



Predicting traffic congestion relief on LBJ Express: A case study in Dallas, Texas

Introduction

Texas has a historically rapidly growing population that will lead the nation in growth for decades to come. According to the United States Census Bureau 8 out the 15 fastest growing cities in 2012 were located across Texas including cities along the I-35 corridor and large Texas metropolitan areas including Austin, Houston, and Dallas/Fort Worth (United States Census Bureau 2012). With the rapid growth in North Texas comes the need for transportation infrastructure modification and renovations. Of the fastest growing counties in the country, several are located in North Texas including Denton, Dallas, Collin, and Tarrant and are in serious need of transportation infrastructure improvements (Landers 2008). The Dallas/Fort Worth Metropolitan area (DFW Metroplex) has seen recent modifications and additions to existing roadways along with the development of entirely new highways with the aim at reducing traffic congestion. The Chisholm Trail Parkway in Fort Worth and the proposed “Trinity Parkway” in Dallas are examples of entirely new toll roads in development to help assist with the Metroplex’s population growth. One of the major recent developments in Dallas’s transportation infrastructure is along I-635 (commonly known as LBJ Freeway) and a small segment of I-35E in northwest Dallas County. This ambitious project, known as LBJ TExpress or simply LBJ Express project aims at reconstructing existing interstates in northwest Dallas County for the purpose of relieving traffic congestion today and for years to come. The existing lanes will be significantly improved and several managed toll lanes will be added, giving drivers more

choice in their daily commute. It will be the first highway in DFW to offer free-to-use lanes and toll lanes simultaneously. The combination of free and toll lanes will be in effect on segments of LBJ Highway and I-35E. By mid-2016, the free-to-use segments of the I-635 and I-35E corridors will be extended to eight lanes while those willing to pay a toll can drive on the new six-lane toll section that runs underneath the main roadway (TxDOT 2013).

LBJ Express will be the first of its kind in North Texas. While the overall project consists of approximately 17 miles of renovations, the bulk of changes made to the LBJ Highway spans 10.7 miles where the multilevel roadways will be added (Brown 2010). The 10.7-mile segment mentioned above is intended to provide the most traffic relief for commuters because historical trends show that traffic congestion exists in its most intense form in that segment of highway (Brown 2010). The managed toll lane segments of LBJ Express will be rather complex in terms of development and structure. On the LBJ Highway portion of the toll lanes, drivers who choose to pay a toll for a faster commute will be guided to a tunnel-like area of the highway where they will be driving beneath the free-to-use lanes (illustrated in Figure 1). Going west, drivers on the toll section of the highway will be redirected when going south on I-35E to elevated toll lanes running along the outside edges of the interstate. The portion along LBJ Highway is intended to provide the most relief to traffic congestion and is also the longest span of toll lanes. The elevated toll lanes along I-35E are only several miles long but also allow drivers to bypass a very congested segment of I-35E. Overall, the renovations of LBJ Highway are designed to give drivers for choice of their commute (LBJ TEXpress 2014).

There is a lack of research that helps determine how the public will use LBJ Express and how frequently they will use the toll lanes. In addition, there is very limited information about

the public's driving habits in the DFW Metroplex. The research I am proposing addresses the crucial "choice" factor of this ambitious project. Will the public be willing enough to pay a toll on a road that has historically been free-to-use since 1969? How will the people choose to use LBJ Express and what is an appropriate toll to prevent low usage of managed toll lanes? More importantly, this research aims at predicting relief on traffic congestion based on public opinion and public driving rates based on other local Dallas-area toll roads. In order to better understand future traffic trends, I will be surveying the general public on their driving habits and how they predict they will use LBJ Express. By understanding the public's views on their views on LBJ Express, I will be able to make conclusions as to how willing the general public is to pick the option to pay tolls for a free-to-use highway. For my sampling process, I am interested in surveying geographic subpopulations that exist within the DFW Metroplex. For this project, rural, suburban, and urban subpopulations are of most interest because of the different commuting patterns. This sampling method will help cover important geographic regions in the DFW Metroplex that contain people with different driving habits.

Background

The total cost to improve and modify segments of LBJ Highway and I-35E is approximately \$2.7 billion, most of which comes from private funding (Brown 2010). The large amount of private funds made it possible to implement the transportation project because the state did not have nearly enough funds to allocate toward LBJ Express (Brown 2010). While it is fortunate that TxDOT is able to carry out this large project, it still stands far above other transportation projects in the DFW Metroplex in terms of cost. For example, there is a longly awaited project simultaneously being constructed with LBJ Express called the Chisholm Trail

Parkway. Stretching from Cleburne, TX north to the heart of Downtown Fort Worth, the Chisholm Trail Parkway is being built with a price tag of \$1.4 Billion for a total 27 miles (NTTA 2014). However, the Chisholm Trail Parkway will be purely a toll highway.

The LBJ Express project will be expected to reduce traffic congestion after decades of population growth in the Dallas area and a very limited amount of expansions and renovations to the LBJ Highway. Built in 1969, the LBJ Highway was originally intended to support about 180,000 vehicles per day and as of 2009, the highway now sees about 270,000 vehicles per day with very few additions since initial development (Nichols, 2011). By 2020, projected traffic rates are expected to be as high as 450,000 vehicles daily on the LBJ Freeway (Nichols, 2011). With a population growth rate so high in DFW, it is important to consider the concept of “triple convergence,” which states that new lanes and road modifications may lead to new forms of congestion (MacGregor, Burris, Goodwin, 2010). Regardless, TxDOT and the North Central Texas Council of Governments (NCTCOG) expect traffic relief to be substantial for decades. TxDOT and NCTCOG, along with various other governmental planning organizations have done the appropriate research to ensure that LBJ Express will be useful far into the future.

To total length of highway renovations related to LBJ Express is approximately 17 miles (TxDOT 2014). That distance includes general renovations to LBJ Highway and the main portion of renovations including added managed toll lanes. Shown in Figure 2 is a map of Dallas County with the construction zones highlighted in red. Historically LBJ Highway has 8 lanes total and has remained the same until LBJ Express was initiated. As part of the reconstruction of LBJ Highway, the old 8 free lanes have been significantly improved. The general use lanes will be one foot wider after reconstruction is complete and will allow for better flow of traffic. The

reconstruction of previously existing lanes is crucial to this research because the public will be serviced with a higher quality roadway that is still free to use. While there will be the same amount of lanes as there was before reconstruction of LBJ Highway, drivers still have to option to pay a toll. In addition to the argument stated previously, why should the public choose to pay a toll when general use lanes will be significantly improved?

The cost of using LBJ Express is still being determined until it officially opens in 2016. On completed tollway projects in DFW, tolls typically range from \$.50 to over \$3.00 on highways such as the Dallas North Tollway and the President George Bush Turnpike depending on how long the driver uses the highway in terms of distance. Taking the Dallas North Tollway can be as expensive as \$4.00 per trip assuming the driver stays on the tollway for its entire distance. However, on the Dallas North Tollway one trip can be as cheap as \$0.50 if the driver enters the tollway then exits shortly after. LBJ Express takes a completely different approach. LBJ TEXpress lanes will implement congestion-based pricing by every mile driven and the cost of using LBJ Express toll lanes will vary depending upon congestion status (LBJ Express Infrastructure Group 2014). This practice is common in northeastern U.S. States where congestion is a more severe issue. Currently, most tollways in DFW do not need to implement congestion-based pricing because they do not experience serious congestion. However, as mentioned earlier LBJ Highway will see an extreme influx of drivers in the years to come and might be congested just after being completed. During gridlock hours, LBJ Express pricing will peak and will be lowest with the least amount of traffic (probably during late night hours and midday). As of January 2014, approximately 3.2 miles of TEXpress toll lanes have opened for public use (North Central Texas Council of Governments 2014). Currently, pricing for available TEXpress lanes varies from

\$0.15 to \$0.95 per mile driven making one trip on the toll lanes as expensive as \$3.00 (North Central Texas Council of Governments 2014). The LBJ Express Infrastructure Group, the agency responsible for constructing, funding, and maintaining LBJ Express has announced the tentative pricing for the period beginning 6 months after construction is complete. LBJ Express pricing is as follows:

- \$0.10 to \$0.25 during lighter traffic
- \$0.45 to \$0.75 during heavy traffic or rush hour

The price of \$0.95 mentioned earlier reflects extreme traffic conditions due to heavy construction activity and is expected to change (North Central Texas Council of Governments 2014).

Methodology

The methods that will be used for this study include specific sampling methods, surveying of the general public, quantitative methods, and GIS analysis. Altogether, these methods are intended to capture public perceptions of LBJ Express and how they plan on using the toll lanes when they become available for public use upon completion 2016. I plan on performing statistical tests on survey questions in order to quantify survey responses and make quantitative conclusions about the state of public opinion on LBJ Express.

Complications can arise when sampling populations based on geographic regions. Random sampling across geographic space tends to undermine crucial geographic subpopulations that may exist as a part of a study (Christakos et al 2009). For this study concerning public opinions and perception in regards to LBJ Express, sampling existing subpopulations is crucial for covering all types of commuters in the DFW Metroplex. The Dallas

area is very diverse in terms of population density and varying degrees of urban sprawl. Dallas County contains a healthy amount of rural, urban, and suburban populations. These populations have distinct geographical boundaries and will be important for the sampling methods in this study. While rural communities are decreasing in population all over America, there is an important relationship between urban and rural communities and the commuting patterns of the two groups (Ali et al 2010). Populations from rural geographic areas can expect to commute longer distances at the expense of a lower cost of living than Uptown Dallas for example. Therefore, rural populations will have very different intentions for using LBJ Express due to substantially longer commuting distances. Suburban and urban populations also have commuting patterns of their own that may influence how they use LBJ Express and the frequency of usage. In order to capture the three distinct subpopulations in the Dallas area, stratified random sampling will be used to appropriately cover the area of interest. The sampling area would consist of a 30-mile radius from the location of LBJ Express in northwest Dallas County. Within the 60-mile radius sampling area, the population will be divided into strata (urban, suburban, and rural). ESRI Community Analyst is a web-based subscription demographic research tool that provides a wide variety of demographic and community data by U.S Census defined zones, such as census tracts and block groups. In addition, Community Analyst has the ability to define population types such as rural and urban based on geographic location and boundary. This powerful research tool will be the basis for determining the geographic sampling area and the populations in each of them. Community Analyst does require a subscription fee however, and the funding for this research will be critical for providing the utilization of Community Analyst to execute this project. Looking at the overall

population, the size of each stratum will be proportional to the population. For example, Dallas County has about 2,400,000 residents and they need to be divided proportionally into strata based on the population size. The following is an example of the stratification process using example population sizes:

$$\text{Urban Pop} \approx 800000 * (10000/2400000) \approx 3333$$

$$\text{Suburban Pop} \approx 1300000 * (10000/2400000) \approx 5417$$

$$\text{Rural Pop} \approx 300000 * (10000/2400000) \approx 1250$$

In the example above, the target sample size n is 10,000 for a population N of 2,400,000. Again, the actual population sizes will reflect Community Analyst data and is likely to be different than the example. Once the population is divided up into strata, the proportional sample size for each stratum will be sampled randomly in each geographic subset. In theory, the process of stratified random sampling should be very effective in reaching out to crucial subpopulation effectively for this study.

Once the strata for the population are identified and defined geographically, the surveys will be mailed to individual addresses. Although in today's society the Internet may seem like the most effective choice is distributing surveys, research suggests that surveys by mail are still the most effective. First, mailing surveys is more cost effective. Sending people surveys by mail has been shown to be cheaper due to the lack of dependency on survey research organizations (Dillman 1991). The most historically effective way to distribute mail surveys is using the Dillman Total Design Method. The Dillman Method has very specific guidelines to encourage participants in a survey to engage and return the filled out forms. To start, a post-marked survey is sent out to the target sample strata of the study, which in this case is urban, suburban,

and rural subpopulations. The first stage is typical being that the survey is mailed out with the hopes that it is completed and returned. However, the group of people that does not complete the survey the first time will receive a follow-up survey, typically after one week as a reminder (Bass and Hoddinott 1986). After repeating the process of following up with participants, response rates can reach as high as 80% (Dillman 1991). While the Internet is the most commonly used tool for communication, especially in marketing the response rates do not compare as such. This may be due to the quickness to overlook something in the email inbox or that many emails sent from unknown email addresses are immediately allocated into spam folders. Nonetheless, the Dillman Total Design Method will be the most effective survey distribution design for this study.

The actual questions on the mailed surveys will implement the Likert scale. Many surveys of all types implement Likert scale questions because it give participants more options in measuring attitude toward a particular subject and also allows for quantitative analysis (Jamieson 2004). Likert scale questions measure the participant's attitude on a question relating to a particular issue from 1 to 5, where "strongly disagree" typically equals value 1 and "strongly agree" equals value 5. Typically the middle value is "neutral" and values 2 and 4 are "disagree" and "agree" retrospectively. Many surveys use anywhere from 3 to 7 total values but for the purpose of this study, 5 values will be used. There are two types of methods when creating surveying using Likert questions: Likert-type and Likert scale. Essentially, the difference in terms of questioning is how each question is asked in relation to succeeding and preceding questions. Likert-type questions are answered by the participant without regard or relation to other questions other than the general subject being addressed whereas Likert scale questions

work together in groups of four or more and generally aim to capture the same attitude across all questions within one group (Boone and Boone 2012). The survey for this study will incorporate Likert scale questions in several different sections. The following is an example of how questions (ranging from strongly disagree to strongly agree on 5 levels) will be asked in order to incorporate a Likert scale:

- 1) LBJ Express toll lanes will improve my work commute.
- 2) Paying \$2.00 for more per trip to reduce driving time on LBJ is worth my money.
- 3) If not often, there are occasional times that I will use toll lanes.
- 4) When driving in the DFW Metroplex, I always use existing toll roads when needed.
- 5) The free section of I-635 is still 8 lanes, making the toll lanes more desirable due to past traffic congestion.

The context of the questions asked will presumably result in answers of the same or similar values. There will be several general questions on the survey to capture general information about driving and commuting habits in DFW. First, the survey will ask for the participant's gender and age. Additionally the survey will ask the participant where they fall within provided income intervals starting with < \$25000 and ending with > \$150000 with \$25000 intervals in between. These questions are intended to better understand the results of statistical tests for further analysis. Likert scale questions will be grouped into several categories addressing issues regarding LBJ Express: 1) Frequency of completed toll road usage 2) Frequency of present LBJ Highway usage 3) Future predictions of LBJ Express usage 4) Situational use of LBJ Express and 5) Questions regarding toll prices.

The importance of distinguishing between Likert-type and Likert scale questions relates to how the results are analyzed quantitatively. Quantitative analysis of Likert question data is a large gray area in many research fields. When using Likert-type questions, the resulting data will be ordinal and not have a random distribution (Boone and Boone 2012). However, if the survey asks Likert scale questions, the resulting data will be interval level (Boone and Boone 2012). While interval level data is valid for parametric testing, the distribution still is not random. Even though Likert scale data is not normally distributed, for decades many professional researchers have found valid results while still using parametric tests (Norman 2010). Generally the choice of statistical tests on Likert data is dependent upon the discretion of the researcher. While professional researchers frown upon using parametric testing on Likert data, research on the topic suggests that there is very little difference between the use of parametric testing and nonparametric testing for such data (Murray 2013). The central limit theorem will be the driving force behind the deciding factor on whether or not to use parametric or nonparametric tests depending on the success of response rate.

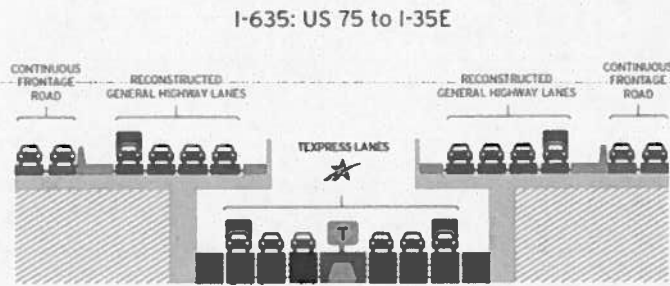
The data will be analyzed through a series of T-tests and ANOVA tests. In regards to the stratification of data, ANOVA tests will determine how the subpopulations (urban, suburban, and rural) differ from each other. ANOVA tests will also be used to test income intervals on different groups of questions regarding LBJ Express. The t-tests will determine possible differences between genders on how they responded to the survey questions. The responses overall will help make conclusions about future driving habits on LBJ Express. The two hypotheses address for this research are as follows: 1) The general public is willing to pay an

optional toll to use LBJ Express 2) The general public does not want to pay optional tolls on a previously free highway.

Conclusion

If this research receives funding, it will be the first in-depth analysis on public opinion of transportation projects in DFW and will also capture important information about the state of public commuting habits. LBJ Express is an incredibly expensive project and might be the necessary direction for improving Dallas's transportation infrastructure. However, it is crucial to understand how people feel about LBJ Express and their intentions on paying tolls. The DFW Metroplex does not have the developed public transportation other American cities have, including high ridership and accessibility. It is important to determine if the public wants to pay money to use a highway that may be congested in the near future before funding and implementing an expensive project like LBJ Express.

Figure 1: Cross section of LBJ Express (LBJ TEXpress 2014).



I-35E: Loop 12 to North of I-635

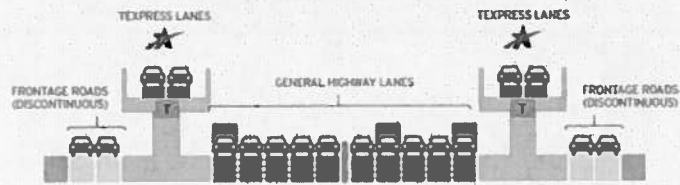
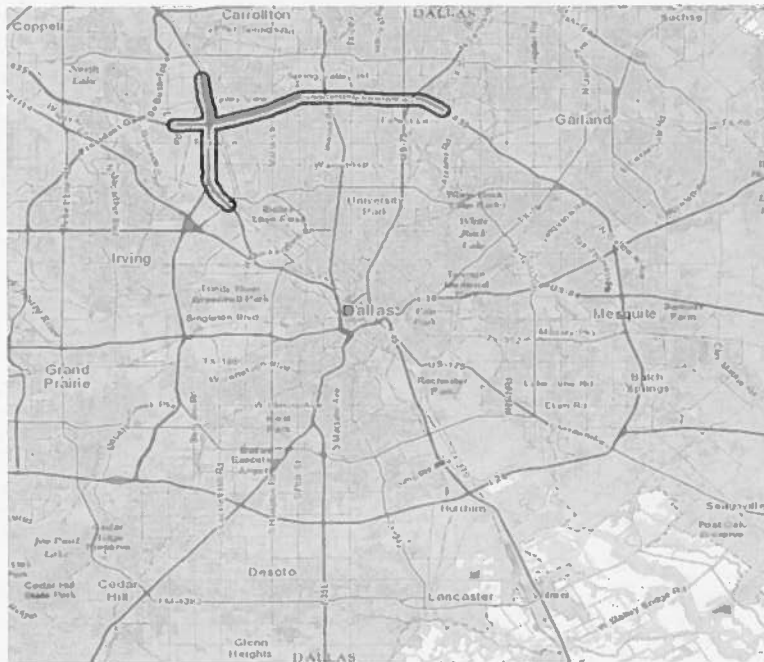


Figure 2: Map of Dallas County. Highlighted in red is the extent of construction on LBJ Highway and I-35E.



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