THE IMPACT OF INCENTIVES ON THE USE OF TOLL ROADS BY TRUCKS

A Thesis

by

LIN ZHOU

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2009

Major Subject: Civil Engineering

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Approved by:

Chair of Committee,	Mark W. Burris
Committee Members,	Luca Quadrifoglio
	David R. Ellis
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ABSTRACT

The Impact of Incentives on the Use of Toll Roads by Trucks.

(May 2009)

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Chair of Advisory Committee: Dr. Mark W. Burris

States are increasingly using toll roads as a means of financing transportation capital needs as well as expanding transportation system capacity. Whether toll roads can attract trucks partially determines the performance of the investment. Unfortunately, the low profit margin in the trucking industry and the relatively high tolls truckers pay leads to their reluctance to use toll facilities. Incentives for truck use of a toll road, State Highway 130 (SH 130) near Austin, Texas, were analyzed in this research. As a parallel toll road to the non-tolled, congested facility Interstate 35 (I-35), SH 130 was projected to carry a lot of traffic, including a significant proportion of trucks. In order to make this tolled facility more attractive to trucks, innovative incentives were considered. The potential truck demand for SH 130 and their potential reactions to the incentives were estimated in this research based on survey data.

According to survey responses, different groups of the trucking industry had very different characteristics. Due to the variation of the characteristics among different categories of trucks, truckers' travel behavior and incentive preference were also different by trucking group. Compared with other groups of truckers, smaller companies (owner-operators) were the least likely to use SH 130, while private carriers were the most likely to use SH 130. It was also found many truckers had already made adjustments both to their time and route to avoid traveling in congested conditions. Among all the categories of truckers, for-hire truckers had the least flexibility.

The average value of travel time savings of trucks around the Austin area was $44.20 per hour. As the price of travel time savings went up, the percentage of truckers using SH 130 decreased. Price-related incentives were discovered to be most popular with truckers. Among all of the price-related incentives, off-peak discounts and a free trip after a number of paid trips were the most popular incentives.

DEDICATION

Dedicated to

My father, Zhiqiang Zhou, and

My mother, Sujuan Ren

ACKNOWLEDGMENTS

Firstly, I would like to thank my parents for their love, understanding and support they have provided throughout my whole life, which encouraged me to further my education in the United States for my Master's degree. I always hold very deep gratitude to my parents that can hardly be expressed adequately through words.

I am grateful for my Committee Chairperson and advisor, Dr. Mark W. Burris, for his great effort in helping me with this thesis. I could have never finished this thesis without Dr. Burris' instruction, advice, and kind help. Also, I appreciate my other committee members, Dr. Luca Quadrifoglio and Dr. David Ellis, for their helpful comments on my thesis. I appreciate the fine education and insight I obtained from Texas A&M University, which are the most valuable treasures in my life.

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CHAPTER I

INTRODUCTION

1.1 Background

States are increasingly using toll roads as a means of expanding system capacity. A 2006 Government Accounting Office (GAO) report estimated that 30 to 40 percent of new capacity was in the form of toll roads (Government Accounting Office 2006; Poole 2006). This estimate did not account for more recent spikes in construction costs (WSDOT Construction 2008) and reduced revenues from gas taxes (Visnic 2008). These both led to the increasing need for alternate forms of financing new construction frequently done through the use of tolls.

However, just because there is a need for alternate revenue sources, and thus an increase in toll road construction, does not mean these facilities will be successful. Although few toll facilities have performed so poorly that they have gone bankrupt or were sold at a loss (Camino Columbia, TX and Northwest Parkway and E-470, CO) a high percentage have failed to attract the traffic and revenue they expected (Kriger et al. 2006). This can result in serious financial difficulties for the toll authority and anyone who may have backed the bonds.

This thesis follows the style of the *ASCE Journal of Transportation Engineering.*

Additionally, the benefits of diverting traffic from congested, non-tolled facilities may not occur. The ability of the toll facility to attract heavy vehicles (trucks) is one of the greatest factors impacting the performance of the toll road, from both a revenue standpoint and the ability to reduce congestion on alternate routes. This can be difficult as many trucks are reluctant to use toll roads due to tight profit margins. The trucking industry has a low profit margin and a highly competitive environment. Therefore, truckers search for the minimum cost method and avoid toll roads (Vadali et al. 2007). However, there may be incentives (monetary, geometric, comfort, etc.) that would attract additional truck traffic to a toll road, finally achieving a mutually beneficial arrangement for the truckers and the toll authority.

SH 130 is a newly constructed toll road parallel to I-35 near the Austin, Texas. I-35 is a non-tolled, frequently congested road with a significant proportion of truck traffic. According to "Central Texas Turnpike System 2002 Project Traffic and Revenue Forcase-2005 UPDATE", 9.7% to 17.5% of all vehicles on I-35 around the Austin area were trucks.

SH 130 was constructed to lure vehicles, especially trucks, from I-35, which would increase the efficiency and safety of I-35. SH 130 was opened in November 2006 without charging tolls. Tolls began in April 2007, at a rate of approximately 12.5 cents per mile for autos. Truck tolls were the auto (base) rate multiplied by the number of axles minus 1. For example, a 3-axle vehicle paid double the base of 12.5 cents/mile rate. TxTag customers (customers using an electronic toll transponder) enjoyed a 10% discount. Compared to highway I-35, this road had no congestion and might save travelers both time and money- depending on travelers' origin and destination, and the time of day they traveled. However, to travel the entire length of SH 130 was over 49 miles plus over 7 miles on FM 1327 (soon to be replaced by SH 45SE) while that segment of I-35 was only 42 miles. Therefore, attracting truck traffic to this road might prove difficult and incentives were going to be offered on SH 130.

Figure I-1.Texas Turnpike System

(Source: http://www.centraltexasturnpike.org/ctts/map.aspx).

1.2 Problem Statement

As a special type of road user, truck traffic significantly impacts the performance of a road in all aspects. Many studies have been conducted to examine auto travelers' route choices between toll roads and non-toll roads and also their reactions to incentives that encourage them to use toll roads. However, little research has been done on truckers' travel behavior with respect to toll roads. Thus a study on truckers' use of toll roads and their reactions to incentives on toll roads may yield beneficial knowledge.

Compared with autos, truckers face a greater tradeoff between travel time savings and toll cost when making their route decisions. On one hand, tolls are often higher for vehicles with three or more axles; on the other hand, travel time savings for trucks can be much more valuable than for autos. This tradeoff makes the estimation of truckers' route decisions more challenging and it is imperative to understand how the truckers would weigh their time savings and monetary costs for a trip.

Furthermore, incentives may be considered to be applied on toll roads. The potential impact of the incentives on trucks is worth in depth research since truckers' route choices may change under the application of incentives. Especially when the price-related incentives are provided, the reduced price might make truckers revise their decisions by reassessing the benefits and costs of driving on the toll roads. A better understanding of truckers' travel behavior response to incentives will be very beneficial for future incentive plans.

Additionally, the same incentive will not influence different individuals identically. Plus the same individual may react differently to the same incentive on any given trip. This makes prediction of toll road and incentive performance even more complicated. A group comparison is necessary to determine the different level of preferences for different incentives by type of truckers. Factors impacting truckers' route decisions should be analyzed in depth to provide insight into any reasons for the discrepancy among truckers.

1.3 Research Objective

With the motivation of obtaining a better understanding of truckers' travel behavior regarding toll roads and examining the potential effectiveness of possible incentives for the policy makers to make a good strategy, the objectives of this study included:

- Examine various characteristics of trucks who will potentially use SH 130 by trucking industry group;
- Analyze the travel behavior of truckers and how different groups of the trucking industry make routing decisions;
- Evaluate how various incentives, especially monetary incentives would affect truck route decisions.

To accomplish these objectives, a survey of truckers was conducted. The responses to the survey were examined by trucking group. Then a travel demand model was estimated, with the value of travel time savings calculated and route choice simulation conducted.

1.4 Thesis Organization

This thesis is composed of five chapters. In Chapter I, background information on SH 130 is presented, followed by the research problem and the research objectives. In Chapter II, literature related to the trucking industry, the performance of previous of toll roads and incentives, and also the related statistic methodology and applications of discrete choice model techniques are presented. In Chapter III, survey administration and methods of data collection, reduction, and analysis are described. In Chapter IV, characteristics of different trucking industry groups are summarized. Truckers' preferences towards toll roads and incentives are then analyzed and explained by groups. Truckers' route choice decisions, their value of travel time savings (VTTS); and the impacts of incentives on truckers' route decisions are then analyzed. Additionally, the influences of relatively significant characteristics on trucks use of the toll road are described. In Chapter V, a brief summary of the main contents of this study, followed by the results and findings is available. Finally, the recommendations for the future research in the truck use of toll roads are provided.

CHAPTER II

LITERATURE REVIEW

In this chapter, literature related to the use of toll roads by trucks and incentives on toll roads are studied. The first section provides a general picture of the application of the toll roads and fundamental characteristics of trucking industry groups. The second section provides an introduction to truckers' value of travel time savings (VTTS) and factors affecting truckers' VTTS. Next, the impacts of value pricing and other incentives on truck use of existing toll facilities are provided. The last section includes the statistical analysis theory and the discrete choice modeling techniques used in this research.

2.1 An Introduction of Trucking Industry

2.1.1 Trends of Toll Roads

Toll roads have a long history in the US. Early in the nineteenth century, between 2500 and 3200 companies financed, built and operated their toll roads successfully (Klein, D.B., Clara, S., and Majewski, J. 2008). Private road building was prolific during that period of time. During 1850's, thousands of miles of roads were operated by private turnpike companies in most of the states (Heminger 2005). By the 1920's, freeway construction was getting underway with the help of the federal government (Sarmiento, accessed 2009). Charles M. Noble (1941) introduced the feasibility and advantage of using toll roads. Based on an estimate in 1937, $3.7 was required for state system construction and maintenance. To meet the shortfalls in highway budgets and also relieve the intense highway congestion, the first government-owned toll highways opened in several states, such as Pennsylvania and Massachusetts, between the late 1930s and early 1950s (McNichol 2003; Aronott 2005). In the 1950's, the Federal-Aid Highway Act provided funding to construct the interstate system by running a fuel tax-based financing mechanism (Heminger 2005). However, during the 1980s, states started facility-based toll authorities to supplement their interstate highway capacity. In the 1990s, toll-based congestion pricing and high occupancy toll (HOT) lanes were authorized and used in several states, such as Texas, California and Minnesota. The federal government is encouraging further investigation and implementation of toll roads as a means of obtaining funding as well as expending capacity for highways.

Additionally, trucks generally cause more traffic congestion and also pay higher tolls to use toll roads when compared to automobiles. Therefore, estimating truck demand on toll roads was very important.

2.1.2 Characteristics of the Trucking Industry

The trucking industry has been experiencing intense competition, especially for the large number of small truck operators. According to ICF Consulting (2003), 40000 out of 53000 Truck Load firms were very small businesses, which have resulted in perfect competition among them. The intense competition resulted in low prices from customers and has resulted in a low profit margin in the trucking industry (see Figure II-1).

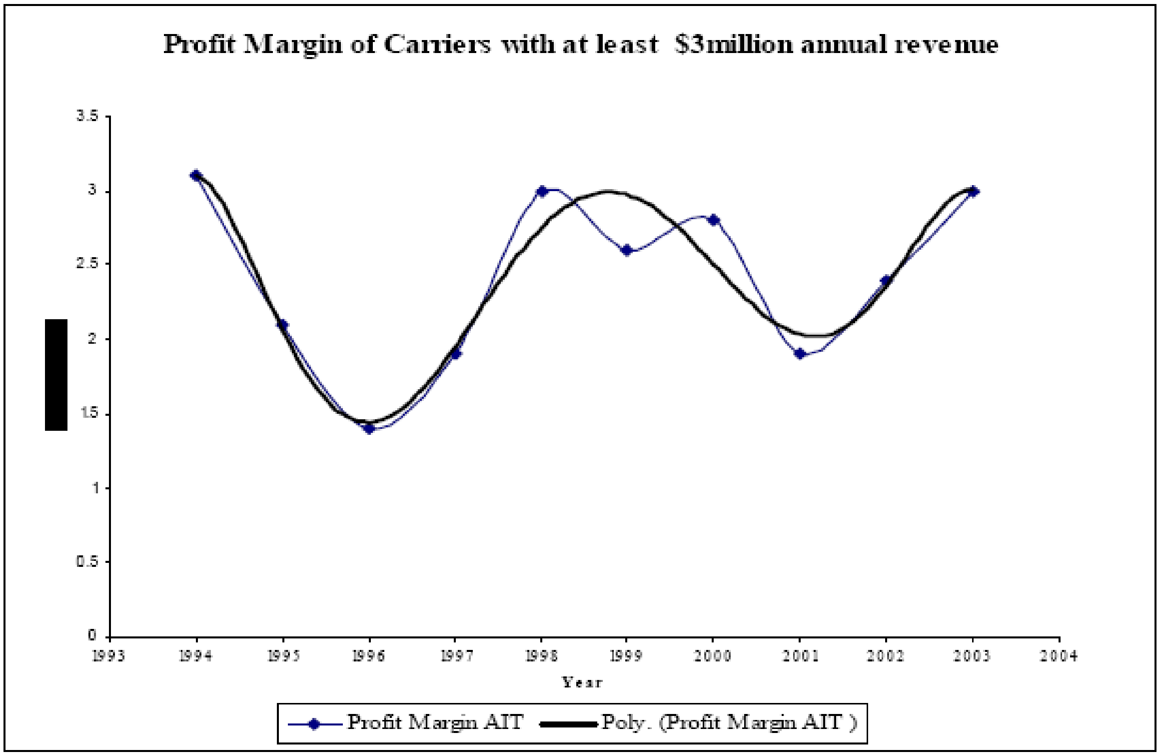

Figure II-1. Profit Margin of Carriers

(Source: American Trucking Trends, 2005 AIT: After Interest and Taxes)

Under the pressure of a tight profit margin, truck operators made efforts to avoid extra costs, such as using toll facilities. On the other hand, the competition among truckers and low benefits also urged them to find the most cost-efficient way to travel. With this in mind, regarding using the toll facility as a pure expense would be myopic. At the very least, truckers should examine the trade-off between cost and time. To seek a better understanding of truck use of toll roads, an in-depth analysis of the trucker route decisions should be conducted.

2.1.2.1 Truck Classifications and Characteristics

Prior to a discussion of the literature, it is important to understand that different groups of truckers do not react to toll roads and any incentives identically. Even truckers serving in the same company, according to their trip patterns, cargos and other factors, could make different route decisions. There were many criteria for truck classification (Geiselbrecht et al. 2008). Examples are listed below, by the classification used in the survey conducted as part of this research.

According to the size of the business, truckers can be divided into following groups:

- Owner operator
- Larger firm
    - Truck Load (TL)
    - Less than Truck Load (LTL)
    - Company (e.g. HEB)
    - Trucking Firm (e.g. Yellow, HB Hunt)

Ownership is another method to classify truckers. The following categories can be used:

- Private
- For-Hire (Common) Carrier
- Contract Carrier
- Both contract and for hire

The current version of the Trucking Research Committee's Trucking 101 document split the industry into several groups:

- Truckload. (Generally one shipper fills the truck with goods for one destination. This group can be broken further into regional deliveries or long haul [more than 500 miles].)
- Less than truckload. (Generally several shippers fill one trailer with goods. This group can be broken further into regional deliveries or long haul [more than 500 miles].)
- Private. (Generally the truck is owned by the company shipping the goods. A subset might include contract carriers. These are owner-operators who are under contact to carry goods for the shipper.)
- Hazmat and other specialized (another broad and diverse group).
- Express (next day)
- Agricultural and food

Based on the literature, previous trucking surveys, and the interview on trucking company representatives, the survey conducted as part of this research divided truckers as follows:

- Owner-Operator
- For-hire Truck-Load Carrier(such as Koch Logistics, Con-Way)
- Private carriage (private carrier, truck is owned by the same company that owns the freight, such as HEB)

- Less-than truck-load (terminal to terminal)
- Local delivery (such as Federal Express)

Since travel behavior of groups of truckers was partially determined by their characteristics, information about the characteristics of different truck groups was examined. Owner-Operators were considered “price-takers” (Geiselbrecht et al. 2008). Any costs incurred during the transport were the responsibility of the carrier. Therefore, toll costs came directly out of any potential profits from the load. As a result, they generally avoided toll roads. Conversely, for-hire truckers were more constrained by customers. They often would make their decisions based on a cost-benefit assessment (Vadali et al. 2007). Private carriers, working for a single customer, had “highest utilization, predicable route and mileage” (Vadali et al. 2007). The high service provision was determined by the company-objective driven nature of this group. Also the toll was often paid by the companies. All of these led to higher willingness to pay for the travel time savings of this group of truckers (Vadali et al. 2007). Less than Truck Load (LTL) operation was identified as “multiple shipments from more than one shipper using a network of terminals with local pick-up and delivery by smaller trucks” (Vadali et al. 2007). It should follow timely coordination and the toll was often paid by the companies. They might consider using toll roads to avoid congestion if the toll road could enhance the time reliability of their delivery.

2.1.2.2 Factors Affecting Truck Route Decision

Vadali et al. (2007) provided a summary of those factors affecting truckers' route choices (see Table II-1) based on previous studies. As shown in Table II-1, routing decisions were based on many factors, such as route attributes, level of congestion, toll, fuel cost, travel time (reliability/uncertainty), speed and vehicle operating costs. According to the summary, travel time (reliability/ uncertainty) was the most significant factor that might affect truckers' route choices. Therefore, if using a route could lead to reliable delivery time for the truckers, they might be more likely to use it. Other relatively frequently mentioned factors impacting truckers' route choices included: congestion, speed, route attributes (e.g. length) and fuel costs.

Table II-1. Factors Affecting Route Choice of Trucking Companies

	Knorring et al (2005)	*Golob & Regan (2001)*	*Bain (2002)*	*Alver et al (2006)*	*Zyl and Raza (2006)*
Region	U.S.	Los Angeles, CA	International experience	Japan	India, South Africa
	Interstate versus a Bypass	*Freight congestion perceptions*	*Traffic Risk*	*Social Experiment of Toll discount*	*Value of Time*
User Group relevant to this study	Long Haul Truck drivers		Trucks	Freight and production companies	
Driver's decision				√	√
Manager's decision					√
Driver wage/income			√		
Route attributes (e.g. Length)	√				√
Congestion		√			√
Toll					√
Fuel cost		√			√
Speed	√	√			
Travel Time (Reliability/Uncertainty)		√		√	√
Vehicle Operating costs			√		

(Source: Vadali et al., 2007)

Congestion and speed were the factors directly related to truckers' travel efficiency. Little congestion and high speeds meant shorter travel times, which was the biggest concern of truckers. A revealed preference study using GPS data was undertaken to determine the influence of actual and perceived travel speeds on truck route choice (Knorring et al. 2006). It was found drivers made their route choices to obtain the minimum travel time based on their perception of driving conditions.

One reason for truckers' concern regarding travel time were the regulations regarding truckers' maximum travel hours, set by U.S. Department of Transportation, Federal Motor Carrier Division's Hours of Service Regulations. The rules of the maximum number of hours a trucker might drive (Federal Motor Carrier Safety Administration 2005) included:

- Can drive a maximum of 11 hours after 10 consecutive hours off duty
- May not drive beyond the 14^{th} hour after coming on duty after 10 hours off
- May not drive after 60/70 hours on duty in 7/8 consecutive days

Regarding this regulation, getting to the destination using the shortest time could allow truckers to make more deliveries within the limited time they can spend driving. Also, truckers might change their time of delivery in order to avoid congestion. For instance, long-haul truckers would probably avoid peak traveling periods in cities if possible, especially when considering this rule (Geiselbrecht et al. 2008).

Another significant factor impacting truckers' route choice was trip length. Truckers' route choice between a downtown route and a bypass often involved a tradeoff between length of route and level of congestion (Knorring et al. 2006). Compared with the bypass, the downtown route was usually the shortest path. However, it often carried a heavier traffic load. This research found that truckers generally knew the length of both the downtown and bypass routes, but did not have knowledge of traffic conditions on each route. Truckers would make a tradeoff between trip length and speed based on their perception of downtown driving conditions. By assuming the truckers' goal was to achieve the shortest travel time, it was estimated 50 percent of truckers would move to the bypass when the speed on the through route dropped from 65 mph to 50 mph. As a result, in 83.4 percent of the cases, truckers would choose the through route. In Houston and San Antonio, this percentage was 81.4.

Based on the results of a truck route decision survey regarding toll roads, the impacts of the various factors were also quantified (Vadali et al. 2007). In their survey, factors were ranked from 1 to 5 according to their importance to truckers (see Figure II-2).

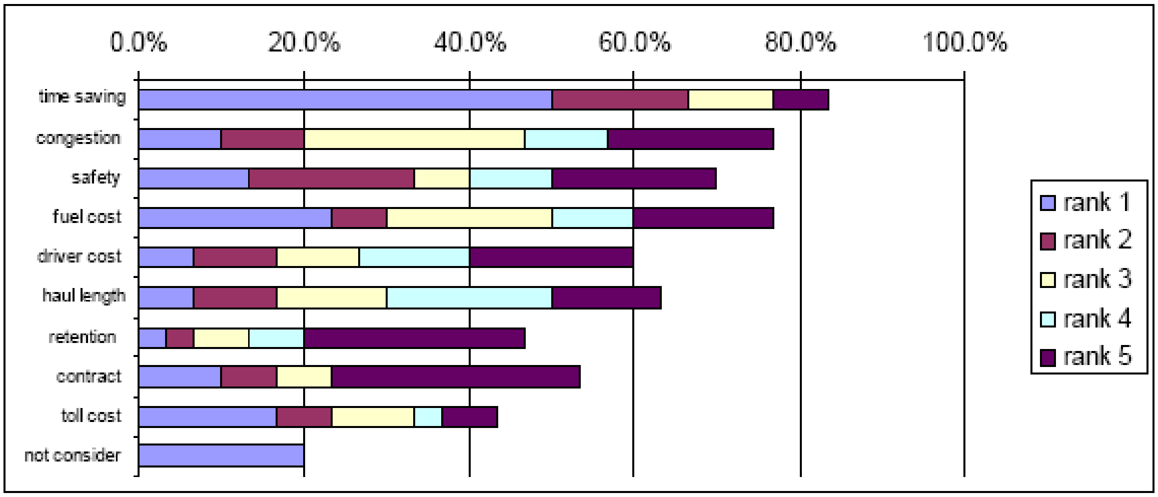

Figure II-2. Factor's Importance on Toll Road Usage

(Resource: Vadali et al. 2007)

Vadali et al. (2007) concluded when a toll road was involved, the three most important factors (determined by the percentage of Rank 1) that affected truckers' route choice were travel time savings (almost 50 percent), fuel cost (around 25 percent), and toll cost.

In the situation of a tolled bypass, the toll was the most important factor (Vadali et al. 2007). One of the key tradeoffs when making the choice between tolled and non-tolled route was the amount of toll versus the travel time savings. Truckers had to make a choice between an uncongested toll road and a free road that required additional travel time. How they made their decision was determined by the toll price, the travel time savings and the truckers' value of travel time savings (VTTS), a reflection of their willingness to pay for the saved time.

2.2 Value of Travel Time Saving (VTTS) for Trucks

As indicated in the previous section, the value of travel time savings would be a key variable in truck use of toll roads. When considering the building of a toll road, policy makers must estimate how truckers value their travel time savings in terms of money. Only then could they make a proper and effective price policy.

2.2.1 Cost of Truck Operation

A truck's value of time, which is also called value of travel time savings, should be evaluated with a comprehensive investigation of other costs of truck operations. Data on trucking costs were found (see Table II-2) in the components of operating cost American Trucking Trends report 2005-2006 (American Trucking Association 2006, see Table II-2).

Table II-2. Components of Operating Cost

Cost In Cents Per Mile (American Trucking Trends)		
	2001	2003
Driver Wages	39	55
Fuel And Fuel Taxes	17.3	20
Outside Maintenance	5.7	7
Tax And License	3	3
Tires	1.9	2
Other Wages And Benefits	46.5	80
Equipment Rents	56.1	65
Depreciation	9.9	11
Insurance	6.4	9
Miscellaneous	21.3	28
Total Cost	207.1	280

Cost Components for US Intra Region Case Studies (Operating Costs in Canada) (2005)	
Driver	36
Fuel	18
Administration	14
Equipment Ownership	12
Repairs	7
Insurance	3
Tires	2
Miscellaneous	3

(Source: American Trucking Trends 2005-06)

Based on the costs estimated in previous studies, and the inflation rate provided by the Consumer Price Index (CPI) website (2008) <http://www.bls.gov/CPI/>, a new cost estimate was made in this research (see Table II-3). These costs were developed as follows:

Table II-3. Compilation of Truck Operating Costs

Cost in Dollars Per Mile		
Fixed costs	Depreciation	0.15
	Interest	0.12
	Tax And License	0.03
	Insurance	0.11
	Admin, sundry	0.03
Running	Fuel and Fuel Taxes	0.64
	Outside Maintenance	0.10
	Tires	0.03
Wages	Driver Wages	0.64
	Other wages (relief driver, on costs, Uniforms)	0.15
Total		2.00

- Fuel costs ($0.64/mile)

According to Barnes and Langworthy (2004), trucks fuel use is approximately seven miles to the gallon. The price of diesel was $4.50/gallon during the time this research was conducted (Energy Information Administration website, August 2008). So the cost of fuel was about $0.64/ mile. Freightfox website (2008) calculated costs for a 44-tonne-gross 6×2 tractor as $0.70/mile. Since these are larger trucks, more common trucks' costs should be lower, indicating that $0.64/mile was reasonable for common trucks.

- Driver wages ($0.64/mile)

According to Vadali et al. (2007), driver wages were the largest expense of trucking companies. However, the recent increase in fuel price caused fuel cost to catch up with wages. By using an inflation rate of 3%, driver wages were calculated as $0.64/mile based on 2003 results in the American Trucking Trends 2005-6 (American Trucking Association, 2006).

According to a presentation of SKM Inc., "Truck Operating Costs Outlook – Major Cause for Concern" (2008), driver wages made up 29.3 percent of operating costs. This was very similar to the proportion of operating costs that were represented by the fuel price, which was 29.8 percent. Based on the fuel and wage costs above, both of these indicated an operating cost slightly above $2.00/mile.

- Tax and license ($0.03/mile)

According to Mark Berwick (1997) and American Trucking Trends 2005-6 (American Trucking Association, 2006), the taxing and licensing portion of truck operating costs had not changed in recent years. It remained steady at $0.03/mile.

- Outside maintenance ($0.10/mile)

According to Barnes and Langworthy (2004), maintenance cost was $0.105/mile. The Freightfox website calculated Costs for a 44-tonne-gross 6×2 tractor as $0.1066/mile. That was the price for large vehicles, which was slightly higher than common ones. Based on 2001 and 2003 results from American Trucking Trends 2005-6 (American Trucking Association 2006), the maintenance cost was calculated as $0.106/mile for the 2007-2008 estimation. According to SKM Inc. (2008), fuel costs represented 29.8 percent of total cost, lubricants 1.5 percent and Maintenance 3.0 percent. The latter two together could be considered maintenance costs. Therefore, if fuel cost was \$0.64/mile, then maintenance cost was approximately \$0.097/mile (\$0.64/mile × 4.5 percent ÷ 29.8 percent).

- Tires (\$0.04/mile)

According to Barnes and Langworthy (2004), tires cost around \$0.021 to \$0.04/mile, so researchers averaged this to obtain a value of \$0.035/mile. The Freightfox website (accessed August 2008) calculated costs for a 44-tonne-gross 6×2 tractor as \$0.045/mile, higher than for common trucks.

- Depreciation (\$0.15/mile)

Based on 2001 and 2003 results from American Trucking Trends (\$0.099/mile in 2001, \$0.11/mile in 2003), the depreciation should be \$0.14 cents/mile in 2007-2008. The Freightfox website calculated wages four times as much as depreciation. Depreciation would be estimated as \$0.16 mile based on that ratio. According to SKM Inc. (2008), fuel cost represented 29.8 percent of total cost, and depreciation was approximately 8.7 percent of the total cost. Based on this ratio and fuel costs of \$0.64/mile, depreciation would be \$0.19/mile. Based on all of these estimates of depreciation, researchers estimated depreciation as \$0.15/mile.

- Insurance (\$0.11/mile), interest (\$0.128 /mile), admin, sundry (\$0.03/mile) and other wages (\$0.15/ mile)

There was not enough information on these items, and the available information varied greatly, depending on insurance companies and locations. It was the same situation with administration fees and other expenses. As a result, all of these were calculated based on the present cost index in SKM Inc. (2008) and the fuel cost, which was an accurate and reasonable standard to base other costs on.

Another cost that should also be considered when examining truck operation cost on the toll roads was the cost at toll plazas. Travel time might be increased because of the queue at toll plazas especially when the toll plaza had a relatively low capacity and level of service (Woo and Hoel 1991). This delay could also increase other costs, such as an increase in fuel use and a potential increase in accidents. However, trucks on SH 130 could use either electronic toll collection (ETC) or video tolling (VT) to travel through the toll plazas at highway speeds. Using ETC or VT eliminated these extra costs for truckers.

2.2.2 Estimation of VTTS

Based on the analysis of route choice decisions by long-haul truck drivers, Knorring, He, and Kornhauser (2006) concluded that time was a significant factor in the decision-making process. Truck drivers were generally time minimizers. They supposed that truck drivers usually did not just take a chance on which route to take when facing parallel routes. Instead, they made route decision based on their perception of each route. The biggest consideration was time. Thus, the value of travelers' time became the most reliable factor that could be referred to when making a price policy.

VTTS was estimated frequently by many departments of transportation. Kawamura (2000) estimated VTTS for trucks from stated preference data collected in California. That study first summarized that VTTS ranged from $14.50/hour to $35.60/hour for trucks according to the results of previous studies. Then, based on their own stated preference data, Kawamura estimated the distribution of truckers' VTTS. The mean VTTS was found as $ 26.8/hour. With the VTTS rising, the percentage of truckers who used the toll road decreased. A very small percentage of truckers would have very high VTTS (see Figure II-3).

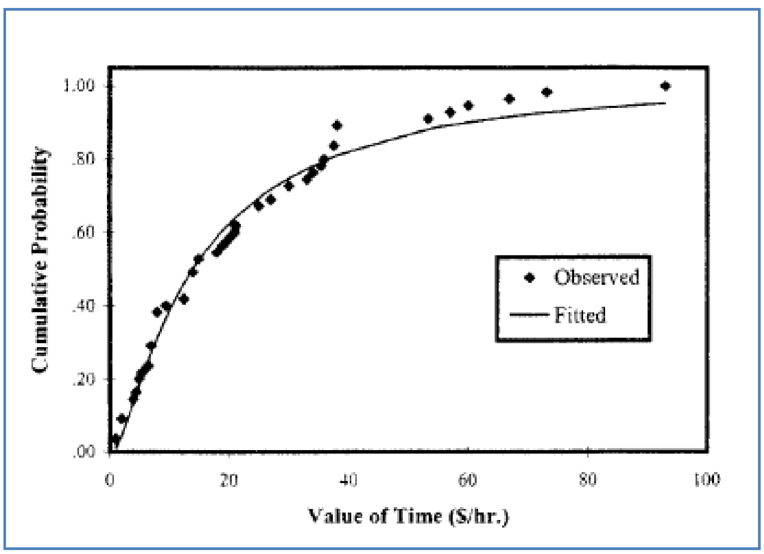

Figure II-3. VTTS for Truck Operators (Kawamura, 2000)

2.2.3 Factors Affecting VTTS

Several stated preference studies have been conducted to estimate the VTTS for truckers. At least two categories of truckers were used in those studies: private carriers and for-hire. Some studies further divided these categories by shipment type. The VTTS ranged considerably in these studies with typical results around $30 per hour (Geiselbrecht et al. 2008). According to the findings of those studies, distribution of VTTS was skewed as many respondents had low VTTS, and conversely a few had extremely high VTTS.

Literature on VTTS of commercial vehicles offered typical factors which determined route choice. Some of these route choice factors which effected VTTS included length of haul, travel time/reliability, income, road condition, income group, travel condition, market segmentation (by axle type) and freight characteristics (Vadali et al. 2007).

They concluded significant variability existed in the VTTS of different trucking groups. These groups could be separated by type of ownership (Private/ For-Hire/ Owner Operator), the type of load, the length of the haul (long/short), the value of cargo transported, logistic practices and also compensation structure. For instance, private carriers would be willing to pay $3.94 for 15 minutes travel time saving on an average, while for-hire carriers $3. Another example was: since LTL carriers had particular requirement of time coordination, they might have higher VTTS than TL carriers. Hense, the VTTS of commercial trucks is a very complex function with both observed (e.g.

freight characteristics, ownership) and unobserved variables (e.g. reliability) involved (Vadali et al. 2007).

Fright category was also a significant factor that influenced VTTS. Zyl and Raza (2006) found that low and high value loads resulted in very different VTTS. Higher VTTS existed in time-sensitive / high value goods such as perishable and manufactured goods relative to non-time sensitive / low value goods, such as bulk commodities. The average labor cost of truck drivers was recommended to be converted into a reasonable approximation of VTTS when considering the non time-sensitive cargo. However, a premium should be added into the carriers' perceived VTTS in the situation of transporting the time-sensitive goods.

VTTS with respect to different types of cargo was estimated in a study on travel time benefits by respondent cargo type (Vadali et al. 2007). As is shown in Figure II-4, expedited service earned the highest benefit from the time saved, followed by hazmat, oversized and perishable cargos (see Figure II-4). All of these cargos led to relatively high travel time benefit when compared to other cargos. As a result, higher value of travel time savings would be expected for the truckers transporting these cargos.

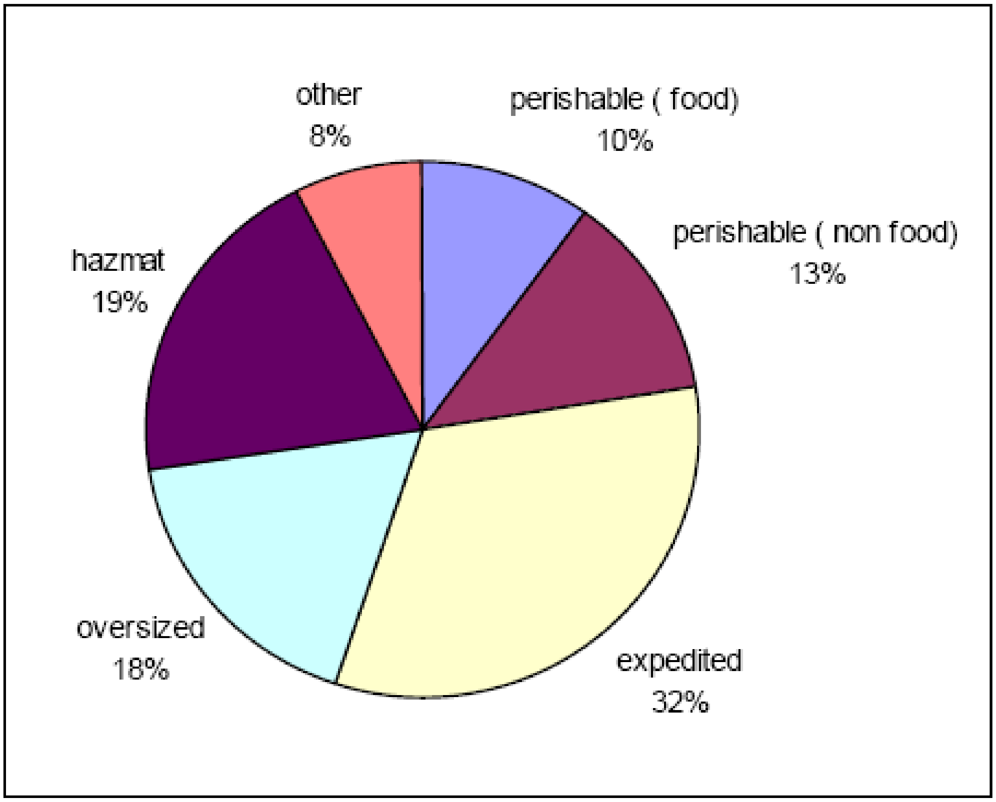

Figure II-4. Travel Time Benefit by Respondent Cargo Type

(Resource: Vadali et al. 2007)

Differences in VTTS among different types of trip patterns and operators were quantified by Kawamura (2000). He calculated the VTTS of private versus for-hire truckers and also truck load (TL) and less than truck load (LTL) truckers. Kawamura finally presented the results in Figure II-5 and II-6.

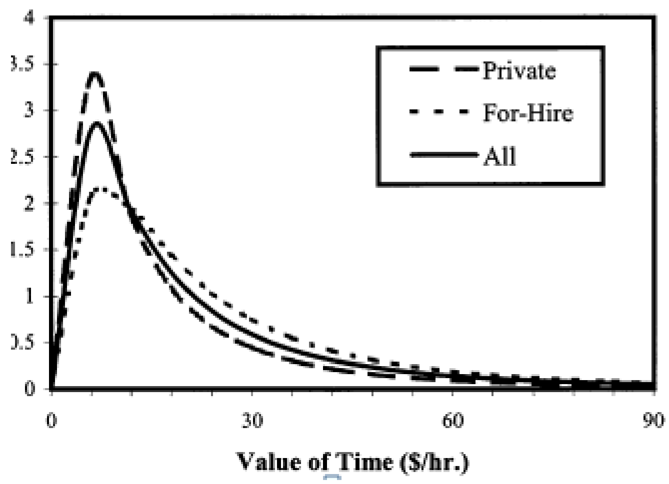

Figure II-5. VTTS for Private and For-hire Truckers

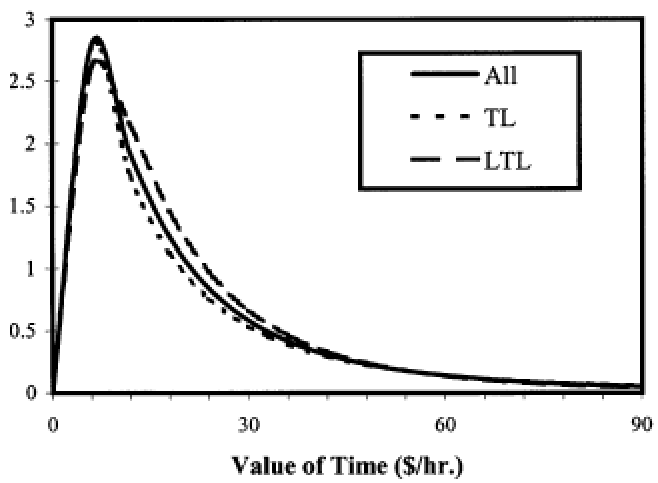

Figure II-6. VTTS for TL and LTL Truckers

According to Kawamura's results, private truckers had steeper slope than for-hire truckers. The VTTS of private truckers were more likely to concentrate around $12 while the VTTS of for-hire truckers were evenly spread in a large range. Therefore, for-hire fleets had higher VTTS than private fleets. The difference of truck load and less than truck load truckers was not very big, while VTTS for LTL was still a little higher.

According to the literature, truckers who have higher VTTS are more likely to use toll roads. Truckers' VTTS are impacted by several factors, such as type of cargo and trip pattern. Compared to private truckers, for-hire truckers exhibited higher VTTS, therefore are more likely to use toll roads.

2.3 Performance of Value Pricing and Other Incentives

Toll roads have tried various incentives to attract traffic, including trucks. One example is variable pricing implemented in Lee County, Florida. Under the policy, travelers using the Midpoint and Cape Coral toll bridges during shoulder periods of 6:30 a.m. to 7:00 a.m., 9:00 a.m. to11:00 a.m., 2:00 p.m. to 4:00 p.m. and 6:30 p.m. to 7:00 p.m. could enjoy a 50 percent discount if they paid their toll electrically. This policy was very successful for two-axle vehicles (Burris 2001). A significant percentage of travelers switched their travel time from peak hours to the off-peak ones when they were eligible to have the discount. However, not every price strategy will work as well. Especially for trucks, the effectiveness of the incentives is low. In Lee County (CRSPE 2004), a 29-question survey was distributed to 955 businesses with three-or-more axle vehicles. The survey results showed even though half-price toll discount could be obtained by adjusting truck routes and/or times, only 1.71 percent of companies indicated they frequently made the adjustment, 6.84 percent replied that they did occasionally, while 36.75 percent of trucks indicated that they never adjusted routes or times to obtain toll discounts, since they were customer driven and did not actually have many options.

2.3.1 Trucks' Demand Elasticity to Toll Discounts

Also in Florida (1996), a Florida's turnpike lowered its toll rate in order to sway trucks from a parallel non-toll road. Unfortunately, the 33 percent price reduction resulted in no measurable change in truck travel, since trucks preferred the shortest path, I-95.

The Ohio Turnpike (2005) decreased its toll rate by 27 percent in order to lure trucks from a parallel non-tolled road to the Ohio Turnpike, however, truck traffic increased only by four percent, an elasticity of -0.148.

The Port Authority of New York and New Jersey (PANYNJ) operated an innovative toll project when the six river crossings (George Washington Bridge, Lincoln Tunnel, Holland Tunnel, Goethals Bridge, Outerbridge Crossing, and Bayonne Bridge) between New York and New Jersey suffered from a heavy eastbound traffic volume of 352,000 vehicles (Ozbay et al. 2006).Trucks were tolled $4.00 per axle when traveling eastbound. However, if the toll was paid with an E-ZPass, the toll was $3.60 per axle. The use of E-ZPass was also a method to offer drivers discounts. However, the variable pricing study conducted for this project concluded price had small impact on travel patterns. It was found although 20.2 percent of the survey carriers changed their behavior after the variable pricing, almost half of them just reacted by charging their receivers more and only a very small proportion of commercial carriers changed their time of delivery to off-peak periods because of the variable toll (Holguin-Veras 2005).

A Georgia study showed that delivery times based on shipper or manufacture requirements were not likely to be rescheduled because of tolls. This study (Short 2007) showed that it was the pressure from shippers' requirement of delivery times that forced the Georgia carriers to make a trip during peak hours. As a result, the effort of adjusting the time that trucks traveled by giving off-peak discount might not lead to a great deal of improvement in switching truckers' travel schedule.

From the cases listed above, it can be concluded that elasticity of demand was generally very small, 0.086 in Massachusetts, -0.09 in New Jersey (Wilbur Smith Associates 1995) and -0.15 in Ohio (Stiener 2007). These low elasticities, coupled with Florida's Turnpike results, indicated it might take huge toll price reductions to attract significant number of trucks to a toll road. Due to the revenue losses related to this, we examined other potential incentives in this research.

Furthermore, any motivation policy or strategy developed without detailed analysis of how the truck drivers would react would be an arbitrary decision that could end in poor results. Since different groups of truck travelers have different characteristics, they might show completely different attitudes towards the same incentive. To reliably predict their reactions and develop proper policies for each target group, it is necessary to make a group comparison based on truckers' characteristics.

2.3.2 Truckers' Reactions to Incentives by Group

Depending on the type of trucks they drive, truckers displayed different characteristics and travel behavior. Research was done to compare different groups of truck drivers. Vadali et al. (2007) compared for-hire and private carriers. They found for-hire carriers were more likely to avoid using toll roads when compared to private carriers, since for the private carriers, toll costs were built into their contracts. Driver retention was more significant for the for-hire carriers. When taking consumption of fuel into consideration, private carriers were more likely to give a higher ranking to fuel costs than the for-hire ones. They might make a cost-benefit analysis with greater attention on fuel costs when determining the route.

Holguín-Veras, Ozbay, and Cerreño (2005) found that on average private carriers made more trips (42.3 percent) during off-peak an overnight hours than for-hire carriers (23.8 percent) in New York and New Jersey. He explained that for the for-hire carriers, customer requirements were usually the key reason for their travel. They were constrained by schedule and had less flexibility on the time. On the other hand, they were less sensitive to tolls because arriving on time at the destination was their goal and their tolls were often paid by customers.

Unfortunately, using other innovative incentives to enhance toll road usage is a new concept and not many examples are available. A very limited number of first-hand studies are available. Additionally, characteristics of truck drivers can be different and are influenced by the local situation. There should be an investigation of the target truckers under analysis before development of a wide-scale survey. Therefore, during the development of the survey studied in this research, interviews with industry representatives were conducted. According to the interview results, the most attractive incentives to use the toll road were the ones related with cost reduction. Company-owned shipping operations and independent owner-operators exhibited completely different attitudes towards SH 130 and its incentives. Some factors were particularly noteworthy that might have a large impact on the use of SH 130 and its incentives and they were discussed in this study.

2.4 Statistic Techniques for Group Comparison

Chi-square tests and Kruskal-Wallis tests (K-W test) were widely used to examine the significant difference among study groups (Field 2009). Burris and Lanan (2005) used both Kruskal-Wallis tests and chi-squared tests to compare the ordinal data and nominal data from a survey. The null-hypothesis was stated that there was no significant response variation across groups. By conducting the statistic analysis, distinctions among different groups can be found providing some hint at the unique characteristics of each certain group. According to Montgomery and Runger (2006), ANOVA test could be used to test the variation among the means.

2.4.1 Chi-square Test

The chi-square test is used to examine the difference between groups for nominal data. Five groups were evaluated in this study. Nominal data represents categories without intrinsic ranking (SPSS Help file). In this research, most values were nominal except for the number of trucks owned by the carriers and the rate of the incentives.

To make a group comparison based on Chi-square tests, Montgomery and Runger (2006) used a contingency table. According to their explanation, since a population can be classified by two criteria, a contingency table can be developed. In this table, the columns and the rows stand for the categories divided by the two different criteria. By conducting the Chi-square test, the hypothesis that "the row-and column methods of classification are independent" can be examined (Montgomery and Runger 2006).

$$\chi_0^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{(O_{ij} - E_{ij})^2}{E_{ij}} \tag{II-1}$$

where,

r = number of rows

c = number of columns

E = expected frequencies (if the row and column categories are independent)

O = observed frequencies

If $\chi_0^2 > \chi_{0.05,2}^2$, the hypothesis of independence was rejected. The two classifications have interactions. Take the truck survey data as an example, the row categories included the responses to survey questions, such as long haul or short haul; while the columns were the groups of truckers, such as owner-operator or for-hire truckers. If the two methods of classification are not independent, it means the type of trip truckers made (long haul or short haul) was significantly different based on the group of trucker. The characteristics of the truckers (such as types of trips) were examined for significant differences.

2.4.2 Kruskal-Wallis Test

The Kruskal-Wallis (K-W) test is used to examine the difference among nominal results with respect to the categories. The difference between the K-W test and chi-square test is that the K-W test can be used to analyze ordinal data. The ordinal variable represents the categories with some intrinsic ranking (SPSS Help file, accessed 2008). In this study, the only item that had an intrinsic ranking was the number of trucks. Since the numbers were ranked from high to low, the number is not merely a symbol of type or classification but offers the information about the levels.

In SPSS, the output shows the number of valid cases and the mean rank of the variable in each group in the ranks table. The output also shows the chi-square, degrees of freedom, and probability in the Test Statistics table. The interpretation of these results is similar to chi-square test mentioned above.

2.4.3 One-way ANOVA

According SPSS help file (2008), the one-way ANOVA, as an extension of the two-sample t test, is a statistical technique that produces a one-way analysis of variance for a quantitative dependent variable by a single factor (independent) variable.

Analysis of variance is used to examine the null hypothesis that several means are equal. (SPSS help file, 2008) Those means can be calculated from ordinal or scale data. A requirement of the factor variables is that the factor variable values should be integer and the dependent variable should be quantitative (interval level of measurement).

2.5 Application of Discrete Choice Model

2.5.1 Introduction

Discrete choice models are innovative and useful tools for transportation demand forecasting. They can be applied to predict a decision maker's selection among a finite set of alternatives. The ultimate result of discrete choice modeling is to describe the decision making behavior of a group of individuals figure out the impacts of different attributes of alternatives and characteristics of decision makers (Koppelman et al. 2006). Discrete choices models can be used by transportation analysts to predict the commuters' use of different travel modes under different service conditions (Train 2003). There are three criteria for the use of discrete choice models:

- The alternative must be mutually exclusive to decision makers, which means choosing one alternative implies not choosing any other. There is only one alternative from the choice set that a decision maker can choice.
- The choice set must be exhaustive, which means all possible alternatives are included.
- The number of alternatives must be finite, which means the alternatives are countable and the counting will be accomplished.

2.5.2 Structure and Principles of a Logit Model

The structure and basic equation is:

$$U_{i,n} = V_{i,n} + \varepsilon_{i,n}. \qquad \text{(II-2)}$$

where,

$U_{i,n}$ = utility of an alternative *i* to an individual *n*;

$V_{i,n}$ = deterministic component $V_{i,n}$, which included the variables of the alternative attributes component V_i and the decision-maker characteristics component V_n;

$\varepsilon_{i,n}$ = a random component.

The utility function can be expressed by this equation:

$$U_{i,n} = \beta_i X_i + \beta_n X_n + \varepsilon_{i,n} \qquad \text{(II-3)}$$

where,

$U_{i,n}$ = utility of an alternative i to an individual n;

i = the set of alternatives available to the individual;

X_i = a vector of measurable attributes of each travel alternative;

X_n = a vector of measurable characteristics of each individual;

β_i = a vector of the coefficients of Xi;

β_n = a vector of the coefficients of X_n; and

$\varepsilon_{i,n}$ = unobservable factors (random utility).

The probability that decision maker n chooses alternative I can be described as:

$$P_{i,n} = \frac{e^{\beta_i X_i + \beta_n X_n}}{\sum_{i=1}^{J} e^{\beta_i X_i + \beta_n X_n}}. \qquad \text{(II-4)}$$

In order to estimate the utility coefficients: β_i, maximum likelihood estimation (MLE) is used. This method was explained by Train (2003). According to the explanation: the probability of person n that chose the alternative that he was really observed to choose is:

$$\prod_i (P_{ni})^{y_{ni}} \qquad \text{(II-5)}$$

where,

y_{ni} =1 if person n chose i and zero otherwise.

Since y_{ni} =0 for all non-chosen alternatives and P_{ni} had the power of zero as 1, this term is simply the probability of choosing that alternative. And since it is assumed that each decision maker's choice is independent of all the other decision makers, the probability of each person in the sample choosing the alternative that he was observed really to choose is:

$$L(\beta)=\prod_{n=1}^{N}\prod_{i}(P_{ni})^{y_{ni}} \tag{II-6}$$

where,

β is a vector containing the parameters of the model.

In order to make it easier to calculate, the log likelihood function is applied:

$$LL(\beta)=\sum_{n=1}^{N}\sum_{i}y_{ni}\ln P_{ni} \tag{II-7}$$

To achieve the maximum probability that a person's observed choice really happen, the derivative of the function with respective to the parameters should be zero:

$$\frac{dLL(\beta)}{d\beta}=0 \tag{II-8}$$

The Alternative-specific constant (ASC) and other coefficients could be estimated in this way. The ASC is an important parameter for each alternative. It is the coefficient of a dummy variable which directly tells the effectiveness of one alternative. Usually, a positive ASC indicates a greater utility of that alternative, otherwise it would be negative.

2.5.3 Data for Discrete Choice Models

Train (2003) also provided detailed instructions on the data which should be used in the model. There are two types of data: revealed-preference and stated-preference data.

- Revealed preference data

Revealed preference data defined by Train is to describe peoples' choices in real-world situations. The most important benefit of this type of data is it provides the real choices of people. The limitation of this data is it can only reflect the situations that already exist or have happened previously. However, for some strategies that have never been taken into practice, if researchers want to know the people's reactions to a new product or policy, revealed preference data is not available any more. The limitation also occurs even for the existed choice scenarios, since the variation might be not enough to accomplish the estimation with revealed preference data.

- Stated preference data

Stated-preference data is designed with several created scenarios. Survey takers are asked about which option to choose if it really happens. The benefit of this type of question is sufficient variation can be achieved by assuming different scenarios, which overcomes =the real world limitation. Some now policy or methods that have been applied before can be estimated. The disadvantage of stated-preference data is people might not react in the same way in the real-world experience as they chose in the survey. Their actual choice might be influenced by many unpredictable factors.

When developing the model, it is important to combine the revealed and stated-preference data. The revealed preference data can provide a relatively accurate perception on the real world experience while stated preference data provided variations.

2.5.4 Types of Discrete Choice Model

(1) Standard Logit Model

The structure of standard logit model has been exhibited in the previous sections. The advantage of a standard logit model is that it is the easiest discrete choice model. However, there are some limitations of the standard logit model. The standard logit model supposes irrelevant alternatives are independent and proportionally substituted with each other, which is unrealistic (Train 2003). Advanced models should be applied to remove this problem.

(2) Nested Logit Model

Nested logit structure was applied to estimate the combined RP/SP model (Yalcin, A. et al. 2005). Independence of irrelevant alternatives (IIA) property implies "all pairs of alternatives are equally similar or dissimilar" (Hensher et al. 2005). That is equal to assume "for the unobserved attributes, all the information in the random components is identical in quantity and relationship between pairs of alternatives and hence across all alternatives". However, it is not a correct assumption, since in a realistic situation there might be some correlations among pairs of alternatives. The nested logit model is introduced to adjust the probability that correlation might exist among sub-sets of alternatives (Greene, W. H. 1998). The structure of nested logit model is shown in Figure II-7.

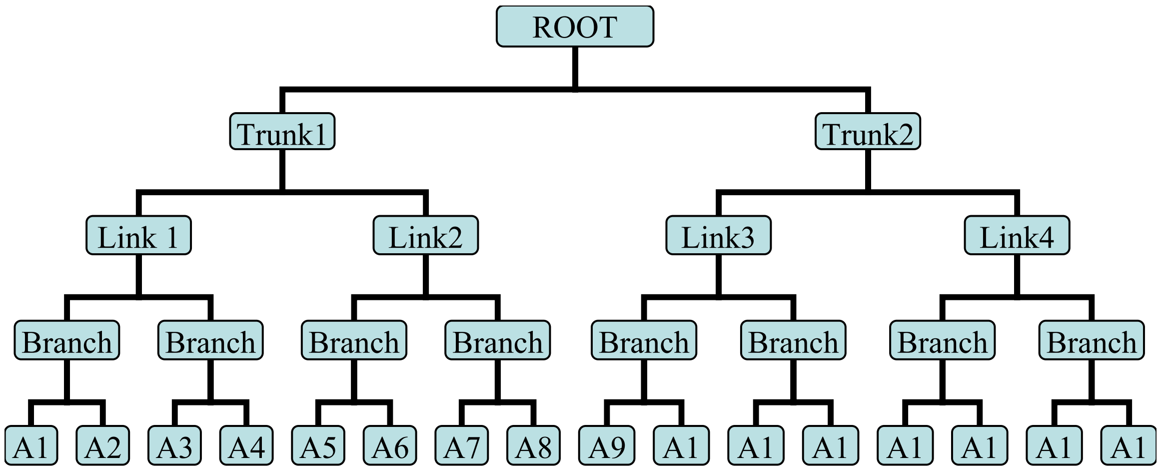

Figure II-7. Structure of Nested Logit Model
(Source: Greene, W.H. 1998)

By estimating the Nested logit model, people's actual travel behavior can be described more accurately.

(3) Random Parameter Logit Model

A random parameter logit model is used to present the variation among individuals. Since coefficients will be different for different individuals, the random coefficient estimated by the model will exhibit the variation among different individuals with similar characteristics for the same issue. The mean value among individuals will be found and the variance will be calculated (Greene, W.H. 1998). According to the manual, this type of model is similar to the random coefficients model for linear regression. The basic formulation is:

$$P(j/u_i) = \frac{\exp(a_{ji} + \theta_j' z_i + \phi_j' f_{ji} + \beta_{ji}' x_{ji})}{\sum_{j=1}^{J} \exp(\alpha_{ji} + \theta_j' z_i + \phi_j' f_{ji} + \beta_{ji}' x_{ji})} \tag{II-9}$$

where,

U (i,j) = $a_{ji} + \theta_j^{'} z_i + \phi_j^{'} f_{ji} + \beta_{ji}^{'} x_{ji}$, j= 1,…,$J_i$, alternatives in i's choice set;

α_{ji} is an alternative specific constant which may be fixed or random, α_J =0;

θ_j is a vector of fixed coefficients, θ_J =0;

ϕ_j is a vector of nonrandom (fixed) coefficients;

β_{ji} is a coefficient vector that is randomly distributed across individuals;

u_i enters β_{ji};

z_i is a set of choice invariant individual characteristics such as age or income;

f_{ji} is a vector of M individual and choice varying attributes of choices, multiplied by $\phi_j^{'}$; and

x_{ji} is vector of L individual and choice varying attributes of choices, multiplied by β_{ji}.

The choice specific constant a_{ji} and coefficient β_{ji} are distributed randomly across individuals. Their distributions can include normal or lognormal distributions.

$$\rho_{ki} = \alpha_{ji} \text{ or } \beta_{ji} = \gamma_k + \delta_k^{'} w_i + \sigma_k u_{ki} \qquad \text{(II-10)}$$

The two parameters, a_{ji} and β_{ji} are random and the structure parameters, γ_k, δ_k and σ_k are estimated. Since the parameters of distribution can be computed, the means of coefficients among individuals will be calculated (Greene, W.H. 1998).

In this chapter, literature was reviewed for all aspects of truck use of toll roads. Previous studies showed that some agencies tried to encourage the use of toll roads by trucks as a method of funding and congestion reduction. Truck use of a toll road by trucks played an important role in both and different groups of truckers exhibited different characteristics regarding the use of toll roads. Many factors could impact truckers' route decisions. Travel time saving was the biggest concern for truckers when planning their trips. Truckers' VTTS could be impacted by many factors, such as the type of cargo and the delivery window. Different groups of truckers had different VTTS, with for-hire truckers having higher VTTS and private truckers having lower VTTS.

Most previous value pricing projects resulted in very low toll road demand elasticities with respect to the reduced toll price. Basically, although the toll price was often reduced a great deal under certain incentives (for example, off-peak discount), few truckers adjusted their route or the time of day they traveled. Different groups of truckers showed different levels of interest in these incentives.

Chi-square, K-W tests and one-way ANOVA were the proper statistical methodologies to conduct group comparisons among different truck groups. These statistical tests had the capability to examine whether there was a significant difference among different groups of truckers. Discrete choices models were found to be the method for travel demand forecasting. Both revealed and stated preference data were needed for model estimation. Different types of models, such as the standard logit model, a nested logit model and the RPL model, were used based on the analysis to be conducted.

CHAPTER III

METHODOLOGY

In this chapter, details regarding the location of this study, the process of survey design and administration, data collection and management, and the method of analysis are provided. The first section briefly introduces the location of this study and also provides information about current tolls on SH 130. The second section includes detailed information regarding the survey design and administration. The next section includes the process of data collection and reduction. The final section, introduces the statistical techniques used for group comparisons and the discrete choice model for demand analysis.

3.1 Study Location

SH 130 is a toll road parallel to I-35 in Texas that opened in late 2006. This toll road extends from I-35 north of Georgetown southward to U.S. 183 southeast of Austin with interchanges at I-35, U.S. 79, SH 45 North, U.S. 290 and SH 71. SH 130 has a connection to all the important corridors on the north side of Austin and is expected to eventually carry a great deal of traffic. SH 45 SE will connect SH 130 to I-35 on the south and is scheduled to open in late 2008. It is important to note that this connection was not open during this research study and thus there was no direct freeway connection from SH 130 back to I-35 (see Figure I-1).

In November 2006, several toll roads in Austin (including SH 130 from I-35 to US290) opened without charging tolls. Tolls began in April 2007, at a rate of approximately 12.5 cents per mile for autos. Truck tolls were the auto (base) rate multiplied by the number of axles minus one. For example, a three-axle vehicle paid double the base of 12.5 cents/mile rate. TxTag customers (customers using an electronic toll transponder) enjoyed a ten percent discount. SH 130 (between US 290 and SH 71) opened in September 2007 as a non-tolled facility for the first two months of operation. Tolls were charged on non-TxTag holders from November 1, 2007, while TxTags holders began to be charged from December with a 50 percent discount in the first month and 10 percent discount in January 2008. SH 130 (from SH 71 to US 183) opened on April 30, 2008. It was toll free for all the users until July, 2008. Users without TxTag started to pay the toll in July, while TxTag holders began to pay from August. At the time of this study the toll was charged with a 50 percent discount.

Compared to highway I-35, this road has no congestion and may save travelers both time and money-depending on travelers' origins and destinations, and the time of day they travel. However, to travel the entire length of SH 130 is over 49 miles plus over 7 miles on FM 1327 (soon to be replaced by SH45se), while that segment of I-35 is only 42 miles. As a result, attracting truck traffic to this road may prove difficult.

3.2 Survey Development and Administration

3.2.1 Stakeholder Interview

During the process of the survey development, interviews were conducted with these target groups. The interviews helped refine the survey instruments and at the same time provided the valuable information directly from the trucking industry, including their perception of toll roads, their potential use of toll roads and their possible reactions towards incentives as well. The interviews were conducted by Texas Transportation Institute (TTI) researchers.

The first group interviewed was industry representatives. These interviews were conducted to obtain general concerns of the industry regarding toll roads and some general industry characteristics. Then shipping companies were interviewed in an effort to provide specific information about the truck operation by type and size to refine of the survey questions. Finally, a draft was distributed to individual drivers for additional input to the survey.

These interviews provided valuable insights (Geiselbrecht et al. 2008):

Company-owned shipping operations were the most receptive to the toll facility, although they might not use the toll road all the time. The main reason for their preference on toll road was that they were more likely to pass their toll costs onto their customers. These big companies regarded tolls as a cost included in their business, especially when tight delivery schedules required avoiding congestion.

Independent owner-operators were the group that was least likely to use the toll road. One reason was because of the difficulty for them to pass the toll cost to their customers. Additionally, this type of trucker had adjusted their trips considering congestion, especially those who primarily made local trips and were familiar with local traffic conditions. This was even more evident for the operations which had wide delivery windows. Therefore, due to their responsibility to pay their own tolls, awareness of traffic congestion and wide delivery schedule, it could be expected that owner-operators would not use the toll facility often.

Significant time saving was found to be a critical factor that impacted drivers' route choices. Most drivers, including owner-operators, exhibited interest in using a toll road if high travel time savings could be achieved. This number was quantified as more than 15 minutes for a $10 toll. If this amount of time savings could be achieved, some companies and their drivers would choose the facility even without other incentives.

Potential incentives were also examined during the interviews. Many of the incentives received interest from the companies and drivers. The most attractive ones were the ones which directly reduced the cost of traveling on the toll road. Improved services, such as "stops offering state of the art in-cab auxiliary systems for maximum comfort during rest periods" (Geiselbracht et al. 2008) might have a positive impact on some truckers' use of

SH 130. However, this benefit was not useful to every type of driver. For instance, short haul operators who made trips lasting less than a day would not find this incentive of use. Also the fuel price reduction incentive at a station located along the toll facility might not have any effect on the truckers who refuel at distribution centers. As a result, a mixed strategy of incentives should be designed in an effort to attract the most truckers.

Based on the literature review and the interviews with trucking/shipping firms, Geiselbrecht et al. (2008) drew the following conclusions:

"

- The trucking industry is complex and segmented
- The different segments of the trucking industry will have different reactions to incentives to use toll roads
- Even within a segment of the industry, reactions to incentives will vary
- Agencies should examine a variety of incentives because some will appeal to different segments "

Therefore, a survey would be necessary to gather information on how the groups of the trucking industry use toll roads (specifically SH 130), how incentives would impact this use, and the variation with these results.

3.2.2 Survey Design

(1) Revealed Preference Questions

The survey contained both revealed preference and stated preference questions. The RP questions had four parts: truck classification, schedule flexibility, route choices, and the current traffic in the Austin area. These questions gathered information on truck drivers' travel patterns, current trip-making, and feelings towards twenty different toll road incentives. For the questions of these twenty incentives, the levels of preference from "Unimportant" to "Very important" were indicated by scoring the incentives from 1 to 3 (see Table III-1).

Table III-1. Scores of Incentives

Please rate your choices on a scale of 1 to 3, with 1 being a feature that is unimportant to you, up to 3 a critical feature that greatly increases your use of SH 130	1 Unimportant /No Change	2 Somewhat Increases	3 Greatly Increases	No answer
Larger, well maintained truck stops with $10 off the cost of a truck wash	☐	☐	☐	☐
Reduced fuel prices	☐	☐	☐	☐
Off-peak toll discounts	☐	☐	☐	☐
Dining facilities with better parking lots for trucks	☐	☐	☐	☐
Truck repair facility	☐	☐	☐	☐
Wider lanes for large loads	☐	☐	☐	☐
Truck stops with in-cab auxiliary power systems (such as IdleAire)	☐	☐	☐	☐
When you pay for three tolled trips you get a fourth trip toll free	☐	☐	☐	☐
80 mph truck speed limit on SH 130	☐	☐	☐	☐
Longer Combination Vehicles (LCV, wiggle wagons) allowed on SH 130	☐	☐	☐	☐
Higher speed limits	☐	☐	☐	☐
No Congestion	☐	☐	☐	☐
Separate lanes for cars and trucks	☐	☐	☐	☐
Travel time information	☐	☐	☐	☐
Wide travel lanes	☐	☐	☐	☐
Good lighting of the road	☐	☐	☐	☐
Long on and off ramps	☐	☐	☐	☐
Clear and easy to follow road striping	☐	☐	☐	☐
Good informational signs	☐	☐	☐	☐
Wide shoulders for emergencies	☐	☐	☐	☐

(2) Stated Preference Questions

Four scenarios were included in the stated preference part of this survey (see Figure III-1 and Figure III-2). Scenario 1 and 2 did not offer any incentive for the use of SH 130. They were designed to examine the influence of the change of the toll and the travel time. In both website and paper surveys, option A and C in Scenario 1 and 2 were I-35 options; option A was rush hour travel and option C was middle of day travel. Both option B and D were SH 130 options; option B was rush hour travel and D was middle of day travel. Tolls and travel times changed in different surveys.

In the website survey, travel time during the peak hour on I-35 was basically set as 85 minutes, while "50 minutes" was set for I-35 middle of day and SH 130 traveling. The toll rates were set randomly in different surveys. Since the website survey was able to achieve dynamic scenarios, the toll rate in Scenario 2 depended on truckers' choices in Scenario 1. If the respondent selected the toll option in the first scenario, the toll rate was bumped up a bit (15 % to 35 %); while if they did not select the toll road, the toll rate would be greatly reduced (35 % to 75 %). In the paper survey, the travel time for the peak period ranged from 60 minutes to 90 minutes on I-35 in five minute increments, while during middle of day this range was from 40 to 60 minutes. The toll price ranged from $15 to $30 for using SH 130, while the travel time on SH 130 was always 50 minutes. Since travel times and tolls cannot be dynamically changed by tailoring to truckers' choice to previous questions in the paper survey. Tolls and travel times were switched randomly in different questions and surveys.

Scenarios 3 and 4 were designed to examine the impact of potential incentives on the truck use of the toll road. Option A of Scenario 3 and 4 was I-35 (non-tolled) Option. Five incentives were applied in option B and C. They were as follows:

- An off-peak discount of X percent (X ranged from 33 to 75);
- X cents per gallon reduced fuel price (X ranged from 3 to 10);
- Every X^{th} trip free (X ranged from 3 to 5);
- X hours of free in-cab auxiliary unit (X ranged from 4 to 8);
- $X off a truck wash (X ranged from 5 to 15).

The first four incentives were tested in the website survey. In Scenario 3, option B offered off-peak discount and C offered fuel discount. In Scenario 4, option B offered every X^{th} trip for free, and C offered X hours free use of In-cab auxiliary unit. The time of travel in Scenario 3 and 4 (except for option B in Scenario 3, which was always the middle of day travel) was determined by the truckers' choices in Scenario 1 and 2. If a trucker chose rush hour option in either Scenario 1 or 2, then the peak hour was used as the default situation for Scenario 3 and 4. If the driver selected both middle of day option in both Scenario 1 and 2, then middle of day was used in Scenario 3 and 4. The travel time was determined by the time they travel (85 minutes for I-35 rush hour; 50 minutes for I-35 middle of day and SH 130).

For the paper survey, all of the five incentives were tested. Option A was using I-35 during the rush hour, the travel time ranged from 60 to 90 minutes. Option B and C were using the toll road SH 130 with incentives applied. In each survey, four out of the five cost-related incentives were involved randomly in option C and D of Scenario 3 and 4.

	A	B	C	D
Time of Day	Rush hour	Rush hour	Middle of day	Middle of day
Route	I-35	SH-130	I-35	SH 130
Congestion	severe	none	light	none
Toll	$0.00	$20	$0.00	$20
Travel Time	65 minutes	50 minutes	45 minutes	50 minutes
SELECT ONE ->	☐	☐	☐	☐

Figure III-1. Examples of Scenarios 1 and 2

Time of Day	Rush hour	Rush hour	Rush hour
Route	I-35	SH-130	SH-130
Toll	$0.00	$20	$20
Incentive	None	Fuel price reduced by 7 cents/gallon	Every 3rd trip on SH-130 is free
Travel Time	65 Minutes	50 minutes	50 minutes
SELECT ONE ->	☐	☐	☐

Figure III-2. Examples of Scenarios 3 and 4

3.2.3 Survey Distribution and Administration

The survey was initially designed as a web-based survey, followed by a paper version. Both of them were created in both English and Spanish. The web survey went live on February 1, 2008. The survey was advertised and announced by Big Rig Network (http://www.bigrignetwork.com/) and the website of the Owner-Operator Independent Drivers Association (OODIA) posted a link to it. The Owner-Operated Independent

Driver's Association Foundation also sent an e-mail to their Texas members, alerting them of the web survey. Many survey responses were obtained from this email alert. The website was closed to survey respondents on March 11, 2008, after receiving 1929 responses.

Paper surveys were distributed at various locations so that truckers who could not access the internet or did not know about the website survey could be reached. About 400 surveys were distributed at toll booths along SH 130 via representatives of the Texas Department of Transportation's Texas Turnpike Authority. Another method used was to send the survey to truckers at the southbound I-35 weigh station located just south of the San Marcos City limits. This process was facilitated by employees of the Texas Department of Public Safety (DPS) and also with the help of researchers due to the large traffic volume. At last 1,669 surveys were distributed at this location. Surveys were also sent to companies in the Austin area. Companies studied were selected carefully. Only the companies who made route decisions were selected by researchers and 200 to 300 surveys were distributed to those companies.

A total of 233 paper surveys were completed and mailed back. This was a response rate of approximately ten percent, which was higher than some found in the literature as truckers generally have a low responses rate to surveys.

3.3 Data Cleaning and Analysis

3.3.1 Data Cleaning and Reduction

The analysis of this paper was based on raw data from the survey studied in this research. The raw data contained missing values, data errors, and data outliers. For instance, some respondents indicated the number of trucks they owned as more than a billion. Those responses were removed since they were not realistic. All of them were removed before data analysis. All of the answers which did not follow the requirements as well as the unreasonable or paradoxical answers were not included in the results. For instance, some truckers selected more than one answer for a single choice question. The answer to that question was removed. Only 40 answers were removed in this process.

Particular categories were used to classify the groups of the trucking industry. Question 1, was a classification question that split truckers into different groups. The surveys missing answers to the classification questions were not analyzed. It was designed as a multiple choice question. Combinations were made to examine all the possible situations. However since some combinations, such as the combination of owner-operator and private carrier, had very few respondents, it was insufficient to make any persuasive conclusions on these combinations The criteria for reducing the data was that all classes that had less than twenty responses were removed. With this filter process, 139 responses were removed, and a total of 2023 valid responses remained for analysis. Truckers who responded to the survey were classified into five categories according to their answers to the first question.

A. Owner-operators, self employed independent contractors who own the trucks they Drive.

B. For-hire truck load carriers (for-hire), truck drivers working for trucking companies

C. Private carriage (private carrier), truck is owned by the same company that owns the freight being hauled, such as HEB.

D. Less than truck load, generally several shippers fill one trailer with goods. This group can be broken further into regional deliveries or long haul.

E. The combination of owner-operators and for-hire truck load (OO and for-hire) drivers having the ownership of their trucks while working for transport companies.

For the questions that respondents could select multiple answers, (such as "What is your typical cargo?") the frequency of each item was simply the number of respondents who selected that option divided by the total number of respondents. As a result, the summation of percentages of responses for these questions often exceeded 100 percent.

3.3.2 Statistical Tests

In this research, statistical tests were used to examine significant differences among truck categories. Since the comparisons of percentages involved both nominal questions (such as vehicle types and cargo types) and ordinal questions (number of trucks operated), both chi-squared tests and Kruskal-Wallis tests were applied. Chi-square tests were used to analyze the nominal data while Kruskal-Wallis tests were used to analyze the ordinal data. For comparing means of continuous data, one-way ANOVA was used to conduct the comparison.

3.3.3 Discrete Choice Modeling

187 paper survey responses were used for discrete choice modeling. After combining similar options, nine potential mode choice options were relabeled as follows:

A. I-35 during rush hour with severe congestion
B. SH 130 during rush hour with no congestion
C. I-35 during the middle of the day with light congestion
D. SH 130 during the middle of the day with no congestion
E. SH 130 with off-peak discount (off-peak travel)
F. SH 130 with $0.0X per gallon reduced fuel price (peak period travel)
G. SH 130 with every X^{th} trip free (peak period travel)
H. SH 130 with X hours of free in-cab auxiliary unit (peak period travel)
I. SH 130 with $X off a truck wash (peak period travel)

Stated preference scenarios 1 and 2 always consisted of options A, B, C, and D, while Scenarios 3 and 4 consisted of option A plus two random selections from options E, F, G, H, and I.

Options F, G, H, I were adjusted in the analysis, so that levels of incentives would be consistent across modes. For incentive F, the level of fuel price discount varied between

$0.04/gallon and $0.08/gallon, in $0.01/gallon increments. These dollar values were changed to vary from level 5 to level 1, with level 5 representing the worst situation ($0.04/gallon discount) and level 1 representing the best situation ($0.08/gallon discount). Similarly, , the 3rd, 4th and 5th trip for free was adjusted to vary between level 1 to level 3, with level 1 being the best (every 3rd trip for free) to 3 being the worst (every 5th trip for free). Incentive H was X hours of free use of an in-cab auxiliary unit, with between four to eight hours of free use in one-hour increments. The incentive was adjusted between level 1 to 5, with level 1 being the best (eight hours) and level 5 being the worst (four hours). Incentive I, $X off of a truck wash, which was from $ 5 to $ 15 in $ 1 increments, was changed between level 1 and level 11, with 1 being the best ($15) and level 11 being the worst ($5). In this way, the incentive levels were consistent across the different options, since they were normalized between 1 and a maximum number, with 1 always standing for the best situation while the highest value standing for the worst.

In summary, this study was based on data collected during a regarding truck use of a toll road in the Austin area. This survey examined truckers' characteristics and their route choice between I-35, the congested non-toll road, and its parallel uncongested toll road SH 130. Both I-35 and SH 130 have intersections with several significant corridors. The survey also asked truckers to select different travel options with potential incentives in four stated preference questions.

During the data cleaning and reduction process, errors and unreasonable data were removed. A total of 2023 surveys remained and were divided into five groups of truckers. The groups were owner-operators, for-hire carriers, private carriers, less than truck load carriers, and a combination of owner-operator and for-hire carriers. The evaluation of truckers' characteristics, travel behaviors and the impacts of incentives were based on the analysis of these five truck groups.

CHAPTER IV

DATA ANALYSIS AND RESULTS

4.1 Introduction

Based on the groups identified in Chapter III, the characteristics of groups of truckers were calculated and compared. A total of 2023 valid survey responses from both the paper and website versions of the survey were analyzed. Most of the responses were from owner-operators (73 percent), while the remaining groups were for-hire truck-load carriers (14 percent), private carriers (5 percent), less than truck load carriers (1 percent), and a combination of owner-operator (OO) and for-hire (7 percent).

This study first summarized truckers' characteristics by groups and examined their responses to the different incentives. This summary provided important information on what incentives might attract trucks to use the toll road. A group comparison was then made among the different truck groups to determine which incentives were most attractive to each group of truckers.

Truckers' route choices between toll and non-toll roads in the absence of any incentive were summarized based on their responses to the stated preference questions. The impact of pricing-related incentives on truckers' route decisions was then evaluated by examining the percentage of truckers using the toll road with different incentives. Additionally, the impact of incentives on different trucking groups was also determined.

In order to quantify the impact of incentives as well as the tradeoff between time and toll, a route choice logit model was estimated based on the combination of RP and SP survey responses. A total of 188 valid paper survey responses were used in this process. The discrete mode choice modeling calculations were conducted using *LIMDEP 7.0*, which is a software tool used to estimate logit models.

4.2 Characteristics of Trucks by Group

According to the truckers' responses to the revealed preference questions, their characteristics (including classification, delivery flexibility, route choice and current travel around Austin) were summarized by trucking group (See Table IV-1).

Table IV-1. Texas Truck Survey Results

Characteristics	Truck Group					
	All N=2,023	Owner-Operator N=1,473	For-Hire N=280	Private carrier N=10	Less than Truck Load N=24	OO and For-Hire N=146
	Percent of Respondents in Each Category					
How many trucks are operated by you/your company?						
0=<number of trucks<=10*	78.6	91.4	29.6	33.0	15.0	78.5
10<number of trucks<=100*	8.8	4.1	19.6	41.8	35.0	11.1
100<number of trucks<=1,000*	6.8	2.9	26.5	8.8	20.0	6.3
1,000<number of trucks<10,000*	5.2	1.6	20.0	16.5	25.0	4.2
10000<number of trucks*	0.6	0.0	4.2	0.0	5.0	0.0
What type of route do you most often run?						
Regional *	8.8	5.9	11.5	47.3	9.1	6.9
Long Haul*	89.6	93.0	87.0	44.1	77.3	92.4
Local/Delivery*	1.6	1.1	1.5	8.6	13.6	0.7
What type of vehicles do you drive?						
Single Unit 2-axle*	2.9	2.3	0.4	13.3	21.7	2.7
Single Unit 3-axle*	3.4	3.8	1.1	5.1	0.0	3.4
Single Unit 4-axle	0.5	0.5	0.4	1.0	0.0	0.7
Semi*	91.1	91.0	97.1	79.6	78.3	91.1
Other	2.1	2.3	1.1	1.0	0.0	2.1
What is your typical cargo? [A]						
Van/General Freight*	50.4	47.8	65.1	33.0	52.2	59.3
High value*	22.9	21.9	23.4	8.2	26.1	40.7
LTL/Package*	11.7	11.4	7.6	6.2	43.5	21.4
Reefer*	19.0	18.6	22.7	12.4	4.3	23.4
Non-Perishable*	21.3	19.0	24.5	23.7	13.0	38.6
Perishable*	9.7	8.2	13.3	13.4	8.7	16.6
Manufactured Goods*	25.4	21.6	32.7	24.7	30.4	49.0
Large/Wide Loads*	11.9	13.5	5.4	5.2	0.0	15.2
Delivery	1.3	1.2	1.4	2.1	0.0	2.8
Hazardous Materials	17.3	16.6	16.9	16.5	13.0	26.2
Other	19.8	20.8	15.4	24.0	8.3	17.8

Table IV-1. Continued

Characteristics	Truck Group					
	All N=2,023	Owner-Operator N=1,473	For-Hire N=280	Private carrier N=100	Less than Truck Load N=24	OO and For-Hire N=146
	Percent of Respondents in Each Category					
How wide is the delivery window on your typical trip						
A week or more	6.2	7.0	3.8	2.2	9.1	5.7
Between 4 and 6 days	14.7	15.6	12.0	6.5	9.1	17.0
Between 1 and 3 days*	42.4	45.2	40.2	12.0	31.8	40.4
Between 12 and 24 hours*	8.7	7.6	10.2	16.3	18.2	11.3
Between 6 and 12 hours*	5.9	4.8	7.5	19.6	9.1	4.3
Between 2 and 6 hours*	8.2	7.6	10.9	18.5	4.5	3.5
Between 1 and 3 hours*	7.6	6.6	9.4	17.4	9.1	7.8
1 hour or less	6.2	5.7	6.0	7.6	9.1	9.9
What time of day do you typically make deliveries?						
7:00 am-9:00 am*	58.5	61.0	53.9	28.9	28.6	63.6
9:00 am-12:00 pm	17.3	16.9	15.7	26.3	21.4	17.8
12:00 pm- 4:00 pm*	5.4	4.1	7.8	15.8	7.1	7.0
4:00 pm- 7:00 pm*	1.3	1.1	1.4	5.3	7.1	0.0
Early morning (before 7:00 am)	15.4	15.6	17.1	18.4	21.4	8.5
Evening (after 7:00 pm)*	2.1	1.3	4.1	5.3	14.3	3.1
Would using an uncongested route, like SH 130, allow you to make deliveries during peak times? [B]						
Yes*	33.3	28.6	33.3		100.0	0.0
No*	41.7	42.9	33.3		0.0	100.0
Maybe*	25.0	28.6	33.3		0.0	0.0
If you are late with a shipment or delivery, what sort of penalties might you face? [A]						
Late delivery fines*	43.6	44.1	46.7	8.2	25.0	59.7
Refund of fees*	7.2	6.0	9.5	3.1	25.0	13.9
Lost shipping contract*	35.5	34.7	40.1	13.4	33.3	50.0
Verbal reprimands*	31.2	27.5	44.5	41.2	20.8	36.8
Lost my job*	13.1	9.8	27.4	16.5	29.2	13.9
Refused shipment*	30.3	29.4	34.7	19.6	20.8	40.3
None*	21.6	22.6	14.2	35.1	25.0	15.3
Other	7.5	7.7	8.2	8.0	8.3	4.1

Table IV-1. Continued

Characteristics	Truck Group					
	All N=2,023	Owner-Operator N=1,473	For-Hire N=280	Private carrier N=100	Less than Truck Load N=24	OO and For-Hire N=146
	Percent of Respondents in Each Category					
Who is in charge of making your route decisions?						
I am*	85.2	92.3	61.1	53.6	45.8	87.2
My boss*	3.1	1.3	7.5	16.5	12.5	2.1
Logistics managers*	5.6	2.9	14.3	19.6	16.7	4.3
Company policy*	3.3	1.2	12.1	7.2	25.0	2.1
Other	2.8	2.2	4.9	3.1	0.0	4.3
What factors do you consider when deciding to accept or reject a load from shippers? [A]						
Amount paid for transporting the load	86.7	86.7				86.9
Ability to deliver the shipment on time*	61.6	59.8				78.8
Contents of the shipment*	34.7	33.0				51.8
If it's a full load*	14.8	14.1				21.2
Trip distance*	39.5	38.2				52.6
Familiarity with the destination of the shipment	13.2	12.8				16.8
I have no choice in accepting or rejecting loads	4.0	4.0				3.6
How are you paid?						
By the mile*	45.2	43.4	70.0	38.7		36.0
By the hour*	1.0	0.4	2.0	29.0		0.4
By the load*	21.2	20.3	12.8	16.1		33.0
Percentage of the line haul *	30.4	33.8	13.8	0.0		29.5
Other*	2.2	2.1	1.5	16.1		1.1
Who pays the toll when you use a toll road [A]						
I do*	74.7	88.8	23.7	15.0	12.5	84.1
My company does*	24.5	11.5	73.0	75.0	91.7	15.2
Unsure, as I have never taken a toll road*	1.5	0.4	5.1	10.0	0.0	0.0
Other*	3.1	2.0	7.9	1.0	8.3	5.5

Table IV-1. Continued

Characteristics	Truck Group					
	All N=2,023	Owner-Operator N=1,473	For-Hire N=280	Private carrier N=100	Less than Truck Load N=24	OO and For-Hire N=146
	Percent of Respondents in Each Category					
What roads do you frequently travel on most in the Austin area? [A]						
Interstate 35	98.6	98.8	98.5	95.8	100.0	99.3
Loop1*	12.5	10.4	11.7	38.9	21.7	15.1
Highway 71 East*	18.0	15.6	16.2	43.2	17.4	28.1
Highway 130*	4.7	3.6	1.5	24.2	8.7	7.2
Highway 183 East*	19.5	18.2	15.0	37.9	17.4	29.5
Highway 290 East*	34.0	33.1	30.8	40.0	26.1	45.3
Highway 183 North*	20.4	18.8	18.4	45.3	17.4	23.7
Highway 290/71*	25.9	24.9	20.3	40.0	21.7	37.4
How often do you travel through Austin area on I-35?						
Multiple times a day*	3.9	1.4	4.3	37.4	27.3	1.5
Once a day*	1.6	0.7	4.3	5.5	9.1	2.2
A few times a week*	11.7	8.9	18.6	24.2	36.4	13.3
A few times a month*	37.8	39.7	38.8	15.4	13.6	35.6
Every few months*	43.5	47.8	32.2	15.4	13.6	46.7
Never	1.4	1.4	1.9	2.2	0.0	0.7
Do you change your driving based on traffic congestion in Austin? [A]						
Yes, I try to avoid congested roadways during the rush hours	48.9	49.1	44.3	56.8	43.5	51.4
Yes, I try to avoid all of Austin during rush hours	29.6	30.6	27.7	18.9	21.7	31.9
Yes, I try to avoid driving during rush hours*	34.8	36.2	31.4	20.0	17.4	39.9
No, I do not have a choice on when and where I drive*	20.8	17.9	28.8	29.5	39.1	25.4

Table IV-1. Continued

Characteristics	Truck Group					
	All N=2,023	Owner-Operator N=1,473	For-Hire N=280	Private carrier N=100	Less than Truck Load N=24	OO and For-Hire N=146
	Percent of Respondents in Each Category					
How often do you change your route during rush hours to avoid traffic congestion?						
Never*	7.7	6.9	15.0	4.9	25.0	2.9
Occasionally	37.9	38.2	37.5	29.5	25.0	45.7
Half the time	11.8	11.2	11.7	11.5	8.3	18.6
Often	30.2	31.5	27.5	24.6	41.7	25.7
Always*	12.3	12.2	8.3	29.5	0.0	7.1
How often do you change your schedule to avoid rush hours?						
Never*	6.8	4.9	7.9	19.6	54.5	1.9
Occasionally	35.5	35.1	39.6	32.6	27.3	35.2
Half the time	9.5	8.7	10.9	10.9	0.0	14.8
Often*	36.3	38.3	32.7	17.4	18.2	44.4
Always*	12.0	13.0	8.9	19.6	0.0	3.7

* These answers significantly differ between types of truckers.
[A] Sum of percentages is greater than 100% because multiple responses were allowed
[B] The question was answered by very few respondents

- Owner-operators

Generally speaking, owner-operators owned a small number of trucks. 91.4 percent owned fewer than 10 trucks. However, they operated big vehicles (91.1 percent operated semis) and most often made long haul trips (93.0 percent of the time). Many (45.2 percent) had delivery windows ranging between one and three days, which was significantly wider than some other groups. The typical time of a day to make deliveries for owner-operators was during the peak hours in the morning. 58.5 percent made deliveries between 7:00 to 9:00 in the morning. 92.3 percent of owner-operators made route decisions by themselves, indicating they had sufficient freedom in route choice (significantly more freedom than most other groups). At the same time, 88 percent of owner-operators paid their own tolls. In order to avoid congestion, around 40 percent of owner-operators “always” or “often” switched their routes while 36.2 percent of them would have liked to change their time of travel, since they made a lot of trips during peak hours in the morning. Changing route or time was necessary if they wanted to avoid congestion.

- For-hire truck load carriers

For-hire carriers’ companies usually owned large truck fleets. As with owner-operators, they operated big vehicles (87 percent of semis) and made long haul trips (97.1 percent). Just like owner-operators, their delivery windows often ranged between one and three days (40.2 percent), and the typical time of day to make deliveries was between 7:00 and 9:00 in the morning (61 percent). For-hire carriers had less freedom in route choice than owner-operators and this difference was statistically significant. Their trip decisions often followed company policy and logistics managers’ decisions while the tolls were frequently paid by their companies (73 percent). Similar to owner-operators, for-hire carriers also changed their times and routes to avoid congestion. However, compared with owner-operators, more for-hire truckers did not have a choice on when and where to drive.

- Private carriages (Private carriers)

Just like for-hire carriers, the private carriers generally owned large truck fleets. However, significantly different from owner-operators and for-hire carriers, this type of trucker made many regional trips (47.6 percent) of trips and local/delivery trips (8.6 percent). Long haul trips were 44.6 percent of their trips. Also 13.1 percent of them used 2-axle trucks, which was a relatively big proportion compared with the previous two groups. Their delivery flexibility was significantly shorter than owner-operator and for-hire carriers. That was, 79.3 percent of private carriers had delivery windows within one day. It could be indicated most of them made their deliveries during off-peak hours (65.8 percent). They had significantly less flexibility than for-hire carriers, and 75 percent indicated their companies paid their tolls. Approximately 65.6 percent of private carriers indicated they avoided congestion by changing routes at least half the time.

- Less than truck load carriers (LTL)

For less than truck load carriers, their companies also owned many trucks and often made long haul trips (77.3 percent). A total of 21.7 percent of LTL carriers indicated they owned single unit 2-axles trucks, which was much more than other groups. More than a half had delivery windows between 12 and 24 hours and between 1 and 3 days. Most of them (67.3 percent) made deliveries in off-peak hours. Compared with other groups, this group of truckers had significantly less control over which route they took and 91.7 percent of them had their companies pay their tolls. That explained why 39.1 percent of them did not have a choice on where and when to drive. However, there was an interesting finding for this group of truckers: 41.7 percent often changed routes to avoid congestion. However, 54.5 percent never changed their schedule. The unbalance on route and time decision could be explained by the nature of this trucking group. Since LTL truckers were comprised of multiple shipments, timely coordination of truck arrivals and departures resulted in very restrictive travel schedules. In order to achieve the goal of time reliability, whatever route led to the most efficient travel was often used by LTL.

- Owner-operator & for-hire carriers

This group of truckers often had the combined characteristics of both owner-operators and for-hire carriers. In most classification issues, such as number of trucks owned, they were very similar to the owner-operator group. Although they worked for certain companies, owner-operator was still their fundamental identity. However, they had less flexibility and control in route and schedule decisions, because they were restricted by the companies they worked for.

In summary, most groups of trucks operated semi-tractor trailers on long haul trips. Private and LTL carriers generally had shorter delivery windows than owner-operators and for-hire carriers. For the route decision and toll payment issue, it was important to note, truckers played a significant role in making route decisions. Although truckers working for certain companies, such as for-hire carriers, private carriers and LTL carriers, had less freedom on route choices, a significant proportion of them made their own route decisions. From Table IV-1, LTL carriers had the least freedom to make route decisions. However, 45.8 percent still had flexibility to choose their own route. Typically, ownership determined the payment of the toll. Owner-operators paid their own tolls, while for company owned trucks, their tolls were often paid by their companies. Routes and Schedules were adjusted in order to avoid traffic congestion by all trucking groups. According to survey results, truckers' route flexibility (40-50 percent made changes on average) was greater than their schedule flexibility (20-30 percent made changes on average).

4.3 Trucks' Potential Reactions to Incentives

4.3.1 Potential Popularity of Incentives

Respondents were asked to rate twenty potential incentives designed to enhance the attractiveness of using SH 130. Since the preference level increased from "unimportant" to "very important" as the score increased from 1 to 3, the higher mean of score indicated a relatively higher preference (1- unimportant, 2- somewhat important, 3- very important).

Table IV-2. Means of Incentive Scores

Incentives	Average Score
Reduced fuel prices	2.31
No congestion	2.16
Dining facilities with better parking lots for trucks	2.05
Off-peak toll discounts	2.04
Wide shoulders for emergencies	2.04
Good informational signs	2.03
Clear and easy to follow road striping	1.98
When you pay for three tolled trips you get a fourth trip toll free	1.91
Long on and off ramps	1.87
Good lighting of the road	1.86
Separate lane	1.78
Wider travel lanes	1.76
Truck repair facility	1.73
Wider lanes for large loads	1.68
Travel time information	1.66
Larger, well maintained truck stops with $10 off the cost of a truck wash	1.64
80 mph truck speed limit on SH 130	1.63
Higher speed limits	1.53
Truck stops with in-cab auxiliary power systems (such as IdleAire)	1.50
Longer Combination Vehicles (LCV, wiggle wagons) allowed on SH 130	1.27

* These answers were significantly different between types of truckers.

Reduced fuel prices earned highest ranking (average score 2.31) among all incentives and followed by “no congestion” (see Table IV-2). That was because fuel cost was the largest proportion of truck operating cost and “no congestion” means efficient trips with travel time savings and therefore lower operating costs. Reducing cost and travel time was generally the greatest benefit to truckers. Monetary incentives such as “off-peak discounts" (average score 2.04) and "after three tolled trips you get a fourth trip toll free" (average score 1.91) obtained relatively high scores as well. However, not all monetary incentives were as attractive. "larger well maintained truck stops with $10 off truck wash" was not a very attractive incentive to truckers (average score 1.64). "dining facilities with better parking lots for trucks" (average score 2.05), "clear and easy to follow road striping" (average score 1.98), "good informational signs" (average score 2.03), and wide shoulders for emergencies" (average score 2.04) were incentives that would enhance truckers' safety and convenience, it was noteworthy that truckers ranked these incentives relatively high.

Some incentives were not very attractive to truckers. "Longer Combination Vehicles (LCV, wiggle wagons) allowed on SH 130" got the lowest average score, since none of the trucks were LCVs. Similarly, the incentive of "truck stops with in-cab auxiliary power systems" was also unpopular. That was because not all the truckers could take advantage of in-cab auxiliary power systems particularly along a specific segment of road, such as SH 130. It was clear that for the incentives which could only benefit a proportion of the truckers, they were likely to get a low overall score. This may indicate that higher speed limit was also an unpopular incentive. This may indicate that truckers considered safety as a significant issue plus many could not exceed certain speed based on company policy. Incentives, such as truck wash discount and travel time information were also unpopular incentives, since they had no direct relationship with cost (time, cost etc.) of truckers.

4.3.2 Trucks' Reactions to Incentives by Group

Table IV-3. Incentive Preferences by Truck Classification

Incentives	Truck Classification					
	All N=2,023	Owner-Operator N=1,473	For-Hire N=280	Private carrier N=100	Less than Truck Load N=24	Owner-operator & For-Hire N=146
	Mean Rating in Each Category					
Reduced fuel prices*	2.31	2.35	2.18	1.99	2.35	2.41
No congestion*	2.16	2.11	2.22	2.66	2.57	2.10
Dining facilities with better parking lots for trucks	2.05	2.02	2.16	1.95	2.28	2.10
Off-peak toll discounts	2.04	2.04	2.00	2.16	2.12	2.09
Wide shoulders for emergencies*	2.04	1.98	2.17	2.36	2.29	2.11
Good informational signs*	2.03	1.97	2.18	2.33	2.24	2.07
Clear and easy to follow road striping*	1.98	1.92	2.13	2.22	2.24	2.02
When you pay for three tolled trips you get a fourth trip toll free*	1.91	1.89	1.87	2.16	2.00	2.05
Long on and off ramps*	1.87	1.81	2.02	2.08	2.19	1.93
Good lighting of the road*	1.86	1.80	2.03	2.10	2.25	1.88

* Significantly different between groups of truckers at the 95 percent level of significance.

Table IV-3. Continued

Incentives	Truck Classification					
	All N=2,023	Owner-Operator N=1,473	For-Hire N=280	Private carrier N=100	Less than Truck Load N=24	Owner-operator & For-Hire N=146
	Mean Rating in Each Category					
Separate lane*	1.78	1.72	1.93	2.02	2.29	1.86
Wider travel lanes*	1.76	1.72	1.92	2.01	1.90	1.74
Truck repair facility	1.73	1.72	1.79	1.62	1.76	1.77
Wider lanes for large loads	1.68	1.66	1.70	1.79	2.06	1.69
Travel time information*	1.66	1.61	1.79	1.87	2.14	1.72
Larger, well maintained truck stops with $10 off the cost of a truck wash	1.64	1.64	1.67	1.56	1.35	1.7
80 mph Truck Speed Limit on SH 130	1.63	1.60	1.70	1.76	1.90	1.62
Higher Speed Limits*	1.53	1.51	1.61	1.69	1.67	1.49
Truck stops with in-cab auxiliary power systems (such as IdleAire)	1.50	1.49	1.58	1.43	1.53	1.55
Longer Combination Vehicles (LCV, wiggle wagons) allowed on SH 130*	1.27	1.25	1.30	1.48	1.89	1.18

* Significantly different between groups of truckers at the 95 percent level of significance.

- Reduced fuel price

Fuel price was the highest proportion of truck operation costs. A Fuel price discount directly reduced the total cost of the trips, and therefore made truckers' reassess the benefit and cost of using the toll road. Truckers' responses toward fuel price reduction were significantly different by group (see Figure IV-1).

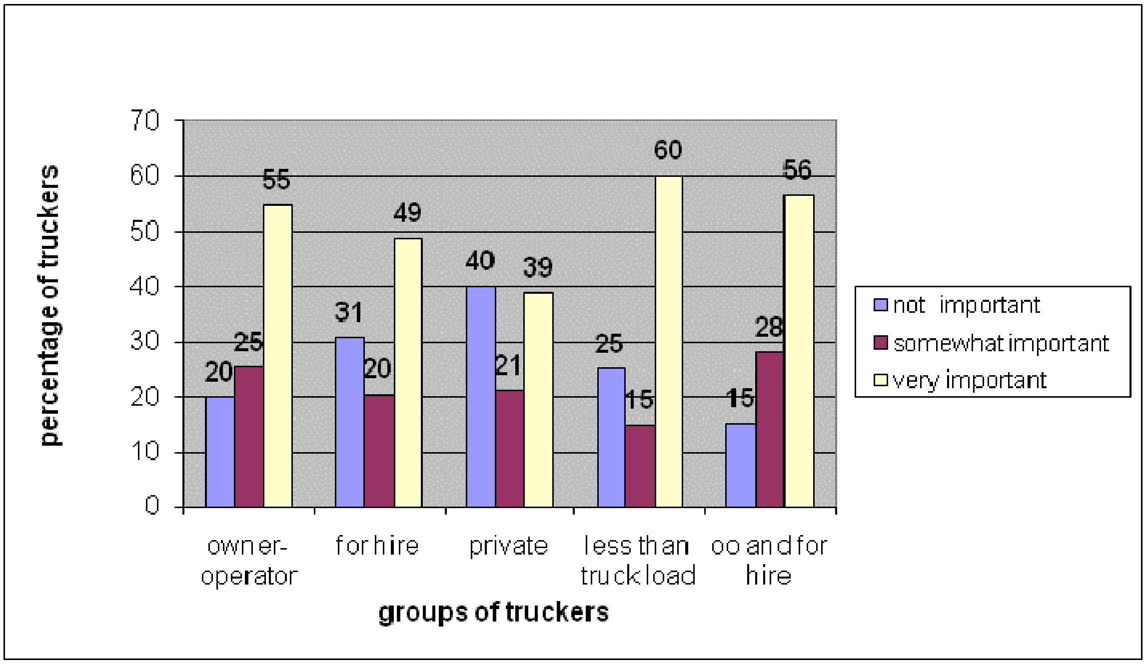

Figure IV-1. Drivers' Responses to Reduced Fuel Prices

As shown in Table IV-2, reduced fuel price was the most attractive motivation for drivers to use SH 130. The majority of truck drivers (55 percent of owner-operators, 60 percent of less than load drivers, 57 percent of owner and for-hire drivers and almost half of for-hire drivers) would consider it a very important factor. One reason may be that fuel price experienced a rapid increase during the time-frame of this study. The cost of fuel was a very big concern to most of drivers and companies.

The fuel cost was so important that there was already some evidence relating extensive trucking company bankruptcies due to rising operating costs. (see Figure IV-2) shows the truck firm bankruptcies correlated with fuel price increases.

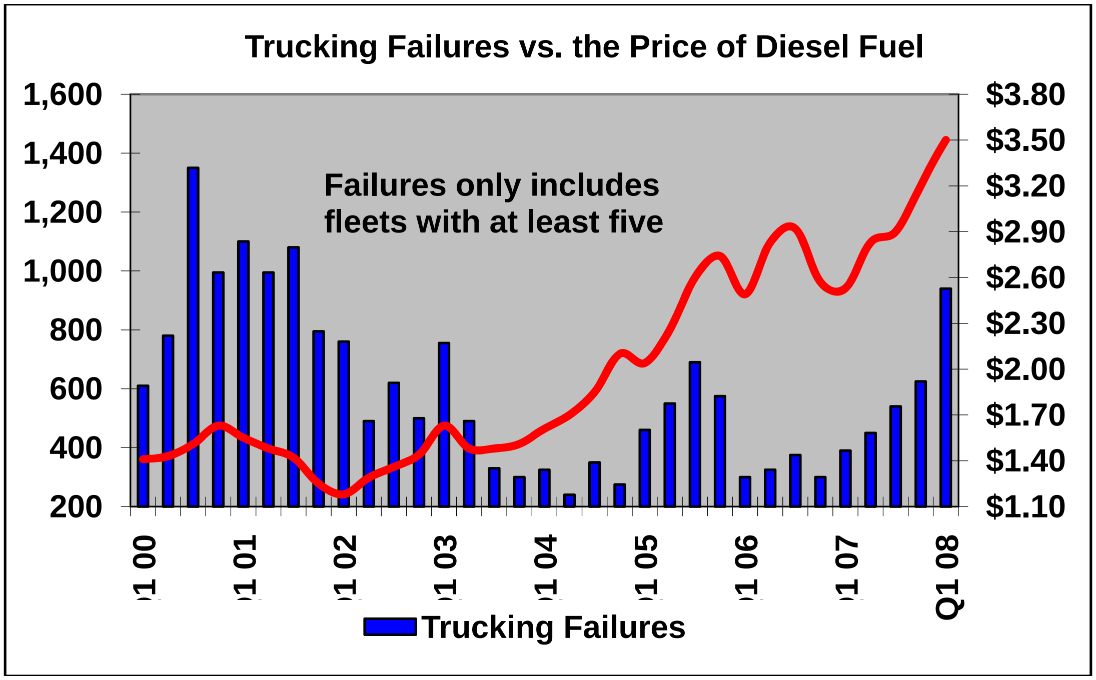

Figure IV-2. Trucking Failures and Fuel Prices (1995-2005)

(Sources: Avondale Partners, LLC and ATA)

Another reason for truckers' concern with fuel cost may be that one of the main complaints against toll roads was that drivers generally felt the toll was a duplicate charge, both gas tax and tolls. If the fuel price could be reduced for some amount, it would reduce this conflict.

Among all these groups of truckers, owner-operators and OO & for-hire drivers showed the greatest interest in the reduced fuel price. That was because owner-operators and OO & for-hire drivers paid the cost of the trips by themselves. Compared to large companies, these small truck transport operators lacked the bargaining ability to negotiate for stable fuel surcharges. It was difficult to maintain a profitable business with the increasing fuel price.

There were some other possible reasons for these trends, one was that owner-operators often made long-haul trips (93.0 percent of owner-operators and 92.4 percent OO and for-hires), and most (91.1 percent of owner-operators and also OO and for-hires) used semi trucks, which might cause higher fuel consumption. For-hire truck drivers, since it was their company who paid the fuel cost, showed less interest in reduced fuel prices than owner-operators and OO & for-hire truck drivers. Less than truck load drivers were also very interested in this policy. The reason may be their short trips allow them to fill up their tanks multiple times on SH 130, which allows them to get more benefit from this policy.

On the contrary, private carrier drivers showed the least interest in this policy (39 percent chose “very important”) and the proportion of drivers who chose “unimportant” (40 percent), was twice that of owner-operators. That was because private carriers did not have the intense motivation to reduce this proportion of cost as owner-operators, since the fuel cost was often paid by the companies. Another important reason was some private carriers have to use company-owned pumps which prevented them to obtain any benefit from the gas station along SH 130 who offered the reduced gas price.

- Off- peak discount

The off-peak discount was another popular policy according to truck drivers' choices. This incentive was a very complicated one since the answers of different groups of drivers varied a lot, depending on their trip schedule, travel flexibility, and what kind of cargo they regularly transported.

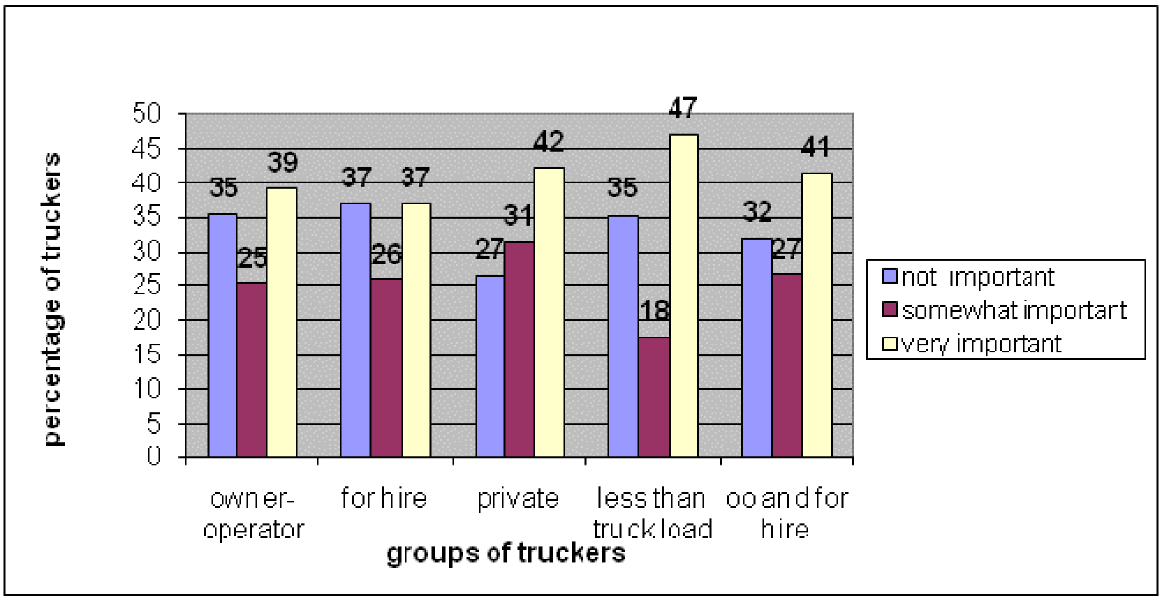

Figure IV-3. Drivers' Responses to Off-Peak Discount

Owner-operators and for-hire truck drivers showed similar reaction to this policy (see Figure IV-3). Both of them did not have as much enthusiasm towards the off-peak discount as did private carriers and less than truck load drivers. The main reason was the typical time they made their trips was during the peak hour 7:00-9:00 am (61 percent of owner-operators and 53.9 percent of for-hire truckers). However, only 28.9 percent of private carriers and 28.6 percent of less than truck load trips were made during the peak. This policy was naturally welcomed by private carriers and less than truck load truckers according to their travel schedules. The interest in this policy from for-hire truckers (37 percent) was lower than the owner-operators (39 percent). Additionally, this group also had the highest proportion of drivers (also 37) choosing this incentive as unimportant. For-hire truckers liked the off-peak discount the least due to their limited travel time flexibility. 29.0 percent of them “do not have choice on route and schedule decision” The customer requirements driven feature made for-hire truckers less sensitive to an off-peak discount. There were some other possible reasons: the penalties of not delivering on time often contained losing the shipping contract, paying fines, and even losing their jobs. Also, for-hire trucks transported more reefer and perishable cargo than other groups of truckers (see Table IV-1), which made their trips even less flexible.

The off-peak discount was generally not as attractive as a reduced fuel price. The most important reason was that the reduced fuel price is a non-conditional benefit that more truckers can take advantage of. However, the off-peak discount had some limitations on drivers’ travel schedule and depended on the flexibility of delivery, which made it less attractive.

- Fourth trip toll free

The policy of rewarding frequent use of SH 130 was another relatively well welcomed incentive. In contrast to the off-peak discount, which was determined by truckers’ travel schedule and flexibility, truckers’ reactions to the frequent use incentive were greatly impacted by truckers’ route choice and flexibility.

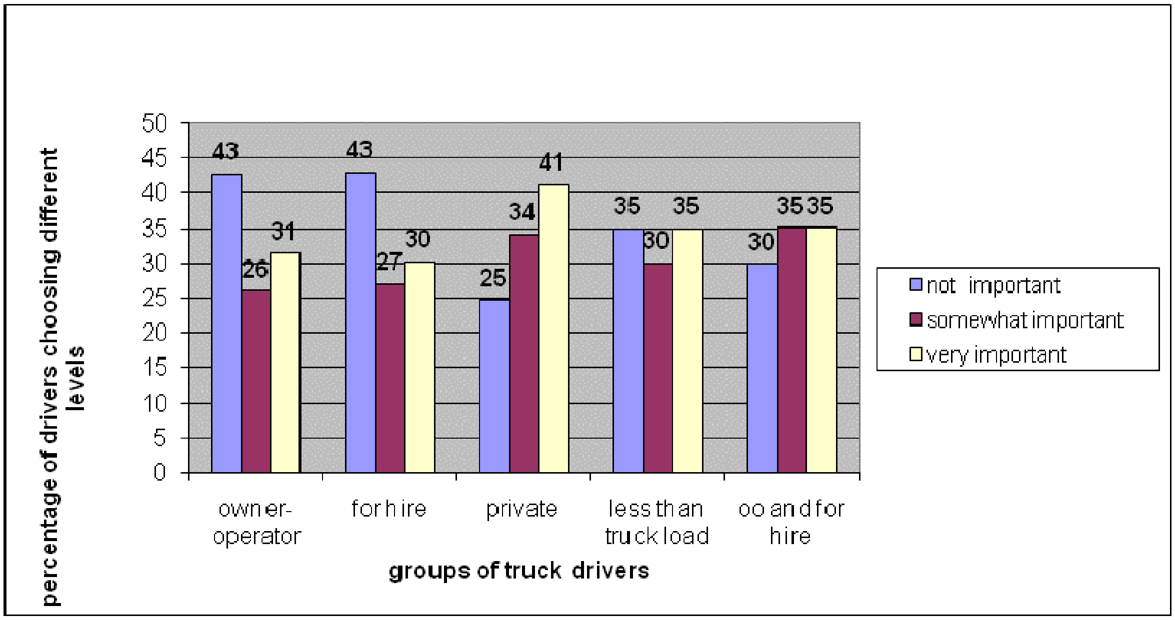

Figure IV-4. Drivers' Responses to Fourth Trip for Free

This incentive was especially attractive for the private carrier drivers (41.2 percent choosing "very important", highest among all the groups and 24.7 percent chose "unimportant", lowest among all the groups, see Figure IV-4). That was because private carriers had a higher potential demand for toll roads. 24.2 percent of private carriers chose SH 130 as the one of the roads they frequently travel on in the Austin area. It was indicated they used the toll road more than any other group. This preference could be explained by one of Vadali et al. (2007) findings -- private carriers might make a cost-benefit analysis with greater focus on fuel costs when determining the route.

Additionally, according to the summary of their delivery flexibility, private carriers had a fairly tight delivery window. Therefore, time reliability was a very important consideration. In order to make on time deliveries, toll cost had already been regarded as part of the operation cost. Vadali et al. (2007) also concluded they could more easily pass the cost onto their customers.

Another reason was that they traveled through the Austin area on I-35 most frequently. 37.4 percent of private carrier drivers traveled on I-35 “multiple times a day” This frequency was much more than any other group of truckers, for instance, almost 30 times as much as owner-operators (1.4 percent). Since SH 130 is an alternative to I-35, the group of drivers using I-35 more frequently does have higher potential demand for SH 130, and might be swayed to this toll road if the benefit is offered to reward their frequent travel.

Additionally, private carrier drivers showed a higher willingness to switch their route (56.8 percent chose “Yes, I try to avoid congested roadways during the rush hours”) and 29.5 percent of them “always” do this, more frequently than owner-operators (12.2 percent) and for-hire trucks drivers (8.3 percent). It indicated private carrier truckers were more flexible in route choice than owner-operator and for-hire drivers.

LTL carriers were more likely to use the toll road than owner-operators and for-hire carriers. They had high flexibility in route choice but were very strict with schedule. They might use SH 130 often to guarantee on time arrival, which made the frequency discount a big benefit to them.

4.3.3 Other Highly Ranked Incentives

Among all the non-monetary incentives, geometric incentives such as “clear and easy to follow road striping”, “good informational signs”, and “wide shoulders for emergencies” were all very popular. The average score for “dining facilities with better parking lots for trucks” was 2.05, which was the third highest. This incentive was discussed in detail below.

- Dining facilities with better parking lots for trucks

An interesting finding was that the incentive of dining facilities with parking lots for trucks seemed to be a very popular strategy among truck drivers.

Truck drivers’ concern with dining facilities was determined by the particularity of their job and eating conditions. Feuz (2007) considered truck driver jobs as one of America's most unhealthy professions, and the most significant reason was their poor and unhealthy eating habits due to time and service limitations. According to Feuz (2007), because of the increase of compensation and health costs, trucking companies and even the Federal Motor Carrier Safety Administration were involved in reviewing regulations to improve truck drivers’ health. Since some time limit always exists, the dining facilities with better parking lots for trucks can make it more efficient to find a place to park and get a meal. Among all the groups of truck drivers, private carriers had the least interest in this issue. That was because 47.3 percent of them took regional trips rather than long haul trips, so they had more choices for dinner (including their own home) and did not rely on particular diner facilities. On the contrary, for the other four groups of drivers, their long haul trip caused less stability of food supply. They had to depend on certain dining facilities, which made better parking place especially important to them.

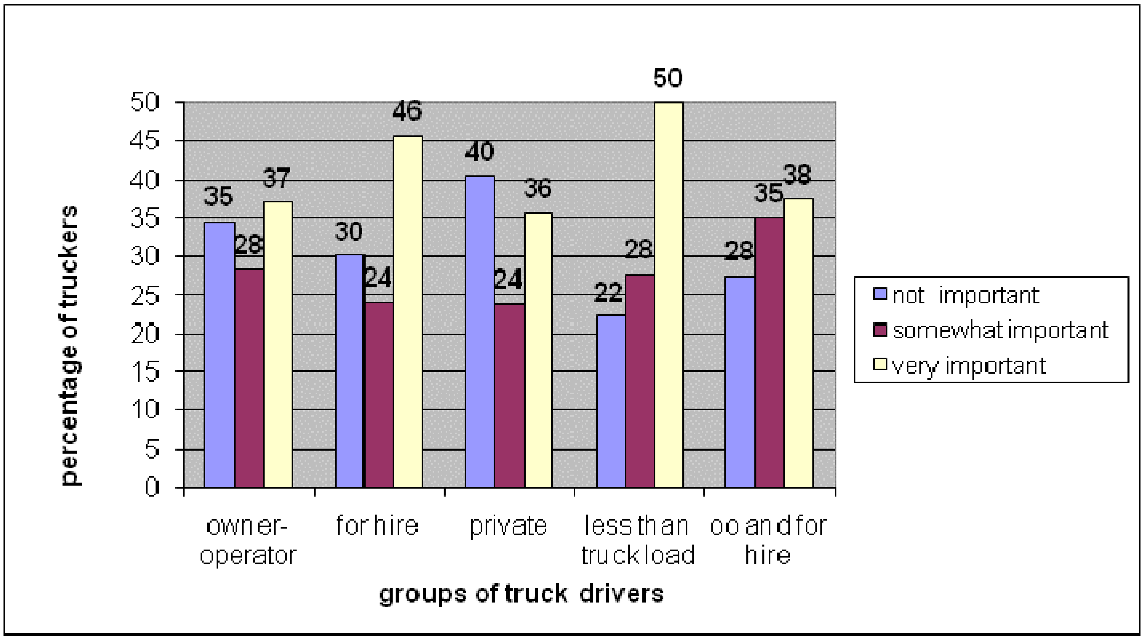

Figure IV-5. Drivers' Responses to Improved Dining Facilities

The other three incentives were all related driving safety and convenience. In addition to the unpopularity of increasing the speed limit incentive, the high ranking of these other safety related incentives indicated safety was a significant concern for truck drivers.

4.4 The Potential Effect of Monetary Incentives on Truckers' Route Choices

The previous section focused on the survey responses to the revealed preference questions, which provided useful information on truckers' characteristics and preferences to incentives. To obtain a better understanding of on truckers' route choices between toll and non-toll facilities, the results of the stated preference questions were analyzed next.

4.4.1 Truckers' Route Choice without Incentives

In the absence of incentives, the first two scenarios of stated preference questions asked truckers' route choice between toll and non-toll roads during peak and off-peak hours under the tradeoff purely between time and toll. The responses to these non-incentive related scenarios could be used as a contrast to the scenarios where incentives were included.

The value of travel time savings (VTTS) is a measurement of truckers' willingness to pay to save travel time. In scenarios 1 and 2, by switching the amount of travel time savings and toll price randomly, different VTTS (reflected by price of travel time saving in this discussion) ranges were created. By examining the percentage of truckers using the toll road within a certain VTTS range, the distribution of truckers' VTTS was obtained.

Since truckers behaved completely differently when making peak and off-peak trips, these two time periods were analyzed separately in this study. However, due to small travel time savings, the price of travel time savings in the off-peak became extremely high, up to $300/hour. As a result, a very small proportion of truckers chose to use SH 130 during the off-peak period. There were only 67 survey respondents among 2023 choosing SH 130 in the off-peak period. The distribution was not calculated given these results.

The percentage of truckers that chose SH 130 during the peak hour, broken into VTTS savings bins, was calculated (see Figure IV-6). The declining distribution curve indicated with the price of travel time going up, the percentage of truckers who chose the tolled route generally decreased. When the given VTTS was smaller than $20/hour (for example, if truckers had to chose between I-35 that took 90 minutes versus SH 130 that took 60 minutes and cost $9, it was a price of VTTS of $18/hour), more than half of the respondents chose SH 130. That was to say more than 50 percent of respondents had a VTTS higher than $20/hour. After the given VTTS exceeded $20/hour, the percentage of truckers choosing SH 130 dropped to around 45 percent. It was noteworthy that this percentage was relatively stable until the VTTS reached $80/hour when the percentage of truckers dropped to 27.3.

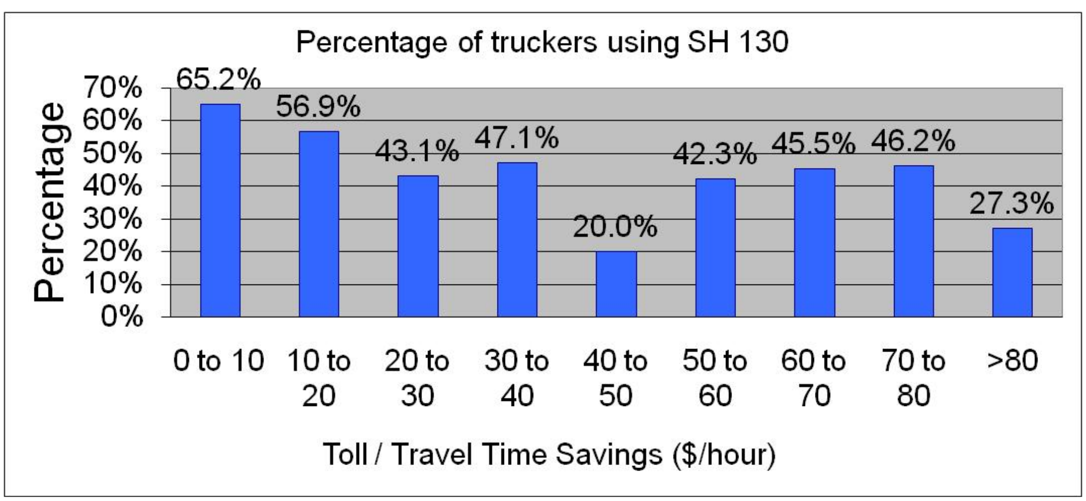

Figure IV-6. Percentage of Truckers Using the Toll Road

In the literature review chapter, Kawamura's study (2000) exhibited a long tailed curve for VTTS, which meant there was a certain percent of truckers whose VTTS was very high. His conclusion could explain the result in this study. When the value/price of travel time savings ranged from $70/hour to $80/hour, 46.2 percent of truckers would use SH 130. Even though when the VTTS exceeded $80/hour, 27.3 percent of truckers would still choose SH 130.

4.4.2 Truckers' Route Choices with Monetary Incentives Applied

Stated preference questions (scenarios) 3 and 4 included monetary incentives for the use of SH 130. Responses to these questions were critical in evaluating potential impacts of incentives on truckers' use of the toll road. As indicated by stakeholders in their interviews, the most efficient incentives to encourage use of toll roads would be those that reduce the cost of using the toll road. Among all the incentives in this survey, five cost-related incentives were selected to be added in the stated preference survey for further evaluation. They were:

- Off- peak discount;
- Fuel price reduced by X cents/gallon;
- Every X^{th} trip on SH-130 is free;
- Free X hours use of in-cab auxiliary units;
- Reduce price of truck wash by $X.

By adding these incentives to the toll road option, truckers' route choices were examined to evaluate the potential attractiveness of these incentives.

Truckers' reactions to these five incentives are shown in Table IV-4. Table IV-4 also includes the average travel time savings (TTS), average toll rate, and average level of the incentive for both the truckers who chose the toll road (with that incentive) and those who chose the non-toll road. It was no surprise that the average travel time savings and levels of incentive were higher for those who chose the toll route.

Table IV-4. Truckers' Responses to Incentives

Incentives	Stated Preference Questions with This Incentive	Truckers' Responses		Percent That Chose the Incentive	Avg. TTS (Minutes)	Avg. Toll ($)	Avg. VTTS ($/Hour)	Avg. Level of Incentives (X)
Off-Peak Discount ($X)	1804	Selected Toll Route	513	28.4	16.07	10.98	40.98	14.00
		Selected an Alternative	1291		9.80	12.45	76.22	10.66
Fuel Price Reduced ($X/gallon)	1753	Selected Toll Road	119	6.8	21.05	24.84	70.81	6.68
		Selected an Alternative	1634		10.54	25.92	147.50	6.51
Every X^{th} Trip on SH 130 Free	1813	Selected Toll Rout	258	14.2	20.33	23.78	70.18	3.94
		Selected an Alternative	1555		10.08	25.86	153.90	3.98
Free X Hours of Use of In-Cab Auxiliary Units	1765	Selected Toll Route	115	6.5	17.70	24.63	83.50	6.21
		Selected an Alternative	1650		10.64	25.23	142.24	5.92
Reduced Price of Truck Wash by $X	137 [A]	Selected Toll Route	19	14.0	27.89	25.53	54.91	9.42
		Selected an Alternative	118		24.92	25.04	60.31	10.65

[A] Due to a glitch in the online survey this incentive was only offered in the paper survey

Based on this simple analysis, the most effective incentive among these five cost related incentives was the off-peak discount, with 28 percent of respondents choosing to use the toll road when this incentive was offered. According to the summary in Table IV-5, the off-peak discount required the least cost of travel time savings among all the incentives for truckers to select this option. For the incentive discount, the average VTTS (the cost of travel time savings) was \$ 40.98/hour; for the other incentives the VTTS ranged from \$ 54.91 to \$ 83.50/hour. Since the discount reduced the cost of truckers' travel time savings, it led to truckers' reassessment of the toll road. As is shown in Table IV-5 more than half of the truckers traveled during the off-peak hours and 45.2 percent of these truckers would like to use the toll road with the off-peak discount. Even for the truckers' who originally made trips during the peak hour, some (31.3 percent) would switch their delivery time to get the benefit from this incentive.

Table IV-5. Choices of Truckers Traveled During the Peak and Off-Peak Hour

Time of Day to Travel	Number of Responses (peak /off-peak)	Number of Responses choosing off-peak discount	Percent Choosing off-peak discount
Peak	48	15	31.3
Off-peak	62	28	45.2

The second most effective incentive was "every X^{th} trip on SH 130 is free", with 14.2 percent choosing to use SH 130 when this was offered. This was another an incentive directly related to truckers' cost. For instance, offering one free trip to the truckers who had used SH 130 three times previously was equal to assigning them a 25 percent toll discount. This toll discount equivalence was very attractive to potential SH 130 users, especially the users who traveled on SH 130 frequently (such as private carriers). The average level of this incentive was around 3.94 (every 4th trip for free).

The result of fuel price discount option in this analysis was somewhat surprising. Only 6.8 percent of truckers chose SH 130 when given the benefit of reduced fuel price. Conversely, from the summary of revealed preference questions, it was found that fuel price discount was the most attractive incentive to truckers. It might be explained by the level of the incentive. The level of this incentive ranged from four to eight cents per gallon, with the average as six cents per gallon. This added up to a considerable dollar amount if the truck could accommodate 200 gallons-but the small cents per gallon may have reduced the attractiveness of this incentive to survey respondents.

Consistent with the findings from the revealed preference analysis, “free X hours use of in-cab auxiliary units” enticed only a small percentage of truckers to use SH 130. Since only truckers who made long distance trips would have to make stops during their trips and use the in-cab auxiliary system, the length of trip directly impacted a truckers’ preference towards this incentive. Long haul truckers were most likely to be interested in this incentive, while the local delivery truckers were not likely to use the in-cab auxiliary system. The choices of truckers by the types of their trips were calculated to provide additional insight to explain the unpopularity of this incentive.

Table IV-6. Truckers' Responses to Free X Hours of Use of In-Cab Auxiliary Units

Types of Trips	Number of Responses	Number of Responses Choosing X^{th} Hours Free Use of In-Cab	Percent Choosing X^{th} Hours Free Use of In-Cab
Regional	31	2	6.5
Long haul	77	12	15.5
Local Delivery	44	0	0

Free X hours use of in-cab auxiliary system was not even popular among long haul travelers. Only 15.5 percent of 77 long haul travelers would use SH 130 with the incentive of free X hours use of in-cab auxiliary units. For regional and local delivery travelers, the percentages that chose SH 130 were 6.5 and 0 percent respectively, which was much lower than long haul truckers. The auxiliary system itself had not yet been used by many truckers. Although the system would benefit the truckers in a long run, seldom truckers had realized this benefit according to the findings from interviews.

The reduced price of the truck wash was in fact not an effective incentive, although it was shown 13.9 percent of truckers would choose SH 130 under this scenario. It was because of the limitations caused by the small sample size. Since this incentive was only used in the paper survey but not in the website survey, only a few respondents (137 responses) were available for the analysis. The average TTS of these respondents was 27. 9 minutes under this incentive, which was much higher than other incentives (less than twenty minutes). As a result, the percentage of trucker who chose SH 130 with this incentive was higher than expected.

Different groups of truckers showed different levels of interest in the five cost-related incentives. From Table IV-7, the percentage of respondents choosing SH 130 at least one time when offered different incentives was calculated by groups. This table was made based on the paper survey, which had both revealed and stated preference data.

Table IV-7. Impact of Incentives by Trucking Group

Trucking Group	Percent Choosing SH 130 at Least Once				
	Off-peak discount ($X)	Fuel price reduced (X cents/gallon)	Every X^{th} trip on SH-130 is free	Free X hours use of in-cab auxiliary units	Reduce price of truck wash by $X
OO	36.1	18.2	29.5	9.1	19.2
For-hire	36.5	26.7	41.5	11.4	16.7
Private carrier	42.0	37.1	32.1	7.5	11.9
Less than Truck Load	28.6	42.9	50.0	0.0	0.0
OO & for-hire	25	33.3	42.9	50	0.0
Total	37.3	28.7	35.8	11.6	14.0

The off-peak discount had the greatest impact on private carriers. 42 percent would choose SH 130 with the application of this incentive, since they often made off-peak trips. Less than truck load truckers chose SH 130 with the fuel price reduced incentive more often than other types of truckers; they also liked the X^{th} trip for free policy. A reduced price of truck wash was generally not an effective incentive. Owner-operators liked this benefit the most. That was because company-owned groups paid or were reimbursed by the companies while owner-operators paid their own bill for a truck wash.

4.4.3 Factors Impacting Truckers' Use of the Toll Road

A detailed analysis was undertaken to establish the relationship between truckers' responses to the four stated preference questions and their characteristics as indicated in the revealed preference questions. The revealed preference questions examined included:

- What type of trucks do you drive? (owner-operators, for-hire truck load carriers, private carrier, less than truck load, the combination of owner-operator & for-hire truckers)
- What is your typical cargo?
- How wide is the delivery window on your typical trip?
- What time of day do you typically make deliveries?
- Who pays the toll when you use a toll road?

First, the truckers were divided into groups based on their answers to the above questions. Then the groups were used to calculated the percentage of truckers who "only chose I-35," "chose SH 130 option at least once" and "chose SH 130 all four times" in the four scenarios of the stated preference questions (see Table IV-8 for results).

This analysis involved both revealed preference data and stated preference data. Unfortunately, a glitch in the survey prevented researchers from matching revealed preference data to stated preference data for on-line respondents. Therefore, only the 187 completed paper surveys were used. Additionally, in order to maintain the consistency of the analysis of the entire paper, all the responses out of the five trucking groups mentioned in the previous chapters were removed. Finally 167 surveys remained with 43 owner-operators, 53 for-hire truckers, 55 private carrier truckers, 8 less than truck load truckers and 8 owner-operator & for-hire truckers. Their responses to the stated preference part of the survey are summarized in Table IV-8.

Table IV-8. Stated Preference Selections by Group

	Percentage of Respondents Who Chose		
	SH 130 at Least Once	I-35 Only	SH 130 Only
Route Choice by Groups			
Owner-Operator	55.8	44.2	4.7
For-Hire	62.3	37.7	15.1
Private Carrier	60	40	12.7
Less than Truckload	62.5	37.5	12.5
Owner-Operator and For-Hire	62.5	37.5	0
Route Choice by Cargos			
Van	59.5	40.5	9.5
High Value	60	40	8.6
LTL	63.2	36.8	10.5
Reefer	59.1	40.9	13.6
Non-perishable	56.3	43.8	8.3
Perishable	55	45	10
Manufactured Goods	58.6	41.4	13.8
Large/Wide Loads	85.7	14.3	11.5
Delivery	60.1	39.9	11
Hazardous Materials	57.7	42.3	7.7

Table IV-8. Table Continued

	Percentage of Respondents Who Chose		
	SH 130 at Least Once	I-35 Only	SH 130 Only
Route Choice by Delivery Window			
A Week or More	80.0	20.0	0.0
4-6 Days	90.9	9.1	27.3
1-3 Days	55.0	45.0	5.0
12-24 Hours	57.7	42.3	19.2
6-12 Hours	70.0	30.0	10.0
2-6 Hours	55.0	45.0	15.0
1-2 Hours	52.4	47.6	4.8
Less than 1 Hour	33.3	66.7	8.3
Route Choice by Delivery Time			
7:00 a.m.-9:00 a.m.	54.2	45.8	8.3
9:00 a.m.-12:00 p.m.	62.5	37.5	13.0
12:00 p.m.-4:00 p.m.	56.5	43.5	15.4
4:00 p.m.-7:00 p.m.	76.9	23.1	25.0
Early Morning (before 7:00 a.m.)	50.0	50.0	0.0
Evening (after 7:00 p.m.)	53.8	46.2	60.0
Route Choice by Who Pays the Toll			
I Pay	53.3	46.7	2.2
My Company	66.7	33.3	15.6
Not Sure	27.3	72.7	11.6
Total	59.9	40.1	10.8

For all groups of truckers, about 40 percent would only use I-35. However, not all groups showed the same interest in SH 130 in all four scenarios. For owner-operators, only 4.7 percent would use SH 130 in all of the four scenarios. It appeared owner-operators might choose SH 130 but only in certain situations (for instance, when I-35 was congested during the peak hour or when some incentives were offered for SH 130). Compared with owner-operators, the three other groups (for-hire truckers, private carrier truckers and less than truck load truckers) had greater likelihood of using SH 130 all the time. That was because owner-operators were "price takers" (the shipper offers a specific amount to transport goods and carriers can accept the price or choose not to take the shipment). Any costs incurred in the transport were the responsibility of the carrier. As a result, they indicated that they could not shift such costs to their customers. Besides, owner-operators had the least bargaining capability for the price of their services. According to the literature review, the trucking industry had been experiencing very intense competition due to the huge number of small businesses (most are owner-operators). This perfect competition environment led to low prices from customers and eventually made the profit margin of the trucking industry very low. All of these characteristics made it less likely for owner-operators to use the toll road. However, for for-hire, private and less than truck load carriers, the transportation was arranged by the company, which took the toll as a part of the cost of running their business. They would be more likely to make a cost-benefit analysis instead of simply avoiding the toll road. Some big companies may even be able to add the toll cost to their contract with their customers, and transfer part of the costs to their customers.

Cargo was another important factor that influenced truckers' route choices. Refrigerated cargo, manufactured goods, and large/wide loads were more likely to use SH 130 than truckers transporting other types of cargo (see Table IV-8). For refrigerated cargo, time was critical. They were supposed to be transported to the destination with minimum time since the quality of the cargo might be impacted. The damage to the cargo would also be added into cost, which increased with increased travel time. This time sensitivity increased their value of travel time savings. For the large/wide load carriers, Vadali et al. (2007) drew the conclusion from a survey that oversized cargo enjoyed more benefits from reduced travel time. Oversized loads would also enjoy the light traffic on SH 130, making transport easier.

Based upon Table IV-8, a wider delivery window was a positive reason to use SH 130 when compared with a narrower delivery window. When the delivery window was wider than three days, fewer truckers would only select I-35. And even more of them would choose SH 130 all the time with a delivery window between four and six days. Since only five responses were in the category of “week or more”, the zero percent of truckers who chose “SH 130 four times” was not reliable data due to the very small sample size. Conversely, when the delivery window was narrower than 1 hour, two thirds of truckers would not choose SH 130 anymore. When managers of delivery companies were interviewed (Geiselbrecht et al. 2008), it was discovered that although the SH 130 facility might allow the grocer to make more deliveries in a given time, this would not be a sufficient incentive to use the toll facility. The manager was also asked whether being able to tell customers when their shipments would arrive, accurate to within a day or two, would be worth the extra fee associated with using toll roads. The manager noted that because deliveries to these customers must be made within a window of only a few hours or less, being able to guarantee delivery within a time frame of a day would not be an adequate incentive to use a toll facility. As a result, a very tight delivery window made the toll road more difficult to satisfy the carriers travel need.

Truckers who traveled during the afternoon peak period were more likely to chose SH 130 at least once. 76.5 percent of truckers indicated they would use SH 130 in at least one scenario. Furthermore, 25.0 percent of truckers traveling in this time period chose SH 130 all four times. That was because during the peak hour travelers suffered from more serious congestion. Using the toll road during this congested period of time meant more travel time savings and as a result the cost of travel time savings become lower.

Who paid the toll was another important factor that impacted truckers' route choices. As expected, if the truckers paid the toll nearly half of them would never use the toll facility. Only 2.2 percent of this type of truckers chose SH 130 all four times. Conversely, if the company paid the toll, 66.7 percent of truckers chose SH 130 in at least one scenario and 15.6 percent chose SH 130 in all four scenarios.

4.5 Modeling Analysis and Results

Next, researchers attempted to fit a route choice logit model to the survey data. Such a model would yield insight to the relative utility each incentive offered truckers, independent of travel time and toll since those would be separate variables. In addition, the value of the travel time and toll rate coefficients provided an average VTTS for the respondents. Unfortunately, a glitch in the survey prevented researchers from matching revealed preference data to stated preference data for on-line respondents. Therefore, only the 187 completed paper surveys were used in the model creation. These 187 respondents answered a total of 748 stated preference questions.

After combinations of similar options in the four scenarios, nine potential mode choice options were relabeled as shown in Table IV-9. In order to build the discrete choice model for SH 130, many combinations and permutations of independent variables were attempted. The final set of variables for the discrete choice model was summarized in Table IV-9. A random parameter logit (RPL) model was used to help account for multicollinearity of answers from the same respondent. By using the random-coefficient model, utility is specified as $U_{nj} = \beta'_n x_{nj} + \varepsilon_{nj}$ with random β_n. (Train, 2003) It allows each variable's coefficient to vary and perhaps even to allow correlations among the coefficients, which can address the limitations of basic logit model. Nested models were also attempted, but did not yield results as good as the RPL.

Table IV-9. Model Specification for SH 130

Utility Function for Mode:	**Variable Description**	**Coefficient Value**	**P-value**
Random parameters in all utility functions	Travel time (min)	-0.056	0.001
	Toll ($)	-0.076	0.002
I-35 during rush hour with severe congestion	The alternative-specific coefficient(ASC)	1.107	0.025
	The dummy variable used to describe if the toll was paid by the trucker, yes = 1, no = 0	0.726	0.004
	The dummy variable used to describe if the trucker or his/her company ran only one truck, yes = 1, no = 0	-0.853	0.003
SH 130 during rush hour with no congestion	The alternative-specific coefficient(ASC)	1.211	0.007
	The dummy variable used to describe if the trucker made long haul trip most often, yes = 1, no = 0	0.899	0.028
	The dummy variable used to describe if the trucker or his/her company ran only one truck, yes = 1, no = 0	-1.577	0.023
I-35 during the middle of the day with light congestion	The alternative-specific coefficient(ASC)	1.467	0.012
	The dummy variable used to describe if the toll was paid by the trucker, yes = 1, no = 0	0.781	0.032
	The dummy variable used to describe if the trucker or his/her company only ran one truck, yes = 1, no = 0	-1.017	0.015
SH 130 during the middle of the day with no congestion (Base Mode)	The dummy variable used to describe if the trucker was an owner-operator, yes = 1, no = 0	-1.885	0.085
	The dummy variable used to describe if the trucker was a for-hire truckers, yes = 1, no = 0	1.206	0.005
SH 130 with off-peak discount, off-peak travel	The alternative-specific coefficient	1.206	0.004
	The dummy variable used to describe if the trucker's delivery window width is narrower than 24hour, yes = 1, no = 0	-0.433	0.218
SH 130 with $0.0X per gallon reduced fuel price, peak period travel	The variable used to describe the level of reduced fuel price ($/gallon) multiplied by the ASC	0.387	0.000

Table IV-9. Table Continued

Utility Function for Mode:	**Variable Description**	**Coefficient Value**	**P-value**
SH 130 with every X^{Th} trip free, peak period travel	The variable used to describe with how many trips the trucker could have a free trip multiplied by the ASC	0.743	0.021
	The dummy variable used to describe if the trucker or his/her company ran more than 1000 trucks, yes = 1, no = 0	1.412	0.002
	The dummy variable used to describe if the trip was made during the peak hour , yes = 1, no = 0	-0.033	0.961
SH 130 with X hours of free in-cab auxiliary unit, peak period travel	The variable used to describe with how many hours that the trucker could use of in-cab auxiliary for free multiplied by the ASC	-0.203	0.335
	The dummy variable used to describe if the trucker was a for-hire truckers, yes = 1, no = 0	0.652	0.267
	The dummy variable used to describe if the trucker made long haul trip most often, yes = 1, no = 0	0.596	0.378
	The dummy variable used to describe if the trucker's delivery window width was narrower than 24hour, yes = 1, no = 0	0.509	0.412
SH 130 with $X off a truck wash, peak period travel	The variable used to describe the level of truck wash discount ($) multiplied by the ASC	0.027	0.976
	The dummy variable used to describe if the trucker drove a semi truck, yes = 1, no = 0	0.568	0.381
Derived standard deviations of parameter distributions	Travel time (min)	0.00011	0.976
	Toll ($)	0.00015	0.967
$\rho^2 = 0.578$	Log likelihood function = -649.6	Percent Estimated Correctly: 47%	
$\overline{\rho}^2 = 0.572$	Number of observations = 747	VTTS=$44.2/hr	

The model results were generally as expected and many of the coefficients were significant. Unfortunately, due to the small number of respondents choosing SH 130 with certain incentives, not all results were significant at the 95% level of confidence or were as expected. Most of the alternative specific coefficients for SH 130 use with an incentive were positive, indicating increased utility of that mode over using SH 130 without a discount or incentive (the base mode). The highest and second highest ranked alternative coefficients were off-peak discounts and a free trip after a number of paid trips, 1.206 and 0.743 respectively. These were the same ranks as the results listed in Table IV-4, which exhibited the popularity of each alternative. It reconfirmed that off-peak discounts and a free trip after a number of paid trips were the most popular incentives. Unexpected results included that the free auxiliary unit usage had a negative specific coefficient and the truck wash discount coefficient was quite small. This was indicative of the fact so few respondents selected either option. Additionally, these two values failed to reach the 95% level of confidence, and therefore could not be used to draw any conclusions.

The alternative specific coefficients (ASC) for modes (1) SH 130 during the peak period, (2) I-35 during the peak period, and (3) I-35 during the off-peak period were positive and significant. This indicated a preference for the toll-free alternative (I-35) or SH 130 during the peak. As expected, the base mode, SH 130 during the off-peak, had the lowest ASC of those that were significant. SH 130 was not a choice for the truckers during the off-peak hour. The modal results also confirmed the conclusion on the impacts of important characteristics discussed in section 4.4.3. For instance, for the mode "I-35 during the middle of the day", the coefficients of the dummy variable used to describe if the toll was paid by the trucker was 0.781. It showed paying the toll by the carriers themselves made them more likely to use the non-toll road during uncongested period of time. This corroborated the result in Table IV-8, truckers who paid the toll by themselves would be more likely to use I-35 only. For the mode "SH 130 middle of day", the coefficients of "if the trucker was a for-hire trucker" was 1.206, which indicated being a for-hire trucker would be a positive factor to use SH 130.

The resulting value of travel time savings was \$ 44.2 per hour. This was in the range found in the literature and in-line with the one-on- one interviews (\$ 40 per hour). This value of VTTS was also within the range \$ 30 to \$ 70 as calculated under non-incentive condition.

Toll elasticities were also calculated to examine truckers' reaction to the change of toll price. The elasticity could be calculated as:

$$E = -\frac{\Delta Q / Q}{\Delta P / P}. \qquad \text{(IV-1)}$$

where,

E= elasticity

ΔQ = numbers of truckers that shifted by changing toll price

Q = initial total number of truckers

ΔP = amount of toll price changed

P = initial toll price

In this study, tolls kept changing in all of the nine modes. The number of truckers who selected the toll option was different with different toll prices. Since the toll prices and truckers' choices were both available in the model, by setting the toll as the "effects variable" for each mode using limdep, the toll elasticities were calculated for all the modes with respect to the changing tolls. The results are listed in Table IV-10.

Table IV-10. Truck Incentive Elasticities

Toll Options	Elasticity
SH 130 Peak	–0.922
SH 130 Off-Peak	–0.745
SH 130 Off-Peak Discount	–0.202
SH 130 Reduced Fuel Price	–0.238
SH 130 X^{th} Trip Free	–0.283
SH 130 Free Hours of Use of In-Cab Auxiliary Unit	–0.288
SH 130 Truck Wash Discount	–0.297

The elasticities for "SH 130 peak" and "SH 130 off-peak" were very high (–0.922 and –0.745, respectively). Elasticities estimated in Central Texas Turnpike System (CTTS) Traffic and Revenue Report (2005), update were also high. In the estimation of the peak hour, the toll elasticity on SH 130 was –0.68, while during the off-peak hour it was –0.6. In that report, the elasticity was calculated based on the increased toll price. It is reasonable to get a very high elasticity when the toll went up, since a lot of truckers would shift back to the non- toll road. The elasticities researchers calculated for other options (SH 130 with incentives) were between –0.2 and –0.3, which were within the range of typical transportation elasticities found in the literature. However, the big difference of in elasticities among all the alternatives brings into question the accuracy of the model and means that the elasticities were not used directly to calculate shifts in truck travel.

In order to evaluate the effectiveness of the incentives, simulations were conducted using different packages of incentives. The initial model with no incentive estimated that approximately 30 percent of trucks would use SH 130, when given the 37 minutes of travel time savings (approximately 63 minutes traveling on SH 130 while 100 minutes traveling on I-35) and $25.00 in tolls. The median levels of incentives were used to examine the potential impacts of the incentives (for instance, fuel discount ranged from $0.04/gallon to $0.08/gallon, so $0.06/gallon was used for the simulation). It was found in order to achieve a 10 percent shift in peak-period trucks, the combination of a $10 price reduction for a truck wash and a 33 percent off-peak toll discount would be the cheapest choice for the toll authority; to achieve a 20 percent shift in peak-period trucks, combination of a reduction in the fuel price by $0.06/gallon and every fourth trip free should be applied; in order to achieve a 30 percent shift in peak-period trucks, the combination of a reduction in the fuel price by $0.06/gallon, a 33 percent off-peak discount, and every fourth trip free would be cheapest (Note that this incentive combination did not achieve a full 30 percent shift in trucks but was one of the highest at 27.3 percent).

In summary, the model results showed the value of travel time savings was $ 44.2 per hour. Incentives generally increased the utility of SH 130 mode over the base mode of SH 130 with no incentive, although the incentive of free hours of in-cab auxiliary unit did not. Among all the incentives, off-peak discount and every X^{th} for free were the most popular ones. There were some other factors that also impacted truckers' mode choice. For instance, paying the toll by themselves made the truckers less likely to use the toll road and being a for-hire trucker had positive impact on the truckers' use of the toll road. 10, 20, 30 percent shift in trucks to SH 130 could be realized by using different packages of incentives.

CHAPTER V

CONCLUSIONS

5.1 Conclusions

In this research, truckers' travel behavior regarding toll roads was examined, which included truckers' travel demand on the toll road under the tradeoff of cost and travel time and their reactions to the changing toll price. Also, the effectiveness of potential incentives were evaluated, especially monetary incentives. An examination of the variation of different trucking industry groups and their reactions to the toll road and the incentives was also conducted. These analyses were based on survey data of truckers in the Austin area.

The average value of travel time savings of trucks around the Austin area was calculated as $44.20 per hour using the coefficients in the travel demand model developed in this study. Stated preference responses were also summarized to determine the reasonable range of the value of travel time savings. The results showed that as the cost of travel time savings increased, the percentage of truckers using SH 130 decreased. The reasonable range for value of travel time savings (VTTS) which was accepted by more than 40 percent of truckers choosing SH 130 was $ 30 to $70 per hour.

Different incentives had different levels of effectiveness in impacting truckers' route choices. By calculating the average score obtained by each incentive, it was discovered monetary incentives were the most popular ones. The percentage of truckers who selected the toll road was calculated for each incentive. It was found among all the price-related incentives, off-peak discounts and a free trip after a number of paid trips were the first and second most popular incentives. Modeling results reconfirmed this conclusion that generally, incentives had a positive impact on truckers' use of the toll road and off-peak discounts and a free trip after a number of paid trips had the greatest positive impact.

Furthermore, significant differences existed in travel behavior and incentive preference among different groups of truckers due to the variation of their characteristics. By conducting a group comparison among five trucking industry groups and summarizing their different reactions towards the toll road, it was found that smaller companies (owner-operators) were least likely to use SH 130 while big companies, such as for-hire and private carriers, indicated a greater likelihood of using SH 130. This can partially be explained by the fact owner-operators were price takers with very low profit margins, while large companies counted toll costs as a part of their business expenses and had some opportunity to pass this cost on to their customers. They also reacted differently to incentive preferences. Toll and non-toll road choices by truck group choices by truck group were summarized under each incentive in order to examine the truckers' reactions towards incentives by group. Owner-operators liked the incentive of reduced fuel price the most, while private carriers exhibited strong interest in the off-peak discount. Those could be explained by their characteristics, since owner-operators paid the fuel price all by themselves, they would like to reduce their operational cost as much as possible while large proportion of private carriers made the off-peak trips, the off-peak discount could benefit them more.

5.2 Recommendation for Future Research

Since trucking industry groups reacted quite different to the route decisions based on potential incentives, additional research should be conducted to determine the reasons for these differences.

This research included a couple of key limitations. First, the absence of information on the existing distribution of different groups of truckers traveling in the Austin area means that we do not know if the percentage of each group among survey respondents might be different from the real percentage of each group on the road. In the future study, this bias should be removed with sufficient data on the real local carrier distribution. Additionally, the inability to link RP and SP data for internet based surveys meant any mode choices models were built using a relatively small sample.

In future studies, more factors which might impact truckers' travel behavior can be evaluated in a route choice logit model. Revenue studies can be accomplished based on the traffic forecasting. By forecasting the changing of truck traffic under different incentive packages, the costs and benefits of applying these incentives can be eventually estimated.

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APPENDIX

Texas Truck Survey

Part I: Truck Classification

1. What type of truck do you drive? *Check* **ALL** *that apply*

☐ – Owner-Operator
☐ – For-hire Truck-Load Carrier (such as Koch Logistics, Con-Way)
☐ – Private Carriage (truck is owned by the same company that owns the freight being hauled - such as HEB)
☐ – Less-than truck-load (terminal to terminal)
☐ – Local delivery (such as Federal Express)

2. How many trucks are operated by you/your company?

☐

3. What type of route do you most often run? *Choose only* **ONE** *of the following*

☐ – Regional (less than 250 miles each way)
☐ – Local / Delivery
☐ – Long Haul (more than 250 miles one-way)
☐ – No answer

4. What type of vehicle do you drive? *Choose only* **ONE** *of the following*

☐ – Single Unit 2-axle
☐ – Single Unit 3-axle
☐ – Single Unit 4-axle
☐ – Semi (all Tractor Trailer combinations)
☐ – Other: ☐
☐ – No answer

5. What is your typical cargo? *Check* **ALL** *that apply*

☐ – Van/General Freight
☐ – Manufactured Goods (automotive parts, furniture, etc.)
☐ – High value (electronics, etc.)
☐ – Large/Wide Loads (Mobile Homes, etc.)
☐ – LTL/Package
☐ – Delivery (Florist, etc.)
☐ – Reefer (refrigerated)
☐ – Hazardous Materials
☐ – Non-Perishable
☐ – Other: ☐
☐ – Perishable

Part II: Delivery Flexibility

6. How wide is the delivery window on your typical trip? *Choose only* **ONE** *of the following*

☐ – A week or more
☐ – Between 4 and 6 days
☐ – Between 1 and 3 days
☐ – Between 12 and 24 hours
☐ – Between 6 and 12 hours
☐ – Between 2 and 6 hours
☐ – Between 1 and 2 hours
☐ – 1 hour or less
☐ – No answer

7. What time of day do you typically make deliveries? *Choose only* **ONE** *of the following*

☐ – Early morning (before 7:00 am)
☐ – 7:00 am - 9:00 am
☐ – 9:00 am - 12:00 pm
☐ – 12:00 pm - 4:00 pm
☐ – 4:00 pm - 7:00 pm
☐ – Evening (after 7:00 pm)
☐ – No answer

8. If you are late with a shipment or delivery, what sort of penalties might you face? *Check* **ALL** *that apply*

☐ – Late delivery fines
☐ – Refund of fees
☐ – Lose shipping contract
☐ – Verbal reprimands
☐ – Lose my job
☐ – Refused shipment
☐ – None
☐ – Other: ______

Part III: Route Choice

9. Who is in charge of making your route decisions? *Choose only* **ONE** *of the following*

☐ – I am
☐ – My boss
☐ – Logistics manager
☐ – Company policy
☐ – Other: ______
☐ – No answer

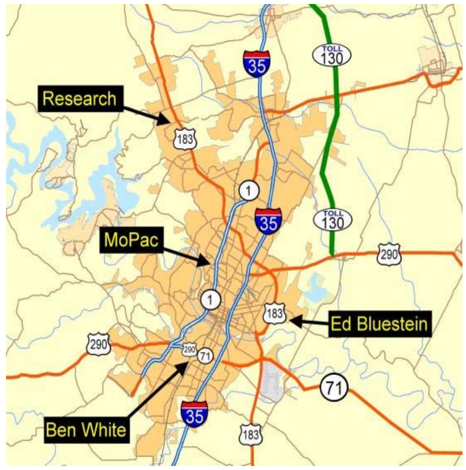
10. Who pays the toll when you use a toll road? *Check* **ALL** *that apply*

☐ – I do (comes out of my pocket)
☐ – Unsure, as I have never taken a toll road
☐ – My company does (they either use a toll tag or reimburse me for any tolls I pay)
☐ – Other: ______

Part IV: Current Travel Around Austin

11. What roads do you frequently travel on most in the Austin area? *Check* **ALL** *that apply*

☐ – Interstate 35
☐ – Highway 130 (toll road)
☐ – Highway 290 East
☐ – Highway 290/71 West (Ben White Blvd.)
☐ – Loop 1 (MoPac)
☐ – Highway 183 East (Ed Bluestein Blvd.)
☐ – Highway 183 North (Research Blvd.)
☐ – Highway 71 East



12. What time of day do you typically start driving?

Hour : Minute [:] O **AM** O **PM**

HH : MM

13. What time of day do you typically stop driving?

Hour : Minute [:] O **AM** O **PM**

HH : MM

14. How often do you drive through the Austin area on I-35? *Choose only* **ONE** *of the following*

☐ –Multiple times a day
☐ –Once a day
☐ –A few times a month
☐ – No answer
☐ – A few times a week
☐ – Every few months
☐ – Never

If you choose "Multiple times a day", please answer this question:
How many times per day on average? [ ]

15. Do you change your driving based on traffic congestion in Austin? *Check* **ALL** *that apply*

☐ –Yes, I try to avoid congested roadways during the rush hours → Go to question 16
☐ –Yes, I try to avoid driving during rush hours→ Go to question 17
☐ –Yes, I try to avoid all of Austin during rush hours→Go to question 18
☐ –No, I do not have a choice on when or where I drive→Go to question 18

16. How often do you change your route during rush hours to avoid traffic congestion?
Choose only **ONE** *of the following*

☐Never ☐Occasionally ☐Half the time ☐ Often ☐Always

☐No answer

17. How often do you change your schedule to avoid rush hours? *Choose only* **ONE** *of the following*

☐Never ☐Occasionally ☐Half the time ☐ Often ☐Always

☐No answer

Part V: Use of Toll Roads

18. State Highway 130 is a toll road east of Interstate 35 that, when completed, will allow travelers to bypass the central Austin area. **How would each of the following change your use of SH 130?**

Please rank your choices on a scale of 1 to 3, with 1 being a feature that is unimportant to you, up to 3 a critical feature that greatly increases your use of SH130	1 Unimportant /No Change	2 Somewhat Increases	3 Greatly Increases	No answer
Larger, well maintained truck stops with $10 off the cost of a truck wash	☐	☐	☐	☐
Reduced fuel prices	☐	☐	☐	☐
Off-peak toll discounts	☐	☐	☐	☐
Dining facilities with better parking lots for trucks	☐	☐	☐	☐
Truck repair facility	☐	☐	☐	☐
Wider lanes for large loads	☐	☐	☐	☐
Truck stops with in-cab auxiliary power systems (such as IdleAire)	☐	☐	☐	☐
When you pay for three tolled trips you get a fourth trip toll free	☐	☐	☐	☐
80 mph truck speed limit on SH 130	☐	☐	☐	☐
Longer Combination Vehicles (LCV, wiggle wagons) allowed on SH 130	☐	☐	☐	☐

19. Please indicate the how following factors that would influence your use of SH130.

Your Choices:	1 Unimportant	2 Somewhat Important	3 Very Important	No answer
11. Higher speed limits	☐	☐	☐	☐
12. No Congestion	☐	☐	☐	☐
13. Separate lanes for cars and trucks	☐	☐	☐	☐
14. Travel time information	☐	☐	☐	☐
15. Wide travel lanes	☐	☐	☐	☐
16. Good lighting of the road	☐	☐	☐	☐
17. Long on and off ramps	☐	☐	☐	☐
18. Clear and easy to follow road striping	☐	☐	☐	☐
19. Good informational signs	☐	☐	☐	☐
20. Wide shoulders for emergencies	☐	☐	☐	☐

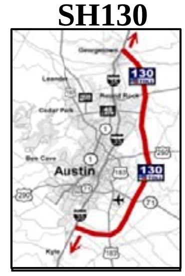
Travel Scenarios

There are four options to choose from for your typical trip through the Austin area. These options will either include toll roads (like SH-130) or toll-free roads (like I-35). They will also have different times of day and levels of congestion. We would like to know which of the four options you would pick.

Highway Choices: *Choose your preferred option for each of the four scenarios*

I-35

SH130



Scenario 1 of 4				
	A	**B**	**C**	**D**
Time of Day	Rush hour	Rush hour	Middle of day	Middle of day
Route	I-35	SH-130	I-35	SH130
Congestion	severe	none	light	none
Toll	$0.00	$20	$0.00	$20
Travel Time	65 minutes	50 minutes	45 minutes	50 minutes
SELECT ONE ->	☐	☐	☐	☐

Scenario 2 of 4				
	A	**B**	**C**	**D**
Time of Day	Rush hour	Rush hour	Middle of day	Middle of day
Route	I-35	SH-130	I-35	SH130
Congestion	severe	none	light	none
Toll	$0.00	$25	$0.00	$25
Travel Time	70 minutes	50 minutes	50 minutes	50 minutes
SELECT ONE ->	☐	☐	☐	☐

Scenario 3 of 4			
	A	**B**	**C**
Time of Day	Rush hour	Rush hour	Rush hour
Route	I-35	SH-130	SH-130
Toll	$0.00	$20	$20
Incentive	None	Fuel price reduced by 7 cents/gallon	Every 3rd trip on SH-130 is free
Travel Time	65 Minutes	50 minutes	50 minutes
SELECT ONE ->	☐	☐	☐

Scenario 4 of 4			
	A	**B**	**C**

Time of Day	Rush hour	Off-peak	Rush hour
Route	I-35	SH-130	SH-130
Toll	$0.00	$14	$20
Incentive	None	Reduce the price to $14 during Off-peak	Free 7 hours use of In-Cab Auxiliary Units
Travel Time	65 Minutes	50 minutes	50 minutes
SELECT ONE ->	☐	☐	☐

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