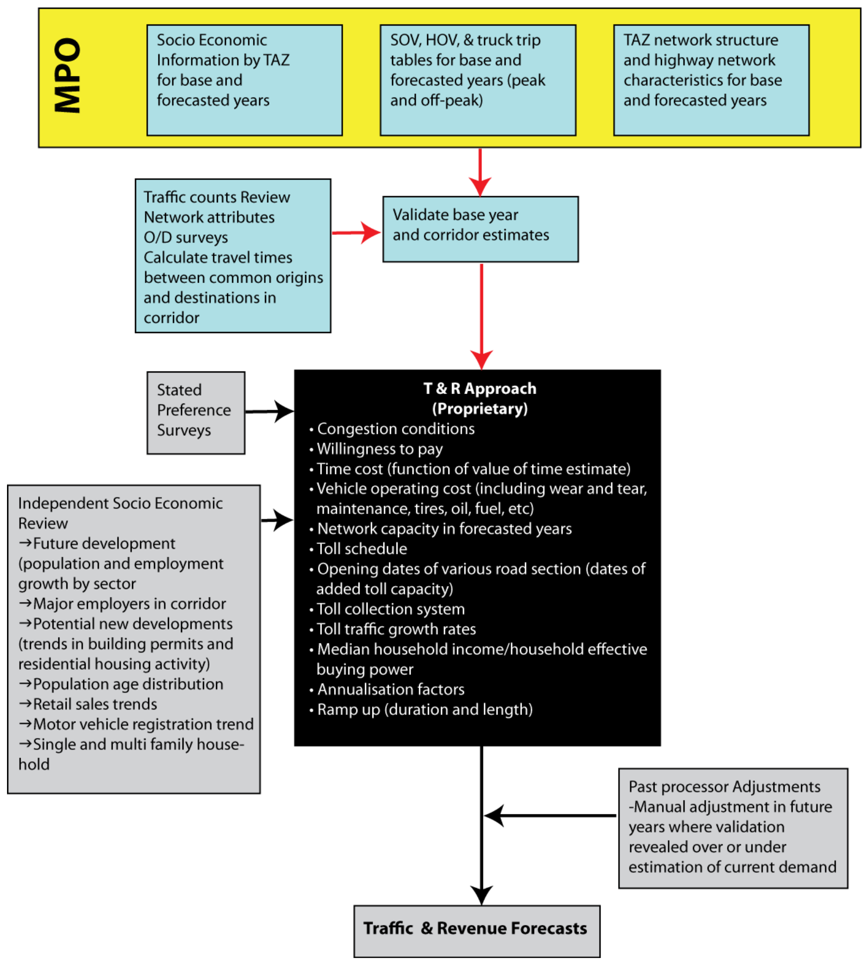


*Figure 2. Traffic and Revenue Forecasting Approach*

The MPO's input data are typically verified for the base year and adapted for the specific toll facility (see Figure 2 for a broad illustration of the inputs obtained and factors considered in conducting T&R forecasts). For example, most T&R consultants stated that they validate the MPO's demographic and socioeconomic datasets (e.g., population and employment growth rates) either in-house or by hiring "independent" consultants. The demographic and socioeconomic characteristics of the area are widely regarded as very important variables in estimating the potential demand for a toll facility. Because the MPO data is typically available on a regional level, it must be adapted for the formal study area (i.e., corridor) of the proposed toll facility.

Most T&R consultants conduct traffic counts and Origin-Destination (O/D) surveys to calibrate the MPO models and to model a corridor specific forecast. Traffic counts are usually conducted along the proposed toll corridors. These counts tend to be collected for weekdays only, and are used to calibrate the models for peak and off-peak travel. The O/D surveys are used to determine if the MPO trip table replicated the observed travel patterns (obtained from the survey data).

Other factors that are typically considered by T&R consultants in their proprietary approach to forecasting toll road usage are:

- the added capacity (i.e., freeways, tolled facilities, and public transit, such as future rail capacity) included in the MTP program,
- willingness to pay or value of time,
- vehicle operating costs, including wear and tear, maintenance, tires, oil, and fuel,
- the toll schedule,
- the opening dates of various toll road sections,
- toll collection system, e.g., ETC only or ETC and non-ETC,
- toll traffic growth, and
- median household income/household effective buying power.

Once the model is validated, forecasts are made for selected model years using one of three approaches.[2] Then the toll usage for non-modeled years is obtained through interpolation. Toll road usage beyond the modeled future years is determined by assuming a transaction growth rate after the last modeled future year. A number of post processor adjustments are also generally made to future year estimates if the model validation step revealed an over or under estimation of base year demand. Finally, annualization factors are required to convert the obtained model outputs—i.e., peak and off-peak trip tables—into annual volumes. This process can be complicated and becomes even more complicated if different toll rates for different time periods (peak, off peak, night, weekend, etc.) are applied.

The study team found that most T&R studies do not explain how different data sources—e.g., the O/D surveys—are used to calibrate the trip tables produced by the MPO model. Even when a wealth of information is collected and provided (as is the case in some of the T&R

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[2] The toll option can be introduced either in:

- the modal split step. In this step, tolling is simply treated as another mode and characterized by mode choice variables (e.g., travel time, cost, reliability, etc.). This is the easiest option to introduce in the existing four-step modeling process. However, it is not necessarily dynamic so that increased congestion on the non-tolled alternatives will not necessarily be accounted for.
- the trip assignment step. In this step, the toll rate is converted to represent a time penalty. This allows the model to account for congestion conditions on the non-tolled routes. For example, if the non-toll road's congestion level increases then the travel time on the non-tolled route will also increase. As the time penalty increases on the non-toll route, the toll paid (as represented by an increase in travel time) will become relatively smaller, and hence the toll road will become more attractive.
- as a sub-step in the trip assignment step or post processor outside the four-step model (almost representing a fifth step). In this option, a T&R consultant develops *"at least two alternative paths for each trip—one using the toll facility and one using the best available (i.e., shortest time) non-toll route. The diversion model compares travel time, distance, toll cost, and occasionally other factors, for the two routes and assigns a percentage of the market to each route. The diversion formulae used in the models are based on an accumulation of empirical data collected by the consulting firms from other toll revenue studies, results of site-specific surveys of potential users, and professional judgment. The precise formulae used are considered to be proprietary to each firm"* (Spear, 2007).

reports reviewed) to describe trip purpose, frequency, vehicle occupancy, etc., it is seldom clear how this information was used in the T&R forecasts. Further, none of the T&R reports reviewed also mentioned specifically how tolling is considered in the four step travel demand model.

### Toll Road Case Study Results

This research attempted to replicate and extend the work conducted previously by the financial analysts. The research team examined five toll road case studies that were comparable in scope and have been implemented in urban areas that have similar demographic and transportation characteristics as central Texas. Also, because the S&P analysis considered only the first one to five years of operation of the tolled facility, this study attempted to include toll roads that have been operational for varying lengths of time. Special care was taken to ensure the inclusion of more mature systems and to exclude toll roads whose initial usage could have been biased by significant changes to the project in terms of design, delayed openings, or renegotiations.

Initially, the research team identified 13 potential case studies, but ultimately, the following case studies were selected in consultation with the Texas Department of Transportation (TxDOT) Project Monitoring Committee:

- Orlando's Eastern Beltway (Florida),
- 407 ETR (Toronto, Canada),
- HCTRA system (Houston, Texas),
- President George Bush Turnpike (Dallas, Texas), and
- the 2002 Central Texas Turnpike Project (Austin, Texas).

All these toll roads, with the exception of the Central Texas Turnpike Project (CTTP)—subsequently called the Central Texas Turnpike System (CTTS)—were considered beyond their ramp-up period, but have not been operational for longer than 20 years. The objective was to conduct a detailed examination of the actual and forecasted toll road usage in an effort to identify factors that introduce uncertainty in toll traffic forecasting. The initial T&R statements (used to structure the debts) were used as the official forecasts. The actual usage numbers were obtained from the road owners. Each documented assumption was evaluated to understand the assumption's qualitative and, if possible, quantitative contribution to the forecast.

There are inherent uncertainties in the forecasting of T&R for tolled facilities (see Wilbur Smith disclaimer in text box). The study team found—based on the case studies reviewed—that the data on toll usage was largely insufficient to draw any conclusions about optimism bias. Also, the forecasted revenue data were more comprehensive and did not point to any systematic optimism bias in the revenue forecasts. For example, revenues were overestimated on all four segments of the Orlando Eastern Beltway (i.e., the

> "Current professional practices and procedures were used in the development of these findings. However, there is considerable uncertainty inherent in future traffic and revenue forecasts for any toll facility. There may sometimes be differences between forecasted and actual results caused by events and circumstances beyond the control of the forecasters. These differences could be material. Also, it should be recognized that traffic and revenue forecasts in this document are intended to reflect the overall estimated long-term trend. Actual experience in any given year may vary due to economic conditions and other factors" *(Wilbur Smith Associates, 2007).*

northeastern segment, the southwestern segment, the southern connector, and the Seminole Expressway), the Hardy toll road (1984), and the Westpark Tollway. Revenues were, however, underestimated on the 407 ETR, the Hardy toll road (1994), the Sam Houston West, East, and South Tollways, the HCTRA system, SH190 Segments I to V in Dallas, and the CTTP. In the case of the West Belt Tollway, revenues were slightly over-predicted in the first 10 years of the road's operation, but subsequently revenues exceeded forecasts.

### Uncertainty in T&R Forecasts

The research study findings on optimism bias have to be caveated, however, because a replication of the work done by S&P was hampered by the fact that the financial analysts did not describe the research method in any detail. For example, S&P noted the use of initial forecasts, but it is unclear whether the forecasts were transactions, daily traffic, or annual traffic. Also, when a facility opened in segments, it was unclear what was regarded as the first year of operation—i.e., was it the opening of the first section or the opening of the whole road? Numerous attempts to interview the bond rating analysts to clarify the methodology were unsuccessful. Furthermore, the analysis was also complicated by the lack of information and specificity included in the T&R reports. A number of the T&R reports reviewed were also quite dated. For example, the T&R studies reviewed for Orlando were conducted in the mid-1980s and early 1990s with the result that the 1986 T&R did not provide any forecasted transactions and only forecasted revenues for six years for the northeastern segment and for four years for the southwestern segment. These older T&R reports also listed very few model input assumptions—for example, only population growth in the case of the 1986 T&R for the northeastern and southwestern segment of the Eastern Beltway in Orlando. Nonetheless, the research study identified a number of areas that require an improved understanding to enhance the reliability of T&R forecasts.

### Traffic Forecasting Model

There seems to be a general consensus in the literature and among T&R consultants that the models adequately perform their function and that unreliability stems from the inputs into the models. In other words, the problems with toll forecasting performance stems from the application of the models, not the models themselves. The exception is Halcrow, who acknowledged that their model introduces some errors.

All the T&R consultants interviewed noted that the travel demand models developed by regional planning bodies or MPOs for long-range planning are typically used as the starting point when conducting toll traffic forecasts. These are aggregate models and each T&R consultant has a proprietary approach to adapt the models and the inputs from these models to conduct corridor types of analysis. Model errors and the estimation methods adopted must thus have an impact on the T&R forecasts, but the issue is that the extent of the model error is largely unknown in the industry.

### Data Sourcing

Oftentimes the data used and included in T&R reports were not sourced.[3] In a number of cases historical population and employment growth rates could be obtained from a reputable government agency, such as the Bureau of Economic Analysis or Statistics Canada, but it was not clear whether this was the original data source. A lack of data also prevented the verification

[3] Newer T&R reports do source data substantially better than the earlier studies done in the 1980s.

of certain assumptions that were documented in the T&R report. For example, actual trips generated from specific land uses could not be verified because origin and destination information are not available from the transaction data.

### Embedded Assumptions

Even recent T&R studies that provide a significant amount of well-sourced data are often not explicit about the assumptions embedded in the T&R approach. Vague statements, such as "*historical demographic and economic trends are assumed to continue into the future"* were standard in many of the T&R reports. The actual rates assumed were often not provided and it is unclear how, or even if, some of the values—e.g., motor vehicle registration trends—are used in the forecasting process.

### Lack of Specificity

T&R consultants typically estimate the number of transactions and revenue for the base year and for selected future modeled years. The annual transaction and revenue numbers for the non-modeled years are then obtained through interpolation or extrapolation. In one case, the T&R consultant claimed to have used simple interpolation to provide the non-modeled year's forecasts. When the study team applied simple linear interpolation in an effort to replicate the values provided, it became evident that simple linear interpolation was not used by the consultant. Also, vague statements, such as *repeat* or *replicate the process*, can be very misleading. On a number of occasions when the research team attempted to replicate a calculation, different results were obtained from what was included in the T&R report.

### Revenue Emphasis

The analysis was also complicated by the fact that, especially in the case of the earlier studies, the emphasis seems to be on revenue estimation as opposed to toll demand estimation. This is reasonable to the extent that these T&R studies are often reviewed to determine the bonding capacity of the facility, but it further reduces the transparency of the calculations. For example, in the Houston case study, the T&R consultant provided ADT values for only a limited number of years and annual revenue values. In this case, there was no discussion about the annualization factors used to estimate either annual volume or revenue.

### Key Variables

In general there is little discussion, if any, about the key variables that could introduce uncertainty into T&R forecasting. The exception is the Halcrow study that was done for the private concessionaire in the bidding for the 407 ETR. This T&R study was by far the most detailed and included both an extensive sensitivity and risk assessment.

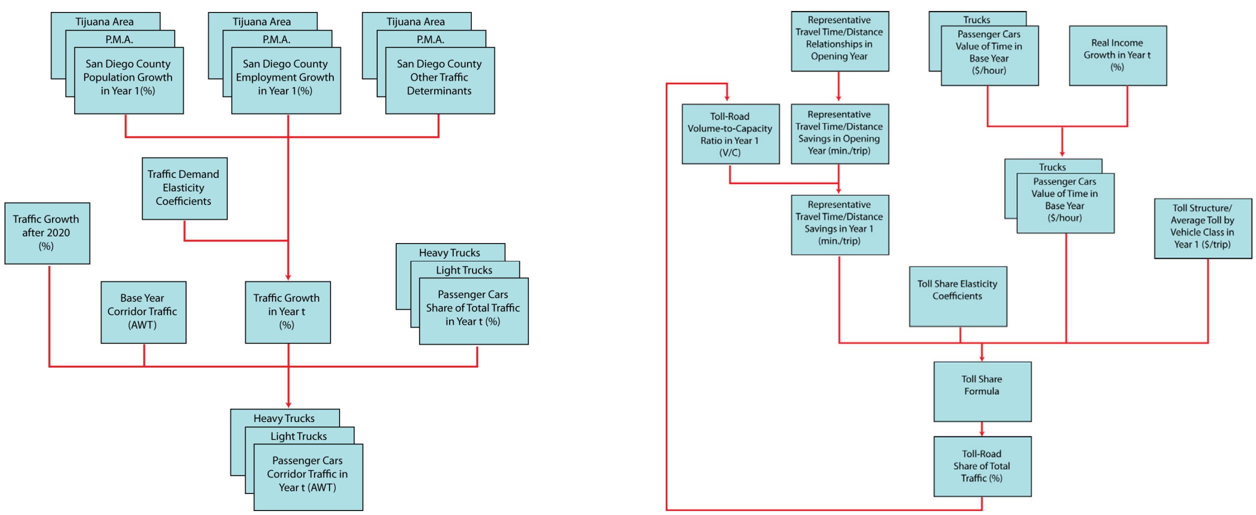
## Mitigating T&R Uncertainty

Specific recommendations were provided to address some of the concerns about data and data sourcing, the identification of key variables and how they are considered in the T&R forecasts, the limitations of the modeling methods used, and the sensitivity of T&R forecasts to changes in key variables.

### Schematics of the T&R Methodology

A key issue seems to be that there are no standards for T&R reports in terms of the data and analysis that have to be included in the T&R study. As mentioned before, T&R studies reveal little information about the T&R forecasting approach—it is considered proprietary by the T&R consultants—when and how various variables impact the analysis, the assumptions, or the estimation methods adopted. Without a better understanding of the modeling approach, and when and how variables are considered in the analysis, little more can be achieved but to note the general effect (overestimation or underestimation) of the T&R forecast and to rely on the explanations of the T&R consultants as to the reasons for discrepancies between actual and forecasted values.

It is thus recommended that the "black box" approach to T&R forecasting be mediated by a more detailed accounting of the variables, assumptions, and estimation methods employed. A positive first step is to provide a schematic of the T&R approach detailing the various variables considered, their interaction with other variables, and when these variables are considered in the T&R modeling process. Figure 3 provides a simplistic example to illustrate the estimation of travel demand and the variables that are considered in estimating the toll share or diversion rate to the toll road.




Source: HDR: HLB Decision Economics Inc., 2003

*Figure 3. Schematic of Travel Demand Forecasting and Toll Share Estimation*

These types of flow charts can provide insight when assessing the factors that introduce uncertainty. It is further recommended that each variable be subsequently discussed in terms of the data sources used (see section below), the factors that impact the variable—e.g., value-of-time (VOT) is a function of household income, inflation, time savings accrued, etc.—and the various implicit assumptions surrounding the estimation of the variable. In this regard, the schematic above clearly demonstrates that the diversion rate to the toll road is a function of the travel time savings, a toll share elasticity coefficient, VOT, and the toll schedule. Many times when forecasts are updated or revised, it is not clear what inputs changed, why the results are different, or even what the underlying concerns with the previous estimate were. A schematic would help clarify at least the inputs, while more detailed documentation of the reasoning employed and assumptions (see below) would enhance the understanding of the process.

**Model Methods and Limitations**

The T&R studies reviewed—with the exception of one Wilbur Smith & Associates (WSA) report—did not provide any information about the trip distribution, mode choice, or the network assignment methods that were used to forecast toll road usage. A better understanding of the methods used is required to evaluate the uncertainty the model introduces. To illustrate this point the traditional four step model typically employs static traffic assignment (STA). However, STA employs a number of simplifications that introduces uncertainty in traffic forecasting. For example, STA assigns the peak-period estimated traffic to the network in a single assignment. Existing traffic prior to the assignment and unassigned traffic that did not reach their destinations in the analysis period are ignored. In reality, traffic arrivals and departures are continuous, and traffic already on the network impacts the demand and behavior of traffic entering the network. Furthermore, because the peak period in most urban networks could extend from around 6:00 a.m. to 10:00 a.m. and 3:00 to 7:00 p.m., a single assignment is prone to significant error.

The model structure and estimation methods adopted are thus believed to contribute to the uncertainty of T&R forecasts. At a minimum, the T&R consultants should be required to specify the methods used, as well as the potential limitations and variability that the method introduces when modeling toll road usage.

### Data and Assumptions

#### *Data Collection*

Forecasting uncertainty also results from inferior data. It is clear from this study that data are an important component of the T&R forecasting process. Most of the T&R consultants interviewed conduct origin-destination surveys, traffic counts, and stated preference surveys, and verify economic and demographic data (usually through an independent consultant) to supplement the information obtained from local planning agencies.

A key input into the T&R studies of the 407 ETR was the *"Transportation Tomorrow Survey."* This extensive travel survey has been conducted every five years since 1986 in the Greater Toronto Area (GTA). The survey gathers information on household location, size, type, and car ownership, as well as information about individuals within the households, such as their age, sex, employment status, and number of driving licenses. More importantly, the survey records important trip details, such as origin, destination, trip purpose, trip time, and trip mode. The 1986 survey was a sample of 4.2% of the households in the GTA. The 1991 survey was an update of the 1986 survey and focused only on the areas that had experienced significant growth in the preceding five years. The 1996 survey included areas outside the GTA. The 1996 survey included 115,000 interviews, representing a 5% sample of the households in the survey area. The *"Transportation Tomorrow Survey"* information is used by the MTO to *"update previous trip tables for the GTA transportation model"* and evaluate *"peak and inter-peak periods."*

TxDOT also has an extensive travel survey program. At the time of writing this report, TxDOT together with HGAC and HCTRA were planning to conduct 5,700 household surveys in the HGAC region. Given that the HGAC area had an estimated 1,865,000 households in 2005, these 5,700 household surveys would represent less than 0.3% of the households (compared to the 5% household survey sample for the GTA).

Further, given the fact that truckers often pay between two and five times the toll rate levied on cars, it is critically important to have robust data and information about truckers' potential usage of toll facilities. No significant truck traffic analysis was, however, conducted in any of the reviewed case studies. Truck surveys and a much more in-depth analysis of trucking patterns and preferences are needed to gain a better understanding of the behavioral responses of truckers to tolling in an area.

***Data Sourcing***

In many of the T&R studies reviewed, the data were not adequately sourced and vague statements such as "*historical demographic and economic trends are assumed to continue into the future"* were standard in many of the T&R reports. In many T&R studies, the actual rates assumed and included in the models were not provided. At a minimum T&R consultants should reveal the data sources used to enable a stakeholder to evaluate the reliability of the data sources and to verify the data included in the T&R reports.

***Document Assumptions***

The calculation of factors, such as the ramp-up factor, the annualization factor, and the ETC factor, involves a number of assumptions, but none of the T&R studies reviewed disclosed any of the underlying assumptions or the rationale for the underlying assumptions. For example, ramp-up characteristics are reported to be determined by the road's characteristics, location, marketing efforts, payment collection type, the existing transponder penetration in the area, the area's transportation network, ramp-up experienced on similar facility types, signage to the road, and most importantly professional judgment. However, it is not clear how each of these considerations impact the ramp-up factor and it is suspected that professional judgment is the dominant consideration. Also, without better documentation of the rationale for these assumptions, it is unclear if discrepancies in assumptions are compounded or whether they balance each other out. Furthermore, many of the T&R reports did not provide the estimated values for the factors calculated. All assumptions and the calculated factor values should be clearly documented in the T&R study.

**Sensitivity of Key Variables**

The more recent T&R studies usually include some form of limited sensitivity analysis of a few key input parameters, such as the demographic forecasts or VOT. Usually three different demographic scenarios reflecting the base case, a low and a high growth scenario are developed and the impact on transactions and revenues determined. However, this section of the T&R study is usually a very brief section, only highlighting the variables that were considered, the scenarios, and the results.

An increased application of sensitivity analyses is recommended to identify key driving variables and their impact on forecasted toll road usage (and ultimately revenues). For example, optimistic assumptions about potential users' estimated VOT and time savings can introduce significant uncertainty in the T&R forecasts. It is thus recommended that T&R consultants identify the key variables that introduce uncertainty in the T&R forecasting process through sensitivity analysis using a range of input values. Also, it is recommended that the tested values of the key variables be graphed against the transactions and revenues for the modeled years to illustrate the impact visually.

**Assessing Forecasting Risk**

***Macro Level***

At the macro level, a number of traffic forecasting risk indexes have been published by the bond rating agencies to judge the potential reliability of toll T&R forecasts produced. While toll T&R forecasts provide a sense of the general magnitude of potential demand, a Traffic Risk Index provides a means to determine the certainty that these returns will be generated at a broad macro level. These tend to be, however, very general tools that can be used in an initial evaluation of a toll facility.

***Individual Project Level***

At the individual project level, a comprehensive risk analysis is thus recommended in assessing the impact of all key assumptions and variable values on T&R forecasts. Typically, a risk assessment involves the following steps:

- identify the key input variables that impact the forecasts (e.g., from a sensitivity analysis),
- provide a minimum and maximum value for each key input variable, as well as the probability distributions for each of them, and
- simulate various scenarios using, for example, the Monte Carlo method (as described in text box).

> Monte Carlo Simulation is a technique that allows the user to input variables in a model and receive outputs as probability distributions. The values for input variables are considered as ranges or probability distributions. Then, using a random number generator, the input values are randomly selected from the given distributions and entered into the model. The process is repeated many times and the results are reported as probability distributions from which conclusions about likely outcomes can be drawn.

The objective of a risk analysis is to quantify the level of uncertainty associated with specific variables within a reasonable range of values. The result is a range of forecasted T&R values within given confidence intervals instead of a point estimate (i.e., the *"expected outcome"*) that is now the standard in T&R forecasts. The confidence intervals enable the analyst to quantify the uncertainty in the forecast. The impacts of assumptions regarding changing conditions in the economy, political climate, regional development, and flexibility to raise toll rates can all be tested in a risk assessment.

Although risk assessment is regarded a positive step and recommended, a number of issues have been raised concerning the risk assessments conducted by T&R consultants, i.e., (a) the values identified are mainly based on the T&R firms' judgment or *"expert opinion,"* (b) probability distributions are often set as normal (even if this is unrealistic), and (c) the ranges are based on vague sources. However, as long as the data sources and assumptions are clearly documented, these concerns should not be used to dismiss risk assessments.

**Independent Socioeconomic Consultants**

Most T&R firms interviewed either used an independent socioeconomic consultant or conduct an independent in-house review of the demographic and economic forecasts obtained by the MPOs in an effort to overcome concerns about optimistic economic growth and land use predictions. When selecting a consultant, the goal is typically to use an independent firm not associated with the MPO, county, or city. However, this perceived objectivity has to be weighed against a firm's knowledge of the area and experience working in the area. Nevertheless, an independent firm acts as a peer review or a due diligence effort and is an effort to improve the credibility of the T&R forecasting process.

However, the details surrounding any revisions to the MPO figures have to be documented in the T&R reports. This has not been the case in the T&R reports reviewed—the exceptions are the T&R for the 2002 CTTP and the investment grade T&R study conducted by WSA in support of the bond issuance for the SH 121 project. The latter includes the detailed report prepared by the independent consultant as an appendix to the T&R. This report details the methodology and rationale for revising the MPO numbers obtained from NCTCOG, as well as the revised numbers. It is recommended that these types of reports and analyses be included in all T&R studies.

### Link between Traffic Forecasts and Revenue Forecasts

T&R consultants usually assume a certain toll rate schedule when conducting T&R forecasts—in some of the older documents these rate schedules were not provided. In some T&R studies, scenarios assuming different rate schedules were tested and toll sensitivity curves were developed to estimate optimum toll rates considering the impact on traffic and the associated revenue generated. In general the toll rate schedule is an input from the owner or the bidder of the facility. Traffic levels are then forecasted based on these set toll rates and revenues are directly calculated from these traffic levels. However, when attempting to calculate the value of an asset up for concession leasing, different revenue models and approaches should be an important component of future T&R reports to ensure that conservative estimates does not impact the lease amount the owner receives for the road. This will require an improved understanding of users' (both passenger cars and trucks) choice processes concerning a tolled route—e.g., VOT, income levels in the area, various toll schedules, time saved, and distance saved—and the development of models that can adequately account for individual preferences.

## Understanding Toll Road Usage

As toll road usage increases to finance new road infrastructure or add capacity to existing road infrastructure, the question of who uses and who does not use toll roads becomes increasingly important to toll road developers, financiers, T&R consultants, and investors, among others. In the spring of 2008, a telephone survey was administered to Central Texas households and in the summer and spring of 2009 a web/telephone survey was administered to Texas trucking companies in an effort to characterize the users and non-users of Texas toll roads. A detailed analysis of actual transaction data from the CTTS was also conducted. This transaction data analysis coupled with the preferences expressed in the surveys therefore provides a detailed look into the characteristics of the users and non-users of Central Texas toll roads.

### Auto Users of Central Texas Toll Roads

A number of studies have been conducted in an effort to characterize the users and subsets of users of toll facilities in various U.S. states, including Texas. Subsets of toll road users are those who use a toll road to commute to work or those who use electronic toll collection to pay the toll. These studies typically explored correlations between toll road usage and income, age, education, household structure, gender, and ethnicity. The most comprehensive studies have been conducted for California's SR 91 Express Lanes. These studies provided a number of interesting observations as to the typical characteristics of the SR 91 toll road user. Survey data collected by Cal Poly in the Fall of 1996, for example, revealed that commuters on SR 91 in California were in their 30s and 40s, male, earning more than $60,000, worked in professional careers, and came from larger households. Similarly, the North Texas Turnpike Authority's 2005 study of their TollTag and cash customers found that the Dallas TollTag user is typically older, Caucasian, has a higher level of education, and relatively higher levels of income compared to cash users. The findings relating to toll road usage and gender seem to be less conclusive. CA SR 91 suggested a higher level of female users, whereas more males used the Pennsylvania

Turnpike. Data for the Dallas tollways seem to suggest an equal gender split of cash users, but more male electronic TollTag users than female TollTag users. In general, the literature pointed to a correlation between toll road usage and higher incomes, as well as toll road usage and education levels and household structure.

> Initiated in 2002, the Central Texas Turnpike Project (CTTP) consists of 65 miles of new roadway in the Austin area. The 2002 CTTP includes three elements that are all managed by TxDOT:
>
> - SH 130 (49 miles), which begins north of Georgetown, Texas and extends to US 183 in southeast Travis County (and to be extended to IH 10 when funding becomes available),
> - SH 45N (approximately 13 miles), from Ridgeline Boulevard west of US 183 to SH 130, and
> - the Loop 1 Extension (approximately three miles), which extends from FM 734 (Parmer Lane) to SH 45N.
>
> The 183A toll road that is located in Northwest Austin is not part of the CTTP and is managed and operated by the Central Texas Regional Mobility Authority.

This study effort differs from previous efforts in that it attempts to explore the differences between the auto users and non-users of Central Texas toll roads. In the Spring of 2008, the research team worked with the Texas Turnpike Authority in administering a survey to Central Texas residents about their usage and non-usage of the CTTP. The administered survey included questions about respondents' trips and their usage and non-usage of the CTTP. In terms of the trip questions, three different trip purposes were considered: commute trips to and from work, non-work related or recreational trips (i.e., going to school, shopping or running errands, going to church, etc.), and business trips (all work trips that are not part of one's commute, i.e., business travel). Respondents answered only questions that corresponded to their toll road usage and/or trip purposes (e.g., those that did not commute to work were not asked about their usage of toll roads on their commute). The trip purpose questions aimed to collect information as to why respondents use or do not use toll roads for the different trip types. All respondents were also asked detailed demographic information, including county of residence, race, gender, income, employment, and household structure. The survey was administered by Harris Interactive and resulted in 1,507 completed surveys of Central Texas residents in Bastrop, Caldwell, Hays, Travis, and Williamson counties.

Survey respondents were characterized as toll road auto users or non-toll road users based on their response to one of the first survey questions that asked whether the respondent has used any of the four toll roads in Central Texas: SH 130, Loop 1 North, SH 45 North, or 183A. Respondents who indicated that they have used a toll road in Central Texas were categorized as toll road users (824 respondents). Respondents that reported that they have not used any toll road in Central Texas were categorized as non-toll road users (683 respondents). It should, however, be pointed out that although respondents were categorized as toll road users and non-toll road users, this did not equate to those characterized as toll road users using toll roads for all trip purposes or for all trips of a particular trip type.

Statistical analysis was conducted to provide insight into the demographic and trip characteristics of the auto users and non-users of the Central Texas toll roads. Two statistical tests were conducted (1) to analyze the relationship between specific demographic variables and toll road usage (i.e., Pearson chi-square test[4]) and (2) to determine if there was any statistical difference between those that use toll roads and those that do not use toll roads (i.e., inferences concerning a difference between population proportions[5]).

**Demographic Characteristics of Users and Non-Users of Central Texas Toll Roads**

A number of important insights were obtained from the statistical tests that were conducted to determine the influence of various demographic variables on toll road usage. Some of the salient findings include the statistical association at the 95% confidence level between:

- household income and toll road auto usage with toll road users having higher household incomes than non-toll road users (see Figure 4),

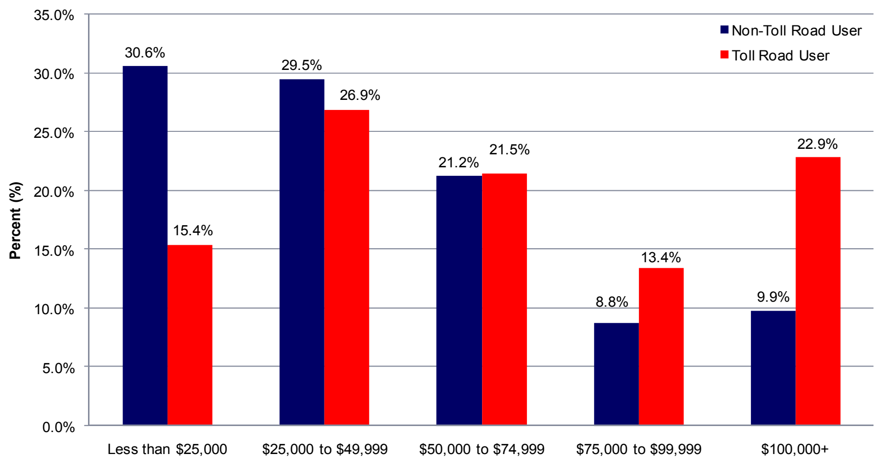



*Figure 4. Income Profile of Toll Road Users and Non-Users*

- age and toll road usage with toll road users tending to be younger than non-toll road users,
- household structure and toll road usage with most toll road users being married with children,
- household size and toll road usage with toll road users tending to live in households of three or more members,
- the number of vehicles available to households and toll road usage with a higher percentage of toll road users having access to two or more vehicles, and
- employment and toll road usage with a higher percentage of toll road users being employed full time.

Also, no statistical association was found between ethnicity and toll road usage or education and toll road usage at the 95% confidence level. Finally, the data analysis revealed a statistically significant difference between the gender profile and home ownership profile of toll

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[4] The Pearson's chi-square test was used as a "test of independence" to assess whether toll road usage is independent of specific demographic variables (e.g., ethnicity, gender, household structure, household type, vehicle ownership, etc.) at a 95% confidence level. The null hypothesis was thus that *"toll road usage is independent of the demographic variable (e.g., ethnicity)."*

[5] The inferences concerning a difference between sample proportions statistical test was conducted to assess whether the proportions (distribution) of responses differ between toll road users and non-toll road users. For example, the test was used to assess whether the gender profile (proportions) of toll road and non-toll road users is statistically different.

road and non-toll road users. Specifically, a higher percentage of males use toll roads and a higher percentage of homeowners use toll roads.

**Trip Characteristics of Users and Non-Users of Central Texas Toll Roads**

Statistical analyses were conducted to characterize the trip characteristics of toll road users and non-toll road users in Central Texas, including trip profile, trip frequency, transportation mode, trip times, and reasons for using or not using toll roads by trip type. Some of the salient insights into the trip characteristics of auto toll road users and non-users were:

- A statistically significant difference between the commuting profile of toll road and non-toll road users with a higher percentage of non-toll road users commuting to work. Furthermore, it appeared that toll road users commute less frequently than non-toll road users.
- Most toll road users that commute to work do not use a toll road for every commute trip with the exception of those that commute to work one day per week. Similarly, the majority of toll road users indicated that they use toll roads infrequently for non-work related trips and the majority of toll road user respondents (65.3%) indicated that they do not use a toll road for work-related trips.

> The majority of toll road users indicated that they use toll roads infrequently for non-work related trips, with almost 60% of the respondents using the toll roads for this trip purpose a few times per month (36%) or a few times per year (21%).

- On average, toll road users live 18.2 miles from their place of employment compared to non-toll road users who live, on average, 15.5 miles from their place of employment. Toll road users who commute to work reported an average commute time to work of 35.4 minutes and non-toll road users reported an average commute time to work of 24.3 minutes. Similarly, toll road users reported an average commute time to home of 32.7 minutes and non-toll road users reported an average commute time to home of 27 minutes.
- The statistical association at the 95% confidence level between toll road usage and the transportation modes used to commute to work with a higher percentage of toll road users commuting to work "driving alone" than non-toll road users.

A major reason for not using toll roads by both toll road users and non-toll road users for all three trip types were that no toll road alternative was available or a viable alternative to existing routes used. Further analysis, however, revealed that there is a statistically significant difference between the willingness to use a toll road if available for all three trip types between toll road users and non-toll road users. In other words, a higher percentage of toll road users indicated a willingness to use a toll road alternative if one were to be available.

Given an available toll road alternative, the most frequently mentioned reason for not using the toll road given by non-toll road users for all three trip types was that it was too expensive. Finally, all non-toll road users were also asked whether they would be willing to use a toll road if it would save travel time. Almost half of the respondents indicated that they would use a toll road if it saved them travel time. Non-toll road users that were willing to pay a toll if it saved travel time were subsequently asked how much time needed to be saved before they would be willing to use a toll road. The responses varied from one minute to two hours, but the majority of respondents (92.2%) needed to save 30 minutes of travel time or less before they would be willing to use a toll road. The average travel time savings needed were 21.9 minutes for a non-toll road user to be willing to use a toll road. Finally, these respondents were asked to indicate how much they would be willing to pay for the travel time savings they indicated in the previous question. The toll/minute of time saved that these respondents are willing to incur was subsequently calculated. It was found that most respondents (54.4%) are prepared to pay between 1 and 10 cents per minute of travel time saved, with 31.6% of the respondents prepared to pay between 6 and 10 cents per minute of travel time saved and 22.8% prepared to pay between one and five cents per minute of travel time saved. Almost 16.1%, however, indicated that they were not prepared to pay for the travel time saved—thereby contradicting their earlier response.

### Truck Users of Texas Toll Roads

Given that truckers often pay between two and five times the toll rate levied on cars, it is critically important to have robust data and information about truckers' potential usage of toll facilities. The literature, however, suggests tremendous uncertainty surrounding assumptions about truck usage in T&R studies. For example, S&P's 2005 analysis found that the errors associated with truck forecasts were substantially higher than those observed for private cars (e.g., light vehicles) in T&R studies. The forecasting error measured for trucks was 33% compared to 26% for light vehicles. T&R consultants often estimate the number of trucks that will use a toll facility by assuming a certain percentage of the total traffic will be truck traffic. This often results in the overestimation of truck usage of toll facilities, especially when trucks are projected to be more than an insignificant fraction of the toll road traffic.

A comprehensive literature review and analysis of available commercial toll road usage data for the John Kilpatrick Turnpike, the Pennsylvania Turnpike, and the Florida Turnpike System suggested substantial variability in truck toll road usage given the characteristics of the tolled facility, the truck market segment, and average trip length. The studies seem to be location specific, which means that caution should be applied in generalizing the results.

> Commercial user information of the Pennsylvania Turnpike suggested that the majority of truck trips are long-distance trips in excess of 500 miles. In the New York/New Jersey area, on the other hand, intra-regional trips represent 70 to 80% of toll transactions. One reason for this difference could be attributable to the characteristics of the toll facilities. The Pennsylvania Turnpike traverses the length of the state, while the New York/New Jersey toll facilities are local facilities in the urban areas.

To improve the robustness of truck toll road usage forecasts, it is very important to acknowledge at the outset that the trucking industry is not homogenous (see text box for additional examples). The trucking sector can be segmented in terms of:

- service area, e.g., local, regional, national, and international (i.e., crossborder U.S.–Canada, U.S.–Mexico, and Canada–Mexico),
- trip type, e.g., intra-city, inter-city, and through trips,
- vehicle ownership, e.g., owner-operator and company truck,
- vehicle operator, e.g., owner-operator and company employee driver,
- fleet size , e.g., small (less than five trucks), medium, and large,

- for-hire or private trucking,
- vehicle characteristics, e.g., light, medium, heavy, and specialized trucks,
- type of trailer, e.g., dry freight, refrigerated, flatbed, liquid tank, dry hopper, auto rack, household goods, and
- type of carrier/operation, e.g., truckload, less-than-truckload, parcel/express, and specialized services.

***Owner-Operators*** are independent drivers that own their trucks and are hired by shippers or other carriers to transport their goods. They typically operate as truckload carriers

***Private carriers*** are trucking fleets owned by a particular manufacturer or retailer and used to transport the company's own products. Examples of these types of carriers are Wal-Mart and HEB.
***Truckload*** (TL) carriers generally move full loads of freight, usually from one shipper to one receiver without having to make an intermittent stop to sort the load in a terminal. JB Hunt is an example of this type of carrier. Typical load sizes are 10,000 pounds or more and the distances covered are usually more than 500 miles for long haul carriers and between 200 and 500 miles for medium or regional haulers.
***Less-than-truck load*** (LTL) carriers generally deliver smaller shipments from more than one shipper to be delivered to more than one receiver. Shipments are typically picked up by a LTL driver along a regional route/service area and transported to a terminal. The shipments are then sorted and consolidated on a second truck that delivers the shipments to the final destination. Load sizes for LTLs are generally 500 to 2,000 pounds. An example of a LTL carrier is Yellow Freight. LTL carriers typically have higher fixed and operating costs than a TL carrier, including increased overhead costs due to the handling of many smaller shipments, additional labor costs for dock personnel at receiving terminals, and the costs of maintaining the terminal areas.

***Parcel express*** carriers make door-to-door deliveries of small packages (usually less than 100 pounds). Examples of parcel express carriers are Federal Express (FedEx) and DHL. These carriers conduct their business in a specific delivery timeframe that ensures on-time delivery based on the customer's specifications.
***Specialized operations*** include the transportation of chemicals or hazardous materials (Hazmat), as well as the transportation of oversize/overweight loads. Specialized trucking firms have additional fixed and marginal costs associated with their type of operation, such as the need for specialized equipment and the cost of special permits for the commodity being transported.

Although these segments are not necessarily mutually exclusive, it is important to recognize the different segments when trying to understand a trucking company's decision to use or avoid a toll facility. An inadequate understanding of the potential truck market segments that would use a particular toll facility has resulted in a number of cases where the forecasted truck usage did not materialize. An owner-operator may, for example, avoid using a toll road at all costs, while a fleet owner may weigh the costs and benefits before making a decision about using a tolled facility. For private carriers, such as a Wal-Mart or HEB trucking fleet, toll roads can present an opportunity to increase the fleet's productivity. In this case, it may also be easier to absorb the toll cost in the cost of the product being hauled. More generally, truckers will choose to pay a toll only if it makes business sense, i.e., the rates paid by the shipper allows the trucking company to recover the increased operating costs associated with using the toll facility or the savings in operating costs (time, fuel, etc.) exceed the additional cost imposed by the toll.

This research study attempted to characterize truck users and non-users of Texas toll roads. In the spring and summer of 2009, the research team administered an internet and telephone survey to Texas trucking companies to gain insight into their usage and non-usage of Texas toll roads. The administered survey included questions about the respondent's company (e.g., type of operation, size of fleet, and type of trucks used), the type of operation (e.g., long, medium or short haul, major commodities transported, delivery windows, time of deliveries, and type of driver compensation), attitudinal questions concerning respondents' use and non-use of toll roads, and finally a number of questions pertaining to respondents' perceptions of toll roads. A total of 108 valid and completed truck survey questionnaires were collected representing the following trucking sectors:

- truckload (TL) – 31% of the respondents,
- private fleet – 21% of the respondents,
- less than truckload (LTL) – 12% of the respondents,
- owner-operators – 9% of the respondents,
- parcel and express services – 6% of the respondents, and
- others, including specialized and heavy hauling services (20% of the respondents).

Survey respondents were characterized as truck toll road users or non-toll road users based on their response to one of the first survey questions that asked whether their drivers used toll roads in Dallas, Houston, and central Texas. Respondents that indicated that their drivers have used or are frequently using toll roads were categorized as truck users of Texas toll roads (63 respondents). Respondents that indicated that their drivers have not used any toll roads were categorized as truck non-users of Texas toll roads (45 respondents). It should, however, be noted that although respondents were characterized as toll road users it does not equate to toll roads being used for all trips. As a matter of fact, only 40% of the toll road users reported that their drivers use toll roads on a daily basis.

**Truck Users of Texas Toll Roads**

Truck toll road users were asked about the benefits of toll road usage, frequency of toll road usage, who was paying the toll, and the company's adoption of electronic toll tags.

The majority of toll road users (39% of the responses) indicated time savings to be the most significant benefit of using toll roads. The next most frequently mentioned benefit (30% of the responses) was less congestion. Other frequently mentioned benefits were better quality (8% of the responses), safer (6% of the responses), and shorter routes (5% of the responses).

Almost 40% of the respondents reported that their drivers use toll roads on a daily basis. On the other hand, approximately 11% of the respondents were infrequent users of Texas toll roads, using the toll roads one to two times per month or less.

The majority of respondents (84%) reported that the company was paying the cost of the toll. Only 2% of the respondents indicated that the customer was responsible for paying the toll. Slightly more than half (55% of the respondents) reported that all their power units were equipped with an electronic toll tag.

**Truck Non-Users of Texas Toll Roads**

Trucking respondents that stated that their drivers have not used toll roads in Dallas, Houston, and Central Texas were characterized as non-users of Texas toll roads. These respondents were asked the reasons for not using toll roads, and under what conditions drivers would be allowed to use toll roads. Of the respondents, 35% indicated that no toll road is available or a feasible alternative, while another 35% indicated that toll roads are not used because of the high costs of the tolls (see Figure 5). Other reasons included that the customer is not willing to pay the toll charges (9% of the respondents) and Texas toll roads do not accommodate oversized and overweight loads (7% of the respondents).

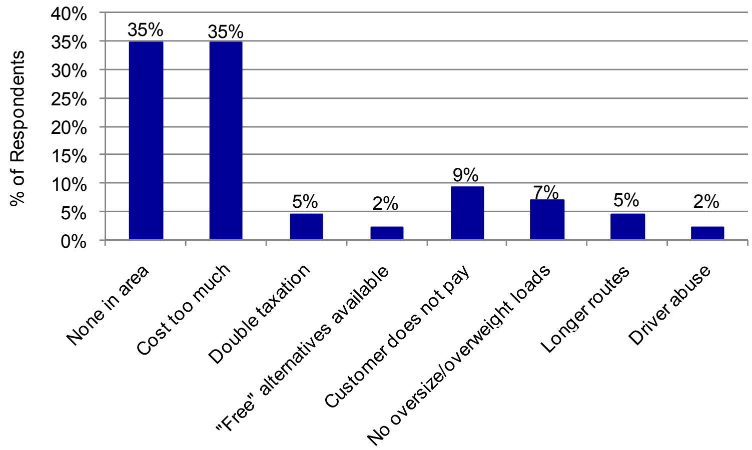


*Figure 5. Reasons for Not Using Toll Roads*

When truck non-users of toll roads were subsequently asked to specify under what circumstances drivers would be allowed to use a toll road, almost one-third of the respondents (32%) answered that they would never use a toll road and another 11% indicated that they would use a toll road only if no other "free route" existed. This seems to suggest that there is a group of truckers that are inherently opposed to toll roads and are therefore not willing to respond positively to any demonstration of the benefits of toll roads. This was also evident from the recorded responses to the following list of incentives provided to truck non-toll road users to determine if any of these incentives would persuade non-users to use toll roads:

- subscribe to a toll road use plan where the company would pay a discounted, fixed monthly fee for a specified amount of usage (similar to a cell phone plan),
- the company could receive a frequent user discount, such as free toll road days, free weekends, or discounted toll rates,
- the toll tag can be used to pay for other driver purchases, such as fast food, fuel, and parking,
- the company could receive a discounted toll rate during off-peak hours,
- the provision of larger, well-maintained truck stops with dining and truck repair facilities, as well as in-cab auxiliary power systems (e.g., IdelAire) alongside the toll road,
- the company could receive a fuel tax refund for the miles driven on the toll road, and
- longer combination vehicles (LCVs) were allowed on the toll roads.

Although none of these incentives resulted in more than 10% of the respondents indicating that they would be willing to use the central Texas toll roads if the incentive was offered, it did appear that those incentives that reduced the costs of using the toll road, such as a fuel tax refund, the allowance of LCVs, and the frequent user discounts were more favorably received by the truckers that choose to avoid toll facilities

### Differences between Truck Users and Non-Users of Texas Toll Roads

Statistical analysis was conducted to provide insight into the differences between truckers that choose to use toll roads and those that choose to avoid toll roads.

The research team found that the "type of operations" profile of truck users and non-users of Texas toll roads differ. Truck toll road users were mostly private carriers (30% of toll road users), followed by TL carriers (28%), and LTL carriers (15%). On the other hand, the majority of the non-users of Texas toll roads were TL carriers (36% of the toll road non-users), 25% comprising the "other" category, and 14% owner operators.

There is a statistical difference in the perception of toll road users and non-toll road users as to the impact of congestion on their business. In other words, a higher percentage of truck toll road users (91%) indicated that their operation is impacted by congestion than non-toll road users (66%).

> The most frequently mentioned impacts of congestion were higher fuel costs (28% of the responses), higher labor costs (19% of the responses), and fewer deliveries/less business (18% of the responses). Some respondents also mentioned that congestion times often resulted in late deliveries.

There is a statistical difference between the proportion of toll road users and non-toll road users that have a delivery window in which to deliver the major commodities transported by their company. A higher percentage of truck toll road users indicated that they have a delivery window in which to deliver the major commodities transported by their company than non-toll road users.

There is no statistical difference between the proportion of toll road users and non-toll road users that transport time sensitive commodities. However, 50% of the truck toll road users reported that their company makes most of their deliveries during the morning peak hours (i.e., between 7:00 and 9:00 a.m.) as opposed to 38% of the non-toll road users. Similarly, 43% of the non-toll road users indicated that the company makes most of their deliveries between 9:01 a.m. and noon (as opposed to 30% of the toll road users).

There is a statistical association between the level of support for the construction of additional central Texas toll roads and toll road usage. In other words, a statistically higher percentage of toll road users indicated support or conditional support for the construction of more toll roads in central Texas than non-toll road users. Furthermore, it was found that toll road users also ranked toll roads more favorably than non-toll road users in terms of providing (a) an alternative to congested freeways, (b) superior pavement quality, (c) a faster alternative, (d) toll rates that are reasonable considering the benefits, (e) a safer alternative, (f) more predictable travel times, and (g) an alternative in emergency situations.

## The Freight Shipper Perspective

Also, because discussions with carriers revealed that in many instances truck usage of toll roads will be determined by the shippers' willingness to pay for the incremental cost of toll charges incurred, the research team asked Texas freight shippers about their willingness to compensate trucking companies for the additional costs imposed when using a toll road. Specifically, Texas freight shippers were asked if they would be willing to pay toll charges incurred by the trucking service to (a) ensure reliable transit times, (b) enable faster transit times, (c) accommodate heavier or larger shipments, and (d) other (please specify). Texas freight shippers were asked to check all the reasons that applied to their business. This question was included in a questionnaire that was sent to 569 Texas freight shippers. A total of 55 completed surveys were collected from freight shippers across the state. Of the 55 completed surveys received, 21 Texas freight shippers (38%) indicated that they would be willing to pay the tolls for one or more of the reasons listed. Seven of the 21 Texas freight shippers indicated that they would be willing to pay the toll if toll roads could accommodate heavier or larger shipments.

### Toll Transaction Data Analysis

The survey information was supplemented with the analysis of a sample of 931,360 actual toll transactions that occurred on the CTTS— i.e., Loop 1, SH 130, and SH 45—during the week of November 5 to November 11, 2007. The transaction data included the day and time of the transaction, the plaza where the transaction was recorded, account type (i.e., commercial or non-commercial), axle count, and the billing zip code where the toll tag is registered. This actual data coupled with the information and perceptions expressed in the surveys provide considerable insight into the characteristics of the users of central Texas toll roads.

### Type of Account

The CTTS can currently be regarded as mostly a commuter system. Both Loop 1 and SH 45 are relatively short sections that aim to provide congestion relief to commuters, while SH 130, which will eventually serve as a bypass around Austin, was not fully constructed at the time of this study. At the time the data were obtained, SH 130 only went as far south as TX 71. Given the characteristics of the CTTS at the time the sample was collected, the commercial transactions as a percentage of total transactions thus appear reasonable. Commercial users are registered as such when applying for an account[6]. It is evident that about 98,460 (or 11%) of the transactions were conducted by commercial account holders. Also, commercial transactions represented less than 10% of total transactions on the mostly commuter toll roads, i.e., on Loop 1 (6.7%) and SH 45 (8.2%). On the other hand, commercial transactions represented almost 20% of total transactions on SH 130. This percentage is anticipated to increase when the road is completed further to the south, thereby forming a bypass around Austin.

### Day-of-Week/Time-of-Day Usage

The transaction data was analyzed to determine day-of-week and time-of-day patterns of travel by commercial and non-commercial accounts. Approximately 80% of non-commercial transactions occur on a weekday and 90% of commercial transactions occur on a weekday. Interesting is the fact that non-commercial weekend transactions thus comprise almost 20% of total non-commercial transactions.

Also of interest is whether a transaction occurred during a peak hour or off-peak hour. Peak hours were defined as the hours between 6:00 and 10:00 a.m. and 3:00 and 7:00 p.m. on a week day. Overall for the CTTS, 62.3% of the transactions occurred during peak hours and 37.7% during off-peak hours. It was evident that a slightly higher percentage of commercial transactions (i.e., 41.8%) occur during off-peak hours compared to non-commercial transactions (i.e., 37.2%). Substantial toll road usage during off-peak hours and weekend days suggest that users use toll roads for reasons other than time savings, because it has been pointed out that the

[6] Commercial accounts are for commercial vehicles with more than two axles or for accounts with more than five vehicles with a single billing address.

parallel non-toll roads are typically less congested during the off-peak hours. The latter could be further explored through additional analysis.

### Axle Configurations

Two-axle vehicles account for the majority of transactions recorded on the CTTS (95.36%)—specifically on Loop 1 (97.53%) and SH 45 (96.39%). A slightly lower percentage of two axle transactions were recorded on SH 130 (91.3%) compared to Loop 1 and SH 45, which seems to correspond to the slightly higher percentage of commercial transactions recorded on SH 130.

Although a small percentage of the two-axle transactions are commercial transactions (7.81%), more interesting to note is the fairly high percentages of the 3+ axle transactions that are non-commercial transactions—for example, 41% of the four-axle transactions are non-commercial transactions. This is likely vehicles towing a two-axle trailer (for example, with a boat) that are registered to non-commercial accounts.

Also interesting to note is that 70.48% of the commercial transactions are 2-axle transactions, 15.25% are 3-axle transactions, and about 3.9% are 4-axle transactions. The 5-axle commercial vehicles comprised only 8.34% of the total commercial transactions on the system.

### Geographic Profile

The transaction data captured the zip code of the billing address of each electronic toll tag account. This data allowed for a geographical analysis of the transactions by the zip codes of the registered account holders in the central Texas area. Though this data represents a one-week period during November, some inferences can be deduced about the residence or base location of users of the system.

Figure 6 illustrates that the billing addresses of CTTS users are concentrated in the north portion of the city around SH 45 and in the Pflugerville area between SH 130 and Loop 1 (i.e., Far West area). The lowest concentrations are observed on the southwest side of the city and on the southeast side between the airport and downtown. The demographic and land use characteristics of these two areas are quite different—the southwest being mostly middle to upper middle class residential, and the southeast being lower income and less developed residentially. The latter could explain the low concentration of billing addresses on the east, and distance from the CTTS could explain that of the west. The spatial data analysis also revealed that the billing addresses of CTTS commercial users are concentrated in the north portion of the city—just north of US 183 and west of Pflugerville—between IH 35 and Loop 1—as well as just south of the Capitol and around the airport.

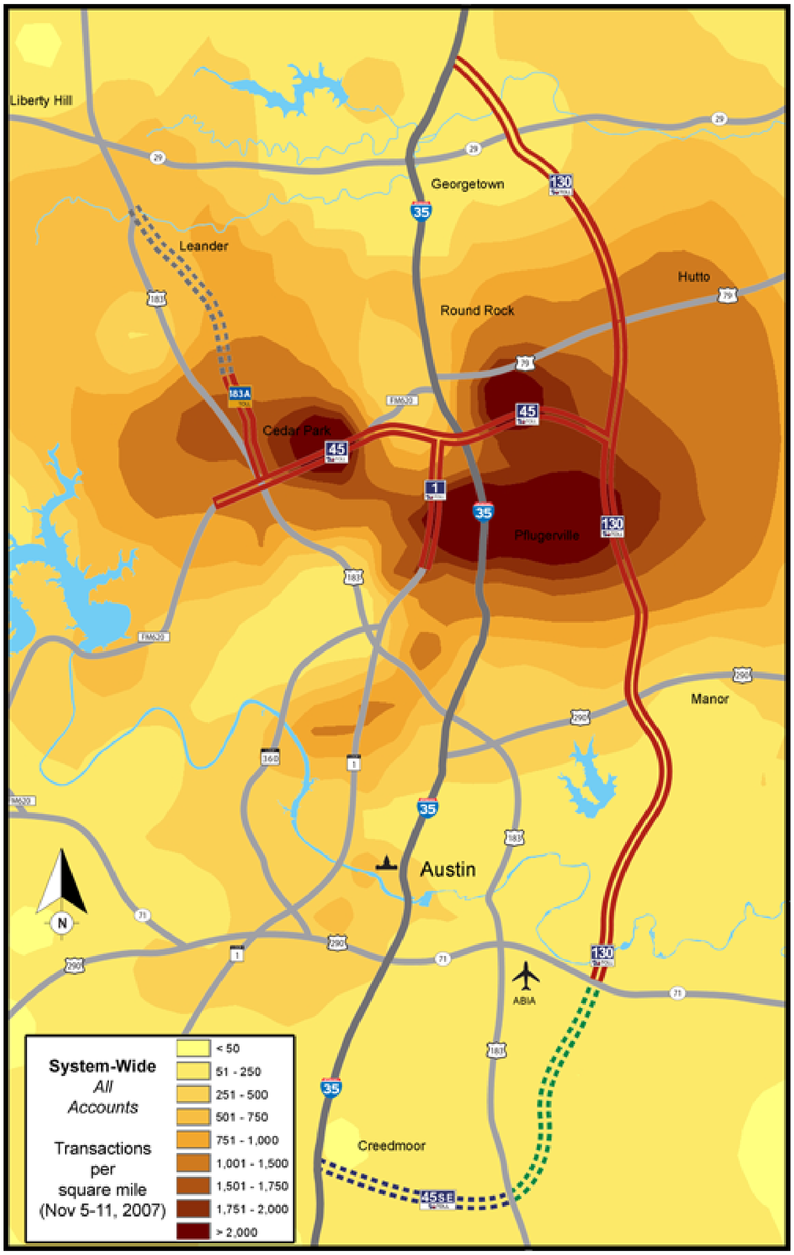


*Figure 6. CTTS Transactions/Mile[2]*

Overall, this type of spatial analysis is very useful to visualize the billing addresses of the CTTS users. Although the geographical representations were solely based on billing address information (and actual origins were unknown), it can be assumed that in the case of the non-commercial transactions, most of these addresses represent the homes of the TxTAG users and thus the trip origins and destinations during peak hour weekday traffic. For the commercial transactions, these billing addresses may or may not represent the trip origins of the vehicles.

## Concluding Remarks

The variability in forecasting traffic for facilities that will rely heavily on traffic and revenue to support debt payment has led to the rating agencies and the capital markets noting that "challenges remain." From the case study analysis conducted in this research study, it was concluded that T&R reports reveal little information about the T&R forecasting approach, when and how variables impact the analysis, the assumptions, or the estimation methods adopted. Without a better understanding of the modeling approach and methods used, as well as the data sources and assumptions, little more can be achieved but to note the general effect (i.e., overestimation or underestimation) of the T&R forecast and to rely on the explanations of the T&R consultants as to the reasons for discrepancies between actual and forecasted values. The study provided specific recommendations to address the concerns about data and data sourcing, the identification of key variables and how they are considered in the T&R forecast, the limitations of the methods used, and the sensitivity of T&R forecasts to changes in key variables. Implementing these recommendations would be a positive first step in mediating the "black box" approach to T&R forecasting without compromising the proprietary approach used by each T&R consultant to forecast toll demand.

In exploring who uses and who does not use toll roads, the responses of 1,507 auto users and non-users of Central Texas toll roads revealed a statistical association at the 95% confidence level between toll road usage and household income, age, household structure, household size, the number of vehicles available to households, and employment. No statistical association was found between ethnicity and toll road usage or education and toll road usage at the 95% confidence level. The data analysis also revealed a statistically significant difference between the gender profile and home ownership profile of toll road and non-toll road users. Specifically, a higher percentage of males use toll roads and a higher percentage of home owners use toll roads. A number of demographic factors are considered when conducting toll feasibility studies and when deciding on service levels. Demographic data are typically obtained from the U.S. Census or through neighborhood surveys. This analysis indicated that particular attention should be paid to the following demographic variables: income, age, household structure/household size, home ownership, number of available vehicles to household, and employment status.

In terms of trip characteristics, the study found that toll road users commute less frequently than non-toll road users, tend to "drive alone" to work, and typically do not use a toll road for every commute trip. A major reason for not using toll roads by both toll road users and non-toll road users for all commute, non-work related, and work related trips was that no toll road alternative was available or a viable alternative to existing routes was used. However, a higher percentage of toll road users regardless of the trip type (i.e., commute, non-work-related or business trip) indicated a willingness to use a toll road if it were available. This suggests that marketing efforts should be targeted to commuters in areas with an existing toll customer base. Finally, almost half of the non-toll road users indicate a willingness to use a toll road if it saved travel time. Marketing efforts should thus clearly demonstrate the potential travel time savings and the average toll per minute of travel time saved to potential toll road users.

In terms of the truck users and non-users of Texas toll roads, the study found that the *"type of operations"* profile of truck users and non-users differ. Truck toll road users were mostly private carriers (30% of toll road users), followed by TL carriers (28%), and LTL carriers (15%). On the other hand, the majority of the non-users of Texas toll roads were TL carriers (36% of the toll road non-users), 25% comprising the "other" category, and 14% owner operators. There is also a statistical difference in the perception of toll road users and non-toll road users as to the impact of congestion on their business. In other words, a higher percentage of truck toll road users indicated that their operation is impacted by congestion. On the other hand, there was no statistical difference between the proportion of toll road users and non-toll road users that transport time sensitive commodities. However, 50% of the truck toll road users reported that the company make most of their deliveries during the morning peak hours (i.e., between 7:00 and 9:00 a.m.) while 43% of the non-toll road users indicated that the company make most of their deliveries between 9:01 a.m. and noon. Truck toll road users also ranked toll roads more favorably than non-toll road users when presented with statements describing the benefits of toll roads (for example, superior pavement quality, faster, safer, and more predictable travel times). This seems to suggest that marketing efforts should be targeted to these types of operations and the existing toll customer base.

Finally, it appears that there is a group of truckers inherently opposed to toll roads, which translates into an unwillingness to respond positively towards most incentives to encourage the use of toll roads. Having said that, the incentives that reduce the costs of using the toll road, such as a fuel tax refund, the allowance of LCVs, and the frequent user discounts seem to be more favorably viewed by these truckers. These are thus incentives that can be further evaluated to encourage the usage of toll roads by the trucking industry.