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16. Abstract

Direct user fees based options are gaining further momentum all across the United States and particularly in the state of TX. The success of such ventures or projects requires a clear assessment of demand for toll roads among the potential user groups. However, there is too little information about the trucking industry as far as their attitude towards toll roads is concerned. This lack of attention to response patterns can lead to optimism bias in truck toll forecasts. Through literature reviews, Texas specific focus groups, and surveys this study aims to establish the range in demand variation and route preferences for tolled roads across various segments of the trucking community. Fuel prices are found to influence route choices and consequently toll road revenue forecasts. In addition to fuel costs, the other trade-offs that emanate from this study include cargo characteristics, haul characteristics, etc. Therefore a better understanding of the demand structure of the trucking firms requires all the relevant trade-offs be taken into consideration.

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# TRUCKING INDUSTRY RESPONSE IN A CHANGING WORLD OF TOLLING AND RISING FUEL PRICES


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# ABSTRACT

Direct user fees based options are gaining further momentum all across the United States and particularly in the state of TX. The success of such ventures or projects requires a clear assessment of demand for toll roads among the potential user groups. However, there is too little information about the trucking industry as far as their attitude towards toll roads is concerned. This lack of attention to response patterns can lead to optimism bias in truck toll forecasts. Through literature reviews, Texas specific focus groups, and surveys this study aims to establish the range in demand variation and route preferences for tolled roads across various segments of the trucking community. Fuel prices are found to influence route choices and consequently toll road revenue forecasts. In addition to fuel costs, the other trade-offs that emanate from this study include cargo characteristics, haul characteristics, etc. Therefore a better understanding of the demand structure of the trucking firms requires all the relevant trade-offs be taken into consideration.

# EXECUTIVE SUMMARY

## Research Scope and Objectives

In a recent Transportation Research Board document "Critical Issues in Transportation", inadequate revenue to finance capital needs in surface transportation was identified as a primary motivation to explore alternative revenue sources such as road tolls. As Texas and several other states consider large scale tolling and the possibility of exclusive truck lanes, it is quite surprising to see that the trucking sector remains understudied. Trucking is currently the dominant mode of freight transportation – earning nearly 75% of the transportation industry's revenues while moving only 25% of the ton-miles – and this situation is likely to remain unchanged in the future.

Fuel constitutes the second largest expense for most of the trucking companies, only next to labor. However, it is not clear how toll roads are viewed in the context of rising operating costs relating to fuel. Nor is it clear what the trade-offs are and how those trade-offs might manifest in route decision and of even greater interest is how those decisions and trade-offs might vary across a broad spectrum of truckers. As Texas moves along to develop toll roads and tolls on trucks, this research provides a key first step in understanding the trade-offs, perceptions, and constraints faced by the trucking firms. To that end, a two pronged approach is taken up.

First, this study examines the route choice decision of truckers in the presence of tolling in an effort to understand the demand for (and consequently diversion to) tolled routes. Next, the role of rising fuel prices is examined for its influence on demand for tolled routes and the demand side risk associated with truck tolls. Keeping these two broad tasks in background, the report is organized in the following manner. Chapter 1 provides the motivation behind this research by identifying the key problems including trends in fuel prices. Chapter 2 takes up the issue of optimism bias with truck toll forecasts as a demand side problem. Several sources of demand side risk are identified. In particular, this chapter focuses on ignorance of operating cost especially running costs like fuel costs as a demand side factor and the lack of user heterogeneity in terms of willingness to pay. Chapter 3 revisits the state of the practice in modeling toll road demand and identifies several theoretical as well as practical limitations therein. In particular, some of the problems with stated choice models and the idea of bounded rationality are brought into the discussion as implemented in diversion and revenue forecasts. Chapter 4 establishes the heterogeneity among trucking firms in terms of their operating characteristics and builds up several hypotheses pertaining to route choice behavior of trucking firms. While Chapter 4 builds upon the existing literature in relation to the industrial structure, Chapter 5 narrows the focus down to the state of Texas. Based on three Focus Group studies and a case study, several complementary hypotheses are developed with respect to perception of toll roads among Texas carriers and the impact of fuel prices on route choice decisions involving tolls. In Chapter 6, several of the hypotheses emanating from Chapters 4 and 5 are analyzed using the survey deployed with the help of American Trucking Research Institute to trucking groups like Texas Motor Transport Association and other groups. Chapter 7 establishes the potential for simulation modeling in dealing with the problems enumerated in Chapter 2. This chapter incorporates three of the key insights that emerged from the previous chapters:

I. Risk analysis can be particularly useful in order to examine optimism bias. As a methodological advancement, Stochastic Dominance analysis is presented as a methodological improvement over direct simulation aiding the objective ranking of stochastic variables and distributions (volume and revenue).
II. Demand variation is a crucial factor behind truckers choice for toll routes and disregard for this aspect in demand/revenue estimations can lead to forecast error.
III. Role of operating costs as a demand side factor is factored in. The simulation analysis establishes that lack of attention to operating cost savings (or losses) can also lead to biased picture of the demand for toll roads.

Finally, Chapter 8 summarizes the findings and provides some key recommendations for planning toll roads. Also provided are recommendations on the informational aspects of planned tolled routes so that truckers can use the material in their internal cost benefit algorithms. Figure 1outlines the chapter content and issues by broad area and also presents the linkages across chapters.

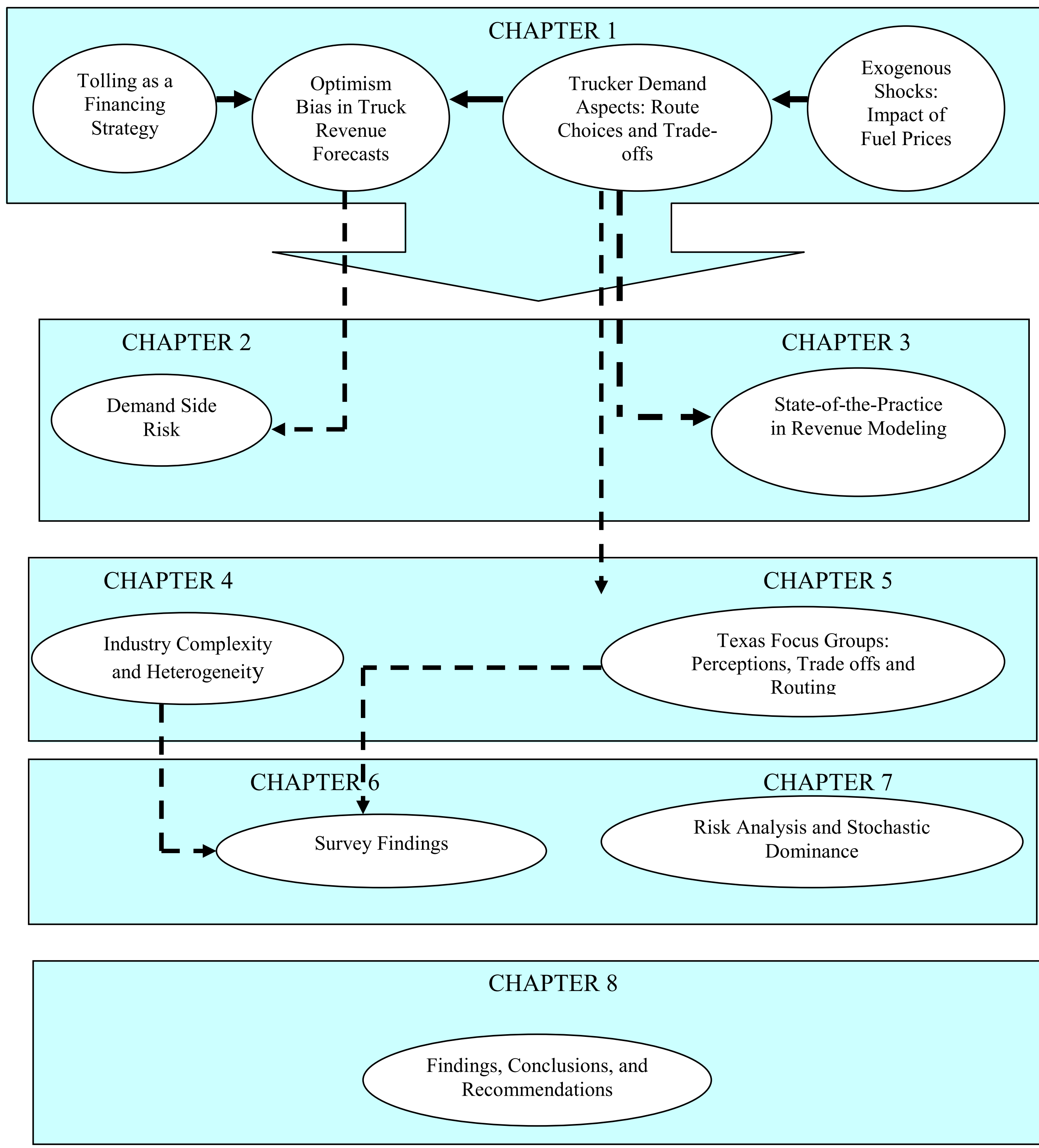


**Figure 1 Project Report Layout**

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Special thanks to the focus group participants of the Transportation Clubs of Houston and Dallas, OOIDA and all the survey participants.

# CHAPTER 1. INTRODUCTION

Surface transportation involves complex interactions between the key players including direct users like trucking industry as well as indirect user groups comprising of shippers, consumers, etc. To conduct feasibility analyses of proposed policies (say construction of a toll road), it is therefore imperative to understand how these different stakeholders view them. In this paper we are looking into a subset of these groups, viz. the truckers, given the importance of this industry to the overall supply chain. This research is motivated by a couple of observations.

First, in the event of inadequate resources to fund surface transportation, TX and several other states are exploring alternate avenues to create new and expand existing highways. With federal and fuel taxes inadequate to meet the increasing traffic and maintenance costs, options like funding highways through direct user fees and particularly truck toll options are gaining further momentum.

Second, in the light of Bain (*1-3*) and NCHRP Synthesis Report (*4*), it is important to quantify the sources of *optimism bias*, which can be defined as consistent overestimation of toll traffic and revenue. In particular, this bias is a rather disquieting feature of truck toll road forecasts. The response of the trucking industry to tolls remains a crucial factor for the financial feasibility analysis behind proposed toll roads. How the demand of the trucking industry is being modeled is therefore a critical factor to examine. In this study, the issue of truck toll forecasts is taken up as a demand side problem.

Third, the behavioral response to tolls needs to be understood in the light of the "critical issues" for the trucking industry as enumerated in Top Industry Issues (*5*). With significant rise in different components of operating costs, the already contentious issue of highway funding through tolls is becoming even more challenging. While there does exist documentation of adverse effects of rising fuel prices on the trucking industry (Stinson (*6*), Kilcarr (*7*)), the literature falls short of addressing one critical issue in this respect. Specifically, as the Industry Issues document (*5*) points out, perceptions to tolling itself need to be understood better and fuel prices add yet another dimension to this aspect since it is not clear how toll roads are viewed in the context of rising operating costs.

With the removal of regulatory barriers, there has been increase in competitive pressure and entry of more firms with significant decline in the rates – thereby making the firms even more constrained in passing on the toll costs to their customers. In the light of these factors, it is it is important to assess what the trade-offs are and how these trade-offs might manifest through their route choices. Of even greater interest is how these decisions and trade offs might vary across a broad spectrum of truckers.

A key objective of this research is to obtain a better understanding of how different segments of the industry approach route choice decisions in the presence of tolls and rising fuel costs. In order to address this issue, we examine both the existing literature and conduct focus groups and survey analysis specific to the Texas trucking community. A secondary objective is to link this understanding of route choice processes to the demand side risk associated with truck toll forecasts. Finally, based on this research, several recommendations are provided that can aid truck toll road planning efforts.

## 1.1 FUEL PRICE TRENDS

Over the time period 1993-2006, the average retail prices of gasoline and diesel have been increasing, with a steeper rise evident during the last four years (Figures 2 and 3).

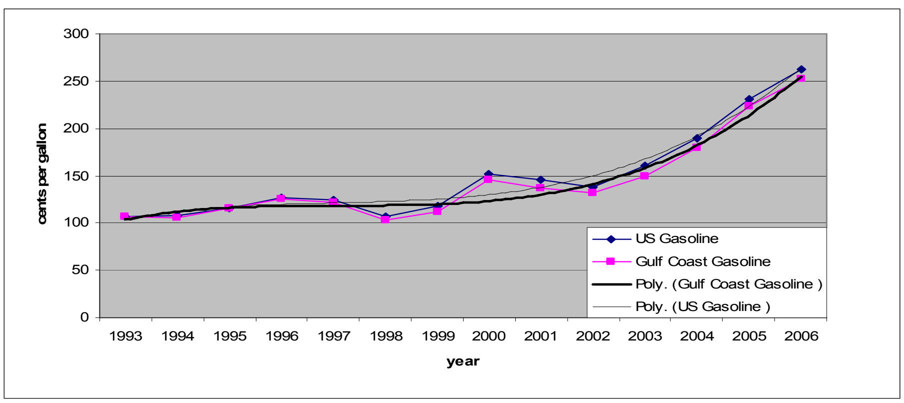


**Figure 2 Trends in Gasoline Prices** (Source: http://www.eia.doe.gov)

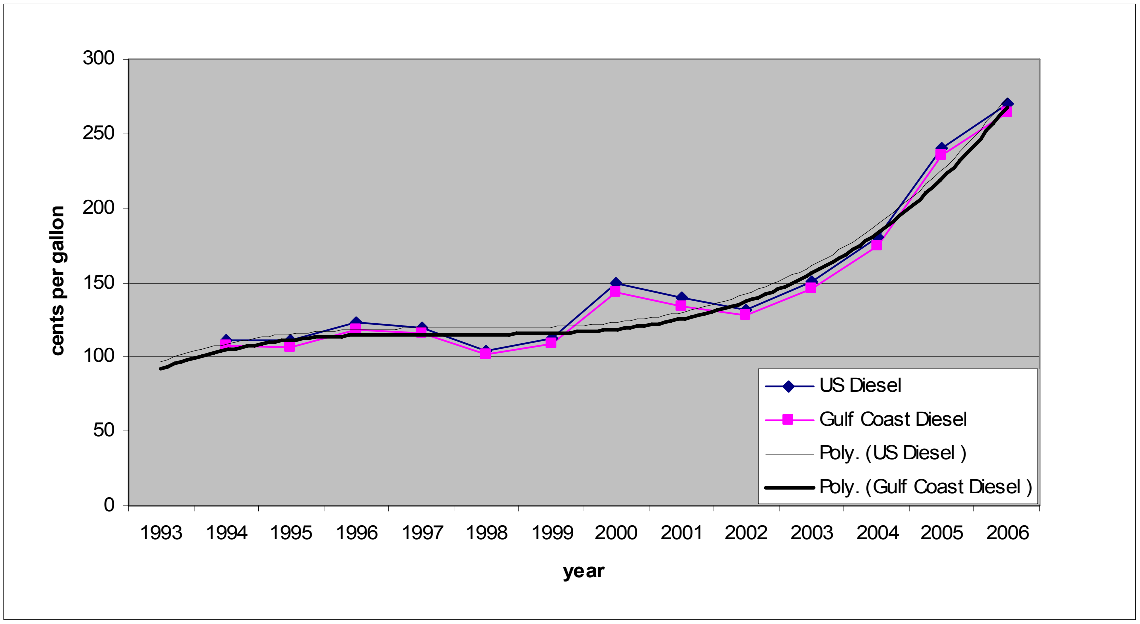


**Figure 3 Trends in Diesel Prices** (Source:http://www.eia.doe.gov/)

At the regional level, Figure 4 demonstrates the upward trend exhibited by regular gasoline prices within Texas.

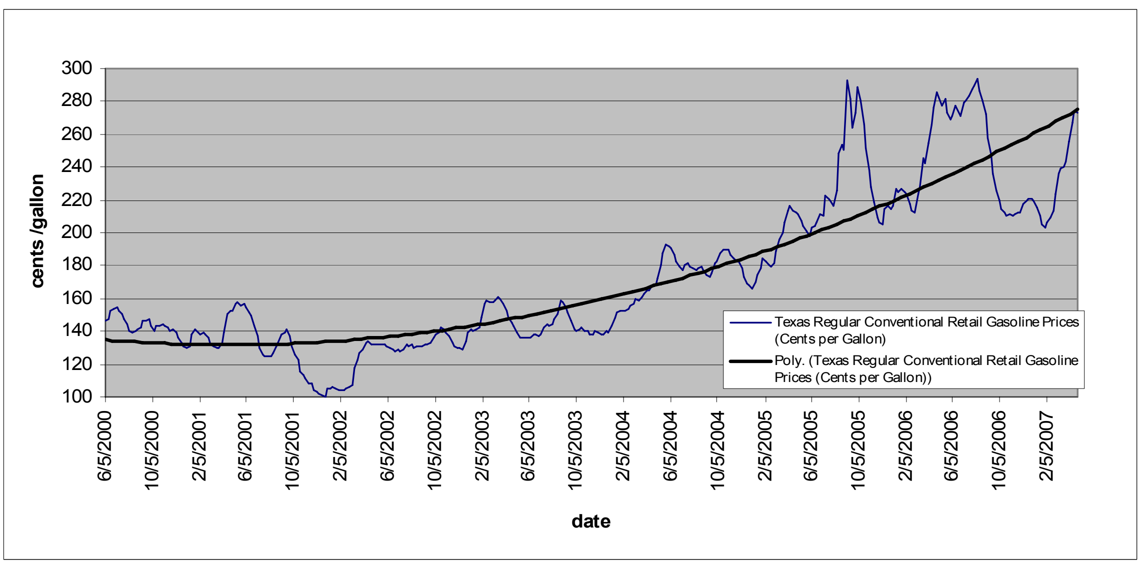


**Figure 4 Trends in Regular Gasoline Prices**
(Source:http://www.eia.doe.gov/oil_gas/petroleum/data_publications/wrgp/mogas_history.html)

Given that fuel accounts for roughly 20-25 % of the operating cost of trucks, persistent increases in fuel prices can impact the industry adversely. With specific reference to tolling applications, the high degree of competition creates problem in absorbing the changes in fuel prices or toll rates through changes in freight rates. There is already anecdotal evidence of extensive trucking company bankruptcies in an era of rising operating costs (particularly due to fuel price increases). This is especially in the light of the competitive environment in which trucking rates are made. Figure 5 shows the trend in company bankruptcies in relation to fuel price increases. This would suggest that during periods of exogenous shocks as what is being experienced recently, the emphasis would be on cost-cutting measures and avoidance of additional costs including new toll costs.

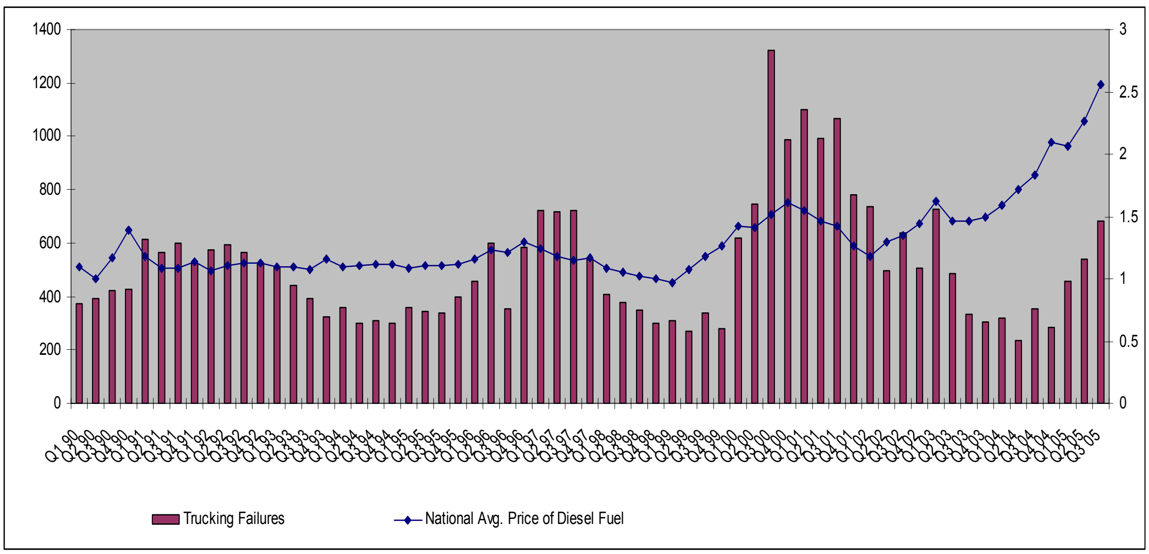


**Figure 5 Trucking Failures and Fuel Prices (1990-2005)**
(Source: A G Edwards and American Trucking Association)

The literature suggests that fuel surcharges as a way to deal with fuel price fluctuations either do not exist, and when they exist, they are characterized by some kind of *stickiness* or inability to match the price rise during the period of the contract. While anticipated changes might be taken care of, unanticipated change in fuel prices are not easy to recoup in the presence of long term binding contracts (*8*).

It is extremely important to appreciate that the rise in fuel price is not going to affect all the trucking firms identically. Broadly speaking, the companies with smaller fleet and owner operators are affected the most, since smaller carriers are typically characterized by larger fuel costs as proportion of total operating costs (*9*). Nevertheless, almost all firms get adversely affected by the rise in fuel prices, depending on their cost structure and other operational characteristics.

The adverse effect of rising fuel prices on toll revenue merit attention at this point. The New Jersey Turnpike and Garden State Parkway, for instance, saw a dip in toll revenues by $ 5 million, as an aftermath of gas price hike post Hurricane Katrina (Higgs (*10*). On a similar note, traffic volumes dipped in 2007 on the Ohio Turnpike and factors such as gas prices and economy were believed to have contributed this decline (*11, 12*). While natural disasters are rare, one cannot rule out the consistent increase in fuel price following oil market dynamics. Likewise, the Official statement for Austin's 183A toll road indicated the possibility of making losses over the next forty years in the event of fuel prices exceeding $3 (Costello (*13*). On the other hand, in the state of Texas, analysis of volume and revenue data from Sam Houston Tollway provided by Harris County Toll Authority (HCTRA) show generally improving trend with only a temporary dip in revenues while volumes remained relatively captive. These are shown in Figure 6 for 3 + axles on all HCTRA tollways with 3+ axles constituting about 2-3% of total tollway volumes and Figure 7 for revenues and total volumes. With much fewer tolled roadways, Texas provides a mixed perspective with low commercial vehicle volumes on existing tollways like Dallas North Tollway and HCTRA systems of tolled routes, on one hand. On the other side, there are also examples of failed experiments like the Camino Colombia toll road.

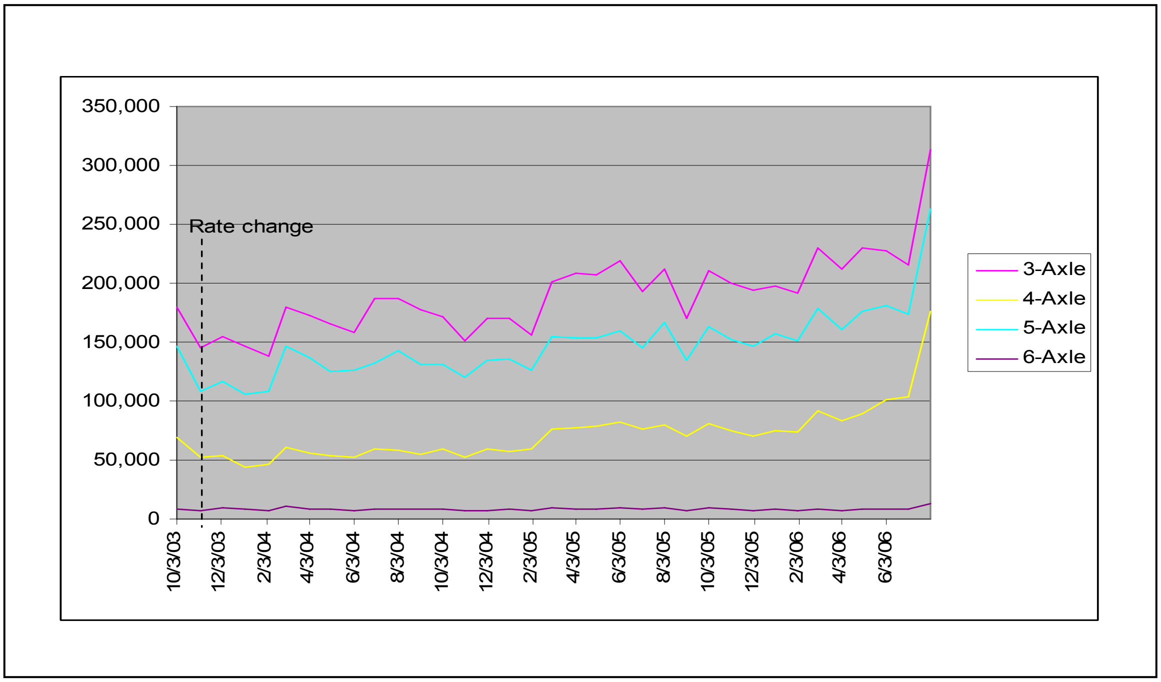


**Figure 6 Volumes of 3 + Axles Vehicle on Harris County Tollways (2003-2006)**

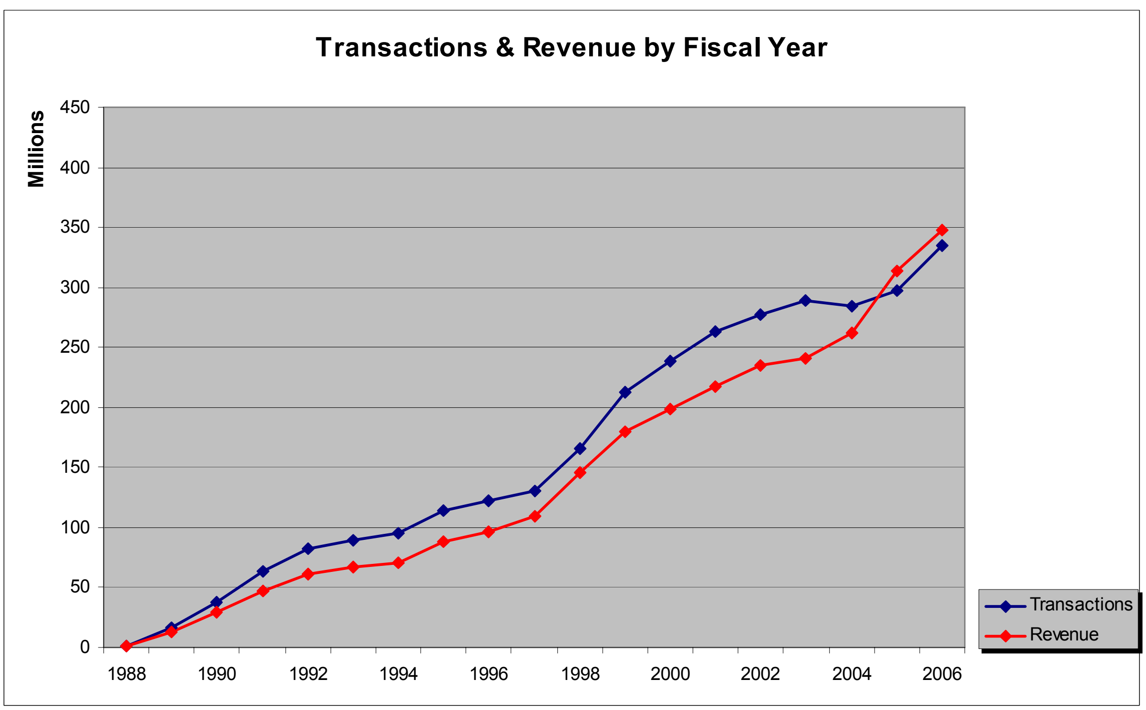


**Figure 7 Historical Transactions and Revenues on HCTRA Tollways (1988-2006)**

# CHAPTER 2. TRUCK TOLL ROAD FORECASTS

## 2.1 RELEVANCE

Better decision making involves some key decisions and judgments from the perspective of bondholders, practitioners, and researchers. For instance, in terms of a proposed toll road project, one ought to have reasonable estimates of expected toll revenue over a specified planning horizon. To that end, reliable data and all other information relevant to the project must be gathered. As rightly pointed out by Baez (*14*), the credit risk of a proposed toll road should be evaluated in the light of economics, traffic and toll revenue forecasts.

## 2.2 OPTIMISM BIAS IN TRUCK FORECASTS

There is a growing body of literature dealing with the problem of overestimation with respect to traffic and the associated toll revenues. The Standard & Poor's Reports, for instance, have shown that the first-year toll revenue estimates have been overestimated by an average of 20 to 30 percent over the sample of projects being studied (*1-3*). This is the so called *optimism bias or a consistent tendency to overestimate the benefits (revenues) and underestimate costs*. According to these reports, the bias in the initial years persisted through the subsequent years of operation, which is evident from the fact that the mean vs. actual projections ranged within 0.77 and 0.8 for the first five years. On a similar note, the NCHRP Synthesis Report also analyzed 26 toll highways in US and found considerable variation in performance of toll roads- ranging from 13%- 152.2% (*4*). This consistent overestimation hints to the fact that there must be both short and long term factors that need to be analyzed in order to obtain reliable forecasts.

The Standard & Poor's Reports also note that variability in truck forecasts has been much higher in comparison to passengers (as captured through standard deviation, which is 0.33 for trucks compared to 0.26 for all vehicles). Given that the trucking industry pays considerably higher tolls than other user groups, any erroneous forecast for this segment would translate to a bigger impact on the realized toll revenue.

## 2.3 SOURCES OF FORECAST ERROR AND OPTIMISIM BIAS

Economic and financial feasibility analysis on toll lanes, as typically done in the literature, involves estimation of agency costs and user benefits in terms of travel time and vehicle operating costs savings (for instance, *15*). While analyses of these kinds are conducted at the *aggregate* level, it's worthwhile to point out that the issue of optimism bias is both a demand and cost side problem. This report primarily focuses on the demand side of the problem. The feasibility and success of toll roads in providing congestion relief rely essentially on how demand is modeled. With respect to truck related pricing options, the immense variation in type and size of the trucking companies presents a challenge in predicting their response to toll roads. Figure 8 below outlines the different channels through which demand uncertainty might impinge on revenue uncertainty.

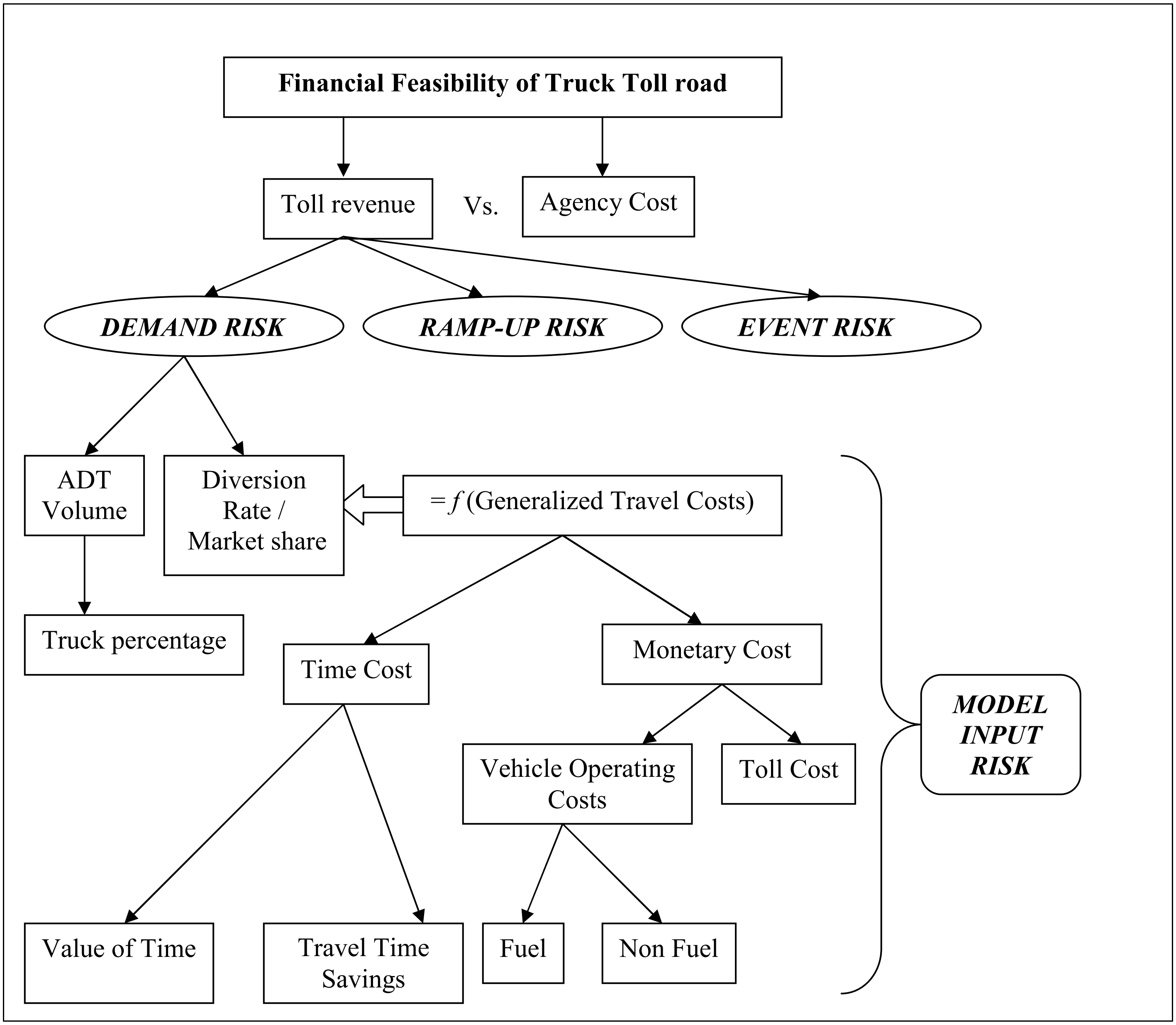


**Figure 8 Different Sources of Optimism Bias**

As should be evident from the above flowchart, demand (and revenue) forecasts involve judicious assumptions with respect to the model inputs, several of which are stochastic. As a consequence, any error pertaining to model inputs gets transmitted to revenue forecasts. With Figure 8 in the background, a brief review of the uncertain elements that affect demand risk follows.

First, projections of gross daily volumes are typically obtained from demographic data included in planning models, which are often unadjusted for exogenous random disturbances such as energy price shocks. While the theoretical link is provided in the ensuing section, the important thing to note is the treatment towards truck traffic. Although the trucking industry is acknowledged as an important source of toll revenue, their inclusion into the forecasting models is far from adequate. As noted in the NCHRP Synthesis (*4*), a typical way to include trucks is to factor the automobile forecasts on each link according to an assumed or observed proportion of trucks. The potential pitfall of this approach is that it pays no attention to the underlying demand structure of the users. This approach is questionable and critical for Greenfield projects. Another category of projects where this assumption requires a reassessment is in pricing applications where there is an element of volition i.e., you may access the toll lanes for a fee. Some of the ways in which this error could manifest on the demand side include errors in a) ramp up duration length and b) ratio of actual to estimated volumes.

The most critical demand input is the diversion rate, which captures the proportion of trucks diverting to the tolled route. While it will be discussed at length in the following chapter, in the present context it is important to note that diversion rate is contingent on the generalized travel cost (GTC) which comprises of time costs including both the value of time and travel time savings, toll costs, and fuel and non-fuel vehicle operating cost components. It is understood that the willingness to take a tolled route is premised on the productivity gains to the trucking firms in terms of travel time savings and operating cost savings, in addition to increased size/weight limits (for instance, *15*). Although rising fuel price raise the cost to operate, vehicle operating costs as a demand side factor has not received its due attention. Trucking firms are characterized by different operating cost structures and therefore a rise in fuel price would not affect them uniformly.

The time cost component of GTC involves assessment of Value of Time (VOT) of the user as well as the travel time saved. Value of time is a crucial demand side parameter which is known to vary across the various segments of the industry. Surprisingly, ignorance of user heterogeneity is a common characteristic of the forecasting models. For instance, Veras et al. (*15*) estimated the productivity gains of trucks by assessing the impact of revised axle load limits on operating costs.[1] However, a limitation of this study is noteworthy in this context. In the absence of data on demand parameters, the feasibility analysis was conducted under a *simplifying* assumption that trucking companies would be willing to pay tolls as much as 50 % of the operating costs saved by using the tollway - thereby paying no attention to user heterogeneity. On a similar note, a recent report by Vollmer Associates on the Central Texas Turnpike Project (CTTP) considers *a* Value of Time parameter for the entire trucking industry while obtaining the diversion estimate for the proposed SH-130 toll road in Austin, TX (*16*). As pointed out by Hensher and Goodwin (*17*), usage of average value as an approximation of a skewed (VOT) distribution can lead to overestimated revenue and underestimated impact of toll.

In addition to the *model input* risk enumerated above, factors like *ramp-up* risk and *event* risk can also add to the distortion on the revenue side (*18*).Put it simply, ramp up risk involves the lag between opening up of a toll road and the time when realized traffic matches the steady state volumes as predicted by the models. This kind of risk can emanate when the users are unfamiliar with a new facility and when there appears to be some information lag as far as the potential benefits are concerned (*4*). Some analysts address the issue of Optimism Bias as a *short run* ramp up problem. The perceived idea is that even though first year traffic is uncertain, the usage would increase over the time (*19*). However, this might not be that simple an issue. Truckers can take substantial time to adapt their behavior towards toll roads, if at all. This calls for proper assessment of both short and long run demand elasticities among the potential users.

Finally, event risk relates to the timing of improvements that compete or complement with the tolled facility under consideration and are considered. In terms of network modeling it represents the extent to which other planned improvements within the network are included for the forecasting and assignment phase. Since priced options may have significant general equilibrium network effects and can lead to spillovers of traffic on to neighboring unpriced facilities, it is also important that these factors be considered for their influence on gross roadway volumes and diversions to planned tolled facility.

[1] In order to estimate the productivity gains, statistical cost functions were developed from proprietary data of the trucking companies.

## 2.4 THEORETICAL LINK BETWEEN VOLUME AND GENERALIZED TRAVEL COST

Theoretically, gross roadway volumes can be linked to generalized travel cost (GTC). Let us denote GTC by

$$G = \frac{f}{e} + h + c \tag{1}$$

where $G$ denotes GTC, $f$ the fuel price, $e$ captures fuel efficiency (miles/gallon) and $h$ is toll cost. Let $c$ denote other travel costs like time costs. The fuel efficiency parameter ($e$) can be taken as a function of fuel price, time-of-day as a measure of congestion ($t$), speed ($s$) and individual characteristics ($X$).Thus fuel efficiency can be linked to price, congestion, speed, and truck characteristics.

$$e = m\,(f, t, s, X) \tag{2}$$

Other travel costs ($c$) can be taken as a function of trucking characteristics ($X$) and speed ($s$).Therefore

$$c = h\,(X, s) \tag{3}$$

The gross volume ($V$) can be taken as a product of stock ($N$), which depends on $G$ and distance $d$, which is a function of $g$ and $X$. Thus

$$V = N\,(G).\, d\,(G ,X) \tag{4}$$

The elasticity of traffic volumes with respect to GTC can therefore be decomposed into two parts: elasticity of stock with respect to GTC and elasticity of distance with respect to GTC. Therefore

$$\frac{\partial \ln V}{\partial \ln G} = \frac{\partial \ln N}{\partial \ln G} + \frac{\partial \ln d}{\partial \ln G}, \text{ or} \tag{5}$$

$$\eta_{vG} = \eta_{nG} + \eta_{dG} \tag{6}$$

Also, the elasticity of volume with respect to fuel prices can be written as a function of elasticities of stock (N) and distance (d) with respect to G ; the share of fuel in total operating costs, and elasticity of fuel efficiency with respect to fuel prices. Mathematically, we can represent this as

$$\frac{\partial \ln V}{\partial \ln f} = \left( \frac{\partial \ln N}{\partial \ln G} + \frac{\partial \ln d}{\partial \ln G} \right) \cdot \beta \cdot \left( 1 - \frac{\partial \ln e}{\partial \ln f} \right) \tag{7}$$

In elasticity terms,

$$\eta_{vf} = (\eta_{nG} + \eta_{dG}) \beta (1 - \eta_{ef}) \tag{8}$$

In the short run, $\eta_{ef}$ can be taken as fixed because of the lags in technology diffusion. Consequently, $\eta_{Vf}$ is a simple function of $\eta_{VG}$ adjusted for the share of fuel costs in GTC , β, suggesting that gross volumes can be theoretically linked to changes in generalized travel costs and also specifically to the fuel price component.

**Some Empirical evidence**

While traffic levels would be proportional to fuel consumption in the short run, it may not be the case in the long run as users can adjust the fuel efficiency (Goodwin, *20*). Transportation elasticities tend to increase over time as users adjust their behavior towards toll roads (*21*). For instance, Goodwin (*22*) obtained elasticity of travel volume with respect to travel time as -0.5 in the short run and -1.0 over the long run. Lee (*23*) estimated elasticity of vehicle travel with respect to Generalized Cost (including fuel, vehicle wear and tear, tolls, travel time, etc.) and found that elasticity in short run was -0.5 to -1.0 and between -1.0 and -2.0 in the long run. Veras et al. (*24*) analyzed response of trucks to E-Z pass tolls. They obtained short term elasticities ranging between -0.31 and -1.97 for weekday and -0.55 and -1.68 during weekends, depending on the time of day.

**Implications for Demand Modeling**

The gross base volumes or supply side projections from regional and statewide planning models used for forecasting rarely consider the effect of generalized cost changes. With a constant assumed percentage of trucks and yet another assumed diversion rate for a tolled route this is tantamount to overestimating tolled roadway volumes.

## 2.5 SHORT AND LONG TERM DIFFERENCES IN ATTITUDE TOWARDS TOLL ROADS

The attitude towards toll roads can vary depending on whether or not we consider it as a short or long run issue. In the short run, as fuel price increases, the driver may choose to take the free route in order to avoid the toll costs. When perceived as a case of informational asymmetry, the short run behavior of the truckers can therefore be considered myopic. While this decision is an outcome of bounded rationality (discussed in details in the following Chapter), the attitude might change over the time, possibly when they understand the influence of additional miles on revenue and operating costs.

It is important to note that value of Travel Time Savings (TTS) could be different depending on the time horizon involved (De Jong, *25*). For trucking firms, time is a resource that can affect both production and logistical costs which in turn would affect their competitive power.[2] These benefits and hence their competitiveness can vary over time. In the long run, improved travel time can lead to logistical improvements leading to perhaps greater willingness to pay (*26*, *27*). However, truckers may rarely see beyond the immediate benefits and this can lead to differences in short and long run usage.

In summary, optimism bias can be traced to simplifying assumptions and/or implementation of demand side parameters.[3] These assumptions and state-of-the-practice methodology are reviewed in the following chapter. This would help us understand the factors that are typically taken into consideration while modeling route choice (and diversion) as well as identify the shortcomings in the existing methodology, if any. These aspects are consolidated in Fact Sheet 1 in the Appendix.

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[2] McKinnon (*26*) enumerated three explanations as to why firms might be willing to pay for a reduction in travel time. These are spatial concentration, tighter scheduling and market expansion. With a reduction in travel time, trucking firms can concentrate production and distribution processes. With tighter scheduling, wage costs can also be reduced. Finally, travel time reduction can lead to market expansion because greater distance can be traveled for a given amount of time and also due to increased customer satisfaction.

[3] The cost side parameters, on the other hand, are hardly put to sensitivity tests. This is in spite of the fact that fuel price shocks can adversely impact construction costs. For instance the CTTP Report (*16*) considers fuel costs to be fixed at $3 under the *assumption* that fuel will remain in adequate supply during the forecast horizon.

# CHAPTER 3. MODELING TOLL ROAD DEMAND: STATE- OF- THE-PRACTICE

In the traditional four step model of transportation planning, determination of route choice of potential travelers is a key first step. Although there is substantial amount of research on passengers, there is limited information with respect to the route choice decision of the truckers especially as it pertains to toll road usage. It is perhaps due to the fact that route choice decision can depend on a wide range of factors (*28*), and also because it depends on complex interactions between shippers, carriers and receivers (*24*).

Broadly speaking though, the extant theory suggests that carriers would choose their route based on economics (cost of toll versus time, distance saved, fuel and other operating costs) of tolling, safety (especially when adverse weather is an issue), need for the shortest and fastest transit times. Having said that, we review the existing literature below, keeping in mind that some of the factors pertain specifically to the trucking industry.

## 3.1 ROUTE CHOICE FACTORS

At the microscopic level of decision making, the most crucial factor in assessing the demand for a tolled route is VOT of the user. Ceteris paribus, willingness to pay or the demand for toll road is directly proportional to VOT of the user group. Hence the literature on VOT of commercial vehicles provides the typical factors in route choice decisions. One might argue that the optimism bias with truck toll forecasts could potentially be attributed to the overestimated VOT savings for this industry. It is possible that the estimated VOT savings has simply not been realized, *ex post*. Consequently, the predicted increase in the number of trucks using the toll roads falls short of expectation. The discrepancy between *perceived* VOT as used in forecasts and its *actual* realizations therefore require special attention. Route choice factors that might affect VOT, as evident from the literature, are listed in Table 1 below.

**Table 1 Factors affecting VOT distribution**

| *Factors* | *Zyl and Raza (29)* | *Alver et al. (30)* |
|---|---|---|
| Focus of study | Value of Time | Trucks and Production Companies |
| Length of Haul/ Trip purpose | √ | |
| Travel time /reliability | | √ |
| Income | √ | |
| Road condition | √ | |
| Income group | √ | |
| Travel condition | √ | |
| Market segmentation ( by axle type) | √ | |
| Freight characteristics: Low vs. High value goods | √ | |

The existing literature also reveals significant variability in the value of time among different user groups.[4] The behavior in general and VOT in particular of trucking firms can be systematically analyzed once we categorize them by the type of ownership (Private /For Hire/ Owner Operator); the type of load (TL /LTL); the length of the haul (long/short) (*32*).The variations can also emerge from the value of commodity/cargo transported (*29*, *31*, *32*); by logistic practices; just-in-time factors and also by compensation structure. Consequently, "the" VOT of commercial trucking industry is a complex function of several observed (like freight characteristics, ownership) and unobserved variables (like reliability).

Market segmentation in terms of freight category can lead to differences in VOT. For instance, Zyl and Raza found significant differences in VOT among low and high value loads (*29*). The time-sensitive / high value goods like perishable and manufactured goods exhibited higher VOT compared to low value /non time-sensitive goods like bulk commodities. It is often suggested that when the cargo is not time-sensitive, one might resort to average labor cost of truck drivers as a reasonable approximation of VOT (*33*). The haulage of time-sensitive goods however would entail a premium on the perceived VOT by the carrier. The variation in willingness to pay across industry segments, as observed in the literature, has been summarized in Table 2.

[4] For an existing review of VOT as used in demand modeling, one might refer to Smalkoski and Levinson (*31*)

**Table 2 Willingness to pay and Value of Time Across Industry Segments**

| Author(s) | Year | User group | VOT adjusted to 2007 dollars[5] | Significance of Study |
|---|---|---|---|---|
| Haning & McFarland | 1963 | Truck operators | 22.31-29.04 | |
| Kawamura | 1998 | All trucks | 34.43 | VOT ~ lognormal distribution; varies by operational characteristics |
| Kawamura | 2003 | Trucks | In House-20.10<br>For Hire-31.98 | For Hire segment has higher VOT than In-house /Private carries |
| Smalkoski & Levinson | 2003 | Commercial Vehicle Operators | 27.53 -56.45 | Firms with private fleets have lower VOT |
| HERS (US DOT ) | 2003 | Truck | 24.60-34.81 | VOT increases with axle size |
| Northern Ohio Fright Study | 2004 | Truck | 28.04 | |

In addition to VOT, a host of other factors might dictate the route decision. For instance, Knorring et al. (*28*) provide a list of factors pertaining to route choice decision of long haul drivers based on remotely sensed revealed preference global positioning data. These include income and education of the driver, availability of alternate routes, perceived speed on alternate routes, information on traffic, length of alternate routes, anticipated congestion, time-of-day, weather, and hazards involved. In addition to this, the attitude of drivers towards risk could also matter behind route choice.

Table 3 summarizes the route choice factors for the truckers as gleaned from the existing literature.

[5] The figures have been adjusted using Bureau of Labor Statistics Inflation Calculator available at http://www.bls.gov/

**Table 3 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*** | | | √ | | |

While the factors affecting route choice are supposedly numerous (as evident from Table 3 above), the literature demonstrates only limited number of trade-offs involved in route decision. Table 4 below enumerates some of these trade-offs.

**Table 4 Trade-offs involved in Route Choice**

| Trade offs | Alver et al. (2006) | Zyl and Raza (2006) | Knorring et al. (2005) | Smalkowski and Levinson (2005) | Kawamura (1999) | Fischer et al. (2003) |
|---|---|---|---|---|---|---|
| *TTS and Toll* | √ | | | √ | √ | √ |
| *Travel time and User cost* | | √ | | | | |
| *TTS , toll and fuel costs savings* | | √ | | | | |
| *Time and Distance* | | | √ | | | |

Consequently, the typical trade-offs emanating from the extant literature are quite limited.[6] The usage propensity/demand distributions based on these short term time/cost tradeoffs form the background for the market shares or diversions rates to tolled roads (to be discussed in the ensuing section) and are applied to long run models and long run volume projections to obtain diversion estimates.

## 3.2 DIVERSION IN THE PRESENCE OF TOLLING

With the wide range of factors behind route selection, as enumerated above, the issue of diversion off a tolled route merits separate appreciation altogether, partly because it is not "well understood" (*34*), and also due to its importance towards the present study.

### THEORY BEHIND S-DIVERSION CURVE

At this point, we revisit the state-of the practice methodology to model diversion. A *rational* decision maker would choose the route that involves least Generalized Travel Cost (GTC), which includes time and monetary cost. The basic idea is as follows: the decision maker evaluates all the attributes of the alternatives in order to select the route with maximum utility (or it's dual, minimum GTC).

[6] The stated choice designs consequently rely on focusing on "key" attributes in order to reduce dimensionality issues.

Let us denote the utility of the decision maker by $U = \sum_{i=1}^{n} \beta_i X_i$ , where $X_i$'s are the different attributes of the road that affect utility (time and toll, typically). The difference in utility from a tolled route and its alternative free route is thus given by $\Delta U = Utility_{tolled\ route} - Utility_{freeroute}$ .A rational driver would opt for the tolled route if the change in utility is positive. This decision (Y=1) to take a toll road can be modeled as a binary choice between the two alternatives. The standard "market share" or diversion rate is therefore obtained as $\Pr ob(Y = 1) = \frac{1}{1 + \exp(\Delta U)}$ .This is typically estimated using a Logit model, with control (explanatory) variables as time and tolls and dependent variable as a binary choice variable. Eventually, we end up with something like S-curve capturing the probability of diversion to (and off) a tolled route.

### 3.2.2 APPLICATIONS OF THE S-DIVERSION CURVE METHODOLOGY IN TRUCK TOLL ROAD STUDIES

Although the above methodology is applicable to all user segments, we consider the specific applications pertaining to truck studies. Let us revisit the two most important studies in this context.

**The Reebie Study** (*35*)

As part of evaluating different means of increasing capacity, and separating through volumes from local access, the Reebie study aimed at quantifying truck diversions from I-81 at various tolling rates. To that end, two lines of inquiry were conducted:

1) Ascertain the factors important for route selection and to determine the impact of highway tolling in the evaluation of route alternatives, and

2) Application of diversion models that would reflect the decision of the carriers.

### *Methodology*

Impacts of tolling on cargo diversions were conducted by applying the *shortest-path model* (developed by Oak Ridge National Laboratory) to the 2003 Transearch database. These data were coupled with the results from Reebie's proprietary *truck cost model* (TCAM) as well as the information obtained form a survey of trucking firms operating in the I-81 corridor. A diversion model was developed which routed traffic using the *least cost* alternative. The TCAM model is described as a non-linear model used to calculate trucking costs based on mileage, time, route, toll, expected congestion, equipment type, driver type, and carrier size. It was noted that the cost functions reflected the routing decision by carriers and quantified realistic rates of diversion at a given toll cost.

### *General observations*

For toll rates below 12 cents, the diversion impacts were found to be small- accounting for 16 % of vehicle miles and 24 % of the loads. The vehicle miles diverted increased sharply between 12 and 30 cents per mile, before leveling off again as only true captive traffic remained at toll rates above 30 cents. This suggests that the threshold level for local traffic tend to be lower than "over the road" or interstate traffic or "through" traffic.

The report also indicates that there might exist some kind of *seasonality* with respect to the decision to take a toll route. For instance, during the peak season, when the opportunity cost of time increases, more trucks are likely to adopt a toll road. In contrast, when traffic levels are low, more diversions off the toll road are likely to occur.

### *Impact on Load*

The binary routing model predicted that the *number* of vehicles diverted from I-81 increases approximately *linearly* with toll costs (provided tolls are applied in a "uniform manner").[7] Several observations can be gleaned from the estimated linear relationship between loads diverted and toll rate.

- The fact that the intercept term is positive indicates the package express and just-in-time categories, which have limited routing options.

[7] The linear relation between loads diverted (y) and toll costs (x) is captured by the relation $y = 0.13 + 1.1x$.

- There is a reasonably uniform distribution of average detour costs per mile across the entire spectrum of truckers. Consequently, some trucks would find it easier to locate alternative routes.

***Impact on Vehicle Miles Traveled***

Although number of vehicles diverted exhibited a linear relationship, Vehicle Miles diverted followed an *S curve* with respect to toll cost. In this respect we note the following:

- In general, local trucks would divert as soon as a toll is imposed – provided the toll is applied uniformly at every entry and exit.
- For medium distance (~800-1500 miles) hauls, it is unlikely to see diversion until toll costs exceed 15-20 cents per mile.
- Toll rates exceeding 20 cents/mile would be rendered counterproductive.

***Impact by Commodity Type***

Apparently, there were no significant differences across commodity types in diversion rates except for coal, instruments, ores-which exhibited larger diversion rates in comparison to others. In the case of ores, since it is an extremely bulky commodity and is characterized by specific production and consumption sites, the diversion is likely to be *all or nothing*. Coal and aggregates are commodities that generally travel locally tend to be relatively captive.[8]

Just-in-time, parcel, express delivery and high value commodities are least likely to divert, because for them, speed is the most crucial factor.

[8] Although coal tends to be relatively captive, it exhibits higher diversion at lower toll rates.

**The Central Texas Turnpike System Study** (*16*)

The other important study in this context relates to the Central Texas Turnpike System Report by Vollmer Associates (*16*). A Logit model is used to determine the probability of selecting a toll road based on a time–cost trade off. For a given origin–destination pair, this probability gives the share of commuters who would take a toll road. A sensitivity run was performed in order to estimate toll elasticity. The results for the trucking segment are reproduced in Table 5 below. For the sensitivity analysis, the toll rate was changed from 12.2 cents/mile (under the base toll plan for SH 130) to 24.4 cents/mile.[9]

**Table 5 Percentage of Truck Diversion by Time of Day for SH 130**

| *Time of Day* | *Traffic reduction* | *Retained Traffic* |
|---|---|---|
| AM Peak | 69 | 31 |
| PM Peak | 69.8 | 30.2 |
| Off Peak | 68.1 | 31.9 |
| Total | 68.6 | 31.4 |

Source: Central Texas Turnpike System Report (*16*)

**Sensitivity to Toll Rates**

A related concept to diversion is that of elasticity to varying level of toll rates, which is important for adjusting estimates over time and at the time of proposed rate changes. Several studies document the sensitivity of the trucking industry to alternative toll rates. For instance, the effects of toll rates on truck volumes have been estimated for Ohio using ODOT's Statewide Travel demand forecasting model (*36*). Based on the postulate of *cost minimization*, the model determines the expected route traffic. The impedance or cost is defined in terms of congested travel time and tolls. A *single* Value of time for trucks is taken to be $ 0.42/minute, as derived

[9] Under the base toll plan the toll rate is taken as 12.2 cents per mile for the opening year of2007.The sensitivity run was performed to estimate toll elasticity using the 2007 network. The elasticities were obtained for increased toll levels for the year 2007.

from national studies. Using scenario analysis it has been estimated that in response to 50 % reduction in the toll rate, there would be an increase in the number of trucks using the Turnpike by 30 %.

Lake (*37*) had obtained the average toll elasticity (for Brisbane) to be around -0.2 and -0.3. The Central Texas Turnpike System Report (*16*) indicated toll elasticity for trucks to be -0.68, thereby suggesting the highly sensitive nature of the trucking industry.

Finally, Veras et al. (*15*) make an interesting observation in the context of New York- that 70 % of the carriers *did not* exhibit any change in behavior after the 2001 PANYJ toll increase. Customer requirements are cited to be the underlying reason behind this finding. This can also be attributable to the existing tolling culture, whereby it is easier to pass toll increases to the customers.

### 3.2.3 LIMITATIONS OF THE EXISTING METHODOLOGY

**The assumption of Rationality**

The S-diversion curve methodology is of limited use when the underlying assumptions do not hold good. Specifically, it assumes a rational decision maker who has *full-information* with respect to all the routes in the choice set (*4*). For instance, the Reebie analysis assumes that the trucker will choose the cheapest route, after having accounted for cost of labor, equipment, fuel, congestion and tolls (*35*). While most of the economic models assume rationality on the part of the decision makers (for instance *35, 28* and *30*), that might not be an innocuous assumption. Drivers may be either a) bounded rational (BR) or even b) irrational when it comes to route choice.

Agents could be boundedly rational due to several reasons. As demonstrated in Table 3 above, route choice depends on a wide range of factors. Under limited cognitive power, it is likely that the drivers do not have full information with respect to all these factors. For instance, if the toll structure is too complex and unpredictable, it becomes difficult for the driver to behave in a rational way (*38*). Thus they might end up making a suboptimal decision by making a myopic switch to the un-tolled route. Consequently, the lane choice is made instantaneously in response to the traffic condition at a given point of time (*29*). In the event of escalating GTC led by persistent rise in fuel prices, drivers might change their routes in favor of non-tolled alternatives, or even prefer to drive under congested conditions. Running extra non-revenue miles just to avoid the toll cost is a clear indication of the prevalence of bounded rationality, as pointed by Goodson (*39*). He demonstrated this by comparing the variable costs (including fuel costs) for the out-of-route miles vis-à-vis a tolled distance in various states across the country.

On the other hand, irrationality or *inertia* cannot be modeled. By virtue of this, drivers are not willing to take a toll road, no matter what (*29*). This kind of behavior is likely to be observed among owner operators, since they have to bear the toll costs from their own pocket. On a similar note, Taft (*36*) points out that there might be independent agents characterized by irrational aversion towards toll roads.

What are the consequences of BR in terms of the problem in hand? First, in terms of designing Stated Preference surveys, BR often restricts the choice set to a limited set of variables reflecting key trade-offs. As demonstrated in Table 4 above, the extant literature suggests that the typical trade-off pertains to that between time and toll costs. One justification for this often lies in presumption that time costs are a very large proportion of GTC and a second justification being that these are most obvious variables to consider in a choice design. But time savings vs. toll costs need not be *the* only factors behind business decision for the trucking industry (TTAC Summary Meeting, *40*). At the very least, in addition to the time saved, one ought to consider key implicit trade-offs while assessing the competitive advantage of a toll road. For instance, if the proposed toll route is designed to bypass to an existing roadway then operating costs like changes in fuel consumption become relevant especially in periods of rising fuel costs and fuel efficiency requirements as has been transpiring these past few years. On the other hand, for a proposed route that parallels an existing route, time and tolls might still be the key attributes. Misspecified choice sets can lead to biased estimates of demand parameters (i.e. VOT and Willingness to Pay) which would eventually yield erroneous revenue forecasts (Williams, *41*).

**Implementation Problems**

In addition to the limitations explained above, there are problems also in the implementation of the methodology. Studies like Central Texas Turnpike System Report and Northern Ohio Freight Strategy, for instance, obtain toll revenue forecasts by estimating *a* VOT parameter for the entire trucking industry (*16, 36*). While toll rates are varied by axle size, the lack of heterogeneity in terms of operating characteristics (and willingness to pay) could be a serious shortcoming. To have a better appreciation of this point we need to have a comprehensive understanding of the nature of the trucking firms. To that end, we present Chapter 4 below.

The Focus Group Analysis presented in Chapter 5 thereafter is designed to identify the key factors/attributes that are involved in carrier route decision as perceived by Texas carriers in the presence of tolling, to assess the range of trade offs that might be involved, and to identify the type of constraints or decision making objectives guiding their choices.

# CHAPTER 4. THE NATURE OF THE TRUCKING INDUSTRY

A typical convenient assumption made for assessing pricing responses is to assume that *all* segments of the trucking industry are affected identically. The sensitivity to pricing (i.e. tolls) however depends on the underlying heterogeneity of the firms. Presumably, the industry characteristics play a significant role on decision making.

Several intriguing questions that merit attention include:

a) Who pays the toll?

b) Who determines routing?

c) How are tolls looked upon in relation to other operating costs and in particular fuel costs?

d) Can we say anything about the differences in benefits and costs across market segments (characterized by length of haul, ownership, freight, etc.)?

e) To what extent does just-in-time versus flexible scheduling dictate the route choice decision?

This chapter is therefore intended to provide an overview of the industry that would help us assessing the above issues by developing a better understanding the differences in operating characteristics of the firms.

Trucks play a crucial role in the supply chain in transporting intermediate and finished goods between manufacturers and consumers. Figure 9 succinctly identifies the role of the trucking industry in the existing supply chain (*42*).

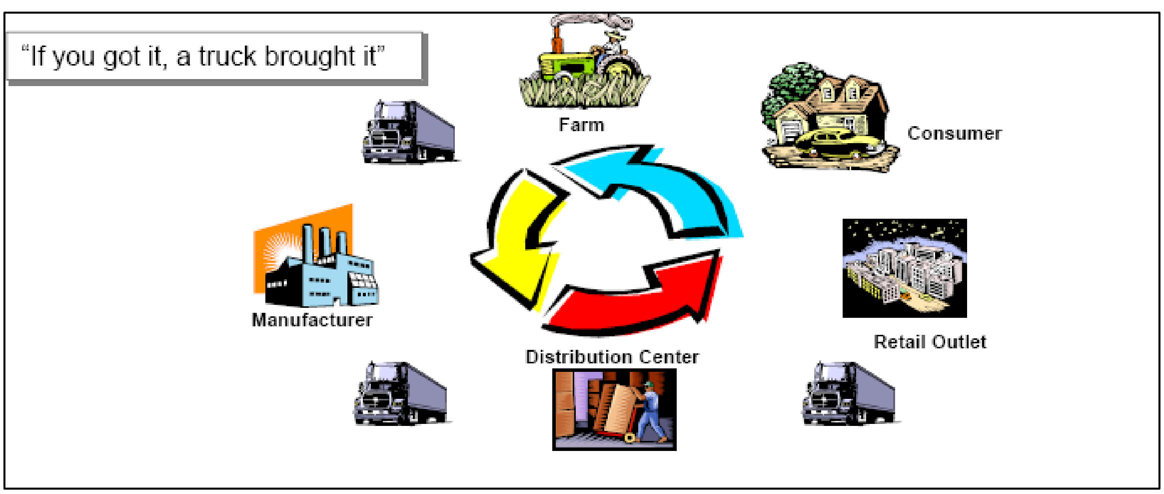


**Figure 9 Role of Trucks in the Supply Chain**

Source: TIOGA Group Study (*42*)

The contracts between the three main players, viz. shipper, carrier and receiver become fundamental in shaping the price, size of the shipment, the level of service, etc. This complex interaction could be understood from Figure 10, which is adapted from from Vadali (*43*).

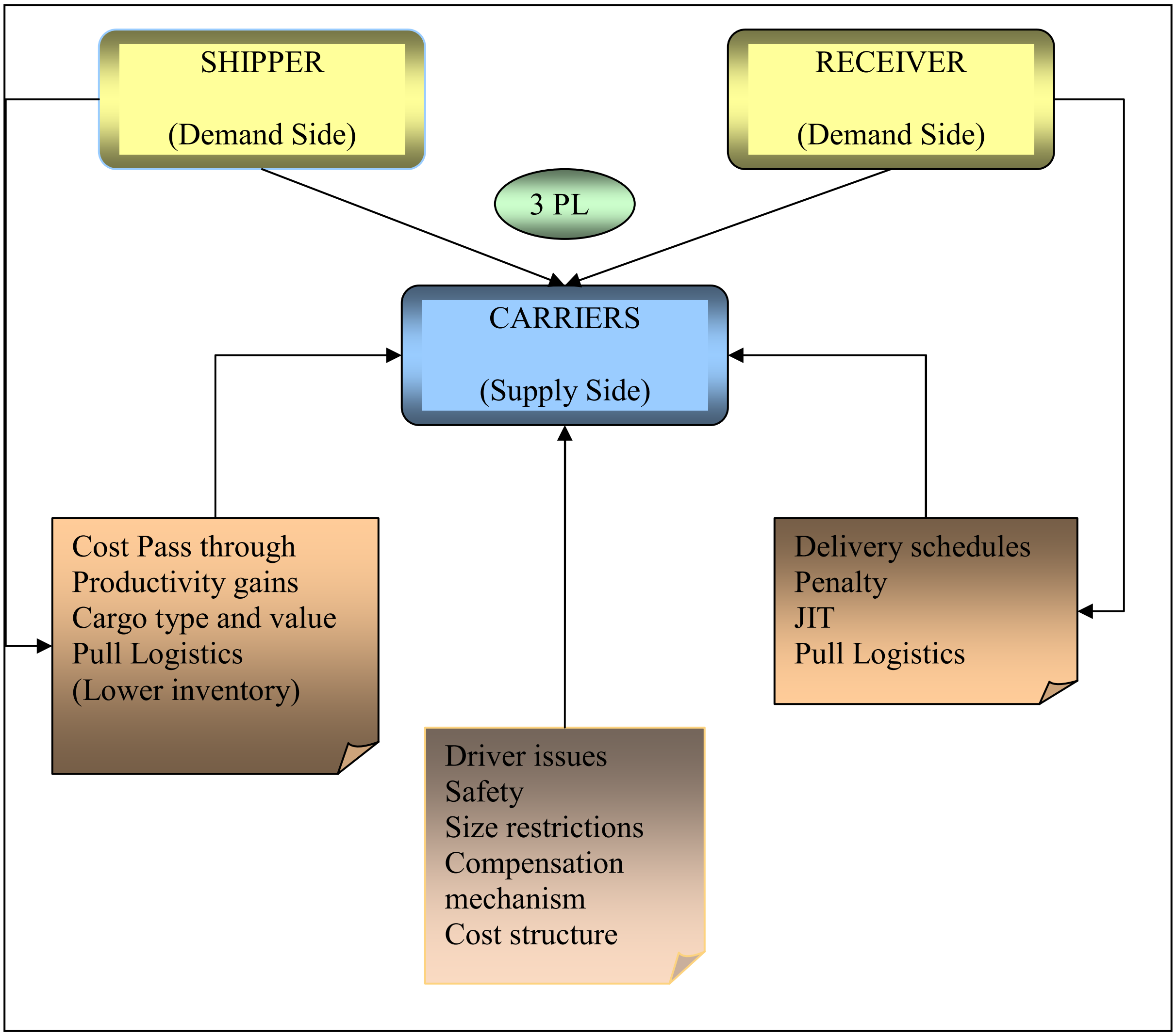


**Figure 10 Complex Interaction between the Shipper, Carrier and Receiver**

As is evident from the above flowchart, the demand side (Shipper and Receiver) impose different sets of constraints on the Carrier, which has its own set of operating issues. Although the interaction between the different parties appears to be complex, the basic goals of supply chain management are to reduce costs and provide improved service.

The importance of each of the above mentioned factors is amplified in the light of a particular trend observed in the supply chain, viz. the shift from "push" to "pull" logistics. It has been observed that manufacturers are shifting away from "manufacture-to-supply" or inventory based logistics model to "manufacture-to-order" type model. This trend is driven partly by rising inventory costs and mainly by customer service demands.

***Implications of pull logistics on carriers***

The shift from push to pull logistics could impact the Carriers in a number of ways, who are always striving to provide the right service to the customers. A couple of them are being identified here, following the Federal Highway Administration Report (*44*).

- Lower inventory requirement would translate to high service truck transport – which in turn might lead to additional traffic on already congested networks.
- Demand for lower inventory would be tantamount to smaller order quantities and shipment size.
- The shift towards "customer-direct delivery" from manufacturer would increase package traffic volume significantly.
- While the carriers are aware of the heat, they are often unable to capitalize the (costly) information systems necessary to raise service and reliability and at the same time maintain competitive rates.

A quote by Smichi-Levi summarizes this:

"*The move to push/pull systems means that more firms are shipping products directly to the customers…, with more direct to customer business, many firms will need to adjust their transportation mode away from bulk shipments toward parcel shipments, creating an increase in demand for small package delivery …*"

The supply chain logistics enumerated above has a clear implication for the trucking industry. With increased demand for just-in-time delivery, in order for companies to remain competitive, they ought to invest more in capital intensive resources- which would ensure reliable and more frequent delivery.

### 4.1 NATURE OF COMPETITION

The trucking industry is far from homogeneous. In spite of that, it is characterized by perfect competition if we look at the different criteria - there are large number of small firms, and limited entry barriers (following deregulation). Small independent truckers are often price takers. However, they might have less knowledge/information about full cost of their operations in comparison to larger trucking companies and logistic firms (*30*).The concentration statistics obtained from the 2002 Economic Census reinforces the highly competitive nature of the industry (*45*).

**Table 6 Concentration in the Trucking Industry**

| *Truck transportation* | *Revenue ( $ 1000)* | *% of total* |
|---|---|---|
| 4 largest firms | 12512537 | 7.6 |
| 8 largest firms | 20926428 | 12.6 |
| 20 largest firms | 35148257 | 21.2 |
| 50 largest firms | 47795610 | 28.9 |

Source: U.S. Census Bureau, 2002

What can be said about the degree of concentration in the Truckload (TL) and Less-than-Truckload (LTL) sector? A 2003 ICF Report (*8*) reports that at the national level there are about 53,000 TL firms, out of which 40,000 are very small (with five or fewer tractors).The LTL segment, on the other hand, is operated by around 1000 operators.[10] It is characterized by a higher level of concentration- about 35 companies accounting for 85 % of the LTL sector

[10] According to FHWA Highway Stats 2005, of for-hire carriers, approximately 50% operate primarily in the truckload sector, 25% in the less-than-truckload sector, and 25% operate in other segments (tanker, refrigerated, hazmat) (*46*).

revenue, while the seven largest earn about half of the total revenue. Fact Sheet 2 in the Appendix summarizes these features of the industry.

***Implications of competition***

Lower degree of concentration has led to highly competitive rates among the trucking firms. Winston (*47*), among others, notes that increased competition in the trucking industry eventually led to lower prices for the consumers. That the industry is characterized by low profit margin is evident from the American Trucking Trends (*48*). Figure 11 shows the trends in industry profit margins over the years 1993-2004.

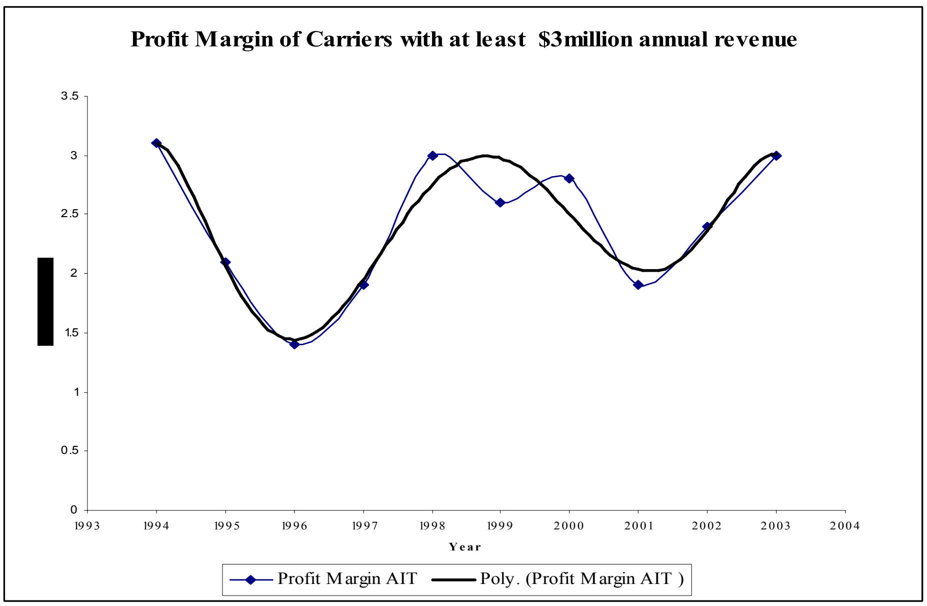


**Figure 11 Profit Margin of Carriers**
(Source: American Trucking Trends, 2005 AIT: After Interest and Taxes)

The thin profit margin (fluctuating within 4 %) is indicative of the highly competitive nature of the trucking industry. Therefore, speaking in terms of economic theory, an individual firm might resort to both *price* as well as *non-price* competitive strategies. With cost cutting as the predominant objective, the firms would seek to keep the avoidable costs at the minimum. Consequently they would try to avoid toll roads to the extent possible; or absorb the toll costs in situations where they are unavoidable. The key points in this respect are summarized in Fact Sheet 3 in the Appendix.

## 4.2 CONSTRAINTS FACED BY THE INDUSTRY

While providing better and efficient service is imperative, we must not overlook the constraints faced by the trucking industry. The competitive nature of the industry in addition to the current environment driven by *pull* logistics and shipper demands impose additional constraint on situations involving trade-offs. The factors that have been adversely affecting the productivity of the industry are surmised below (*49, 50*).

A. Escalating and volatile fuel price leading to higher operating costs.
B. Highway congestion- leading to reduced travel time reliability.
C. Driver shortage as an ongoing phenomenon- Since 2001, the number of drivers has reduced significantly. Heightened securities post 9/11 and higher opportunity costs (through alternative employment) have led to massive fall in the number of efficient drivers.
D. Environmental restrictions have become fact of life.
E. In addition to the above factors, the trucking industry is often constrained by its ability to pass on the fuel and toll costs.

Given this broad structure, let us examine the fragmented nature of the industry in terms of its operating characteristics. The purpose of this section is to aid the development of hypotheses with respect to demand for toll roads.

## 4.3 CLASSIFICATION OF TRUCKING FIRMS

The fact that the trucking industry is highly complex due to its fragmented nature has been documented adequately in the literature. It is this aspect which makes it difficult to assess behavioral responses to pricing. The relative benefits and costs of road pricing will therefore be far from homogenous on different segments of the trucking industry. For instance fleet operators would have different valuations vis-à-vis owner operators, and so would private vs. for hire carriers, etc. The underlying heterogeneity as well as the reaction to road pricing can be best understood once we classify them according to the a) freight characteristics b) carrier /ownership type and c) haul characteristics.

### 4.3.1 CLASSIFICATION BY FREIGHT CHARACTERISTICS

By primary type of load, the firms can be categorized as Truckload (TL), Less than Truckload (LTL) or both TL and LTL. The key features of each of these are described in order to infer their demand for a tolled route and principal underlying objectives in terms of service provision.

**TL Operation: Key Features**

- These involve single (point to point) shipment between shipper and consignee by filling an entire truck (*45*).
- TL carriage requires virtually no coordination across hauls (*51*).
- Typically characterized by irregular routes and schedules.
- Driver retention is a major issue, with highest driver turnover (*8).*
- They seek to keep empty miles low.
- The driver is paid by the loaded route mile and is typically non-unionized.
- Toll is generally paid by the company if it is company owned (*52*).

*Some examples*: Schneider National, J.B. Hunt, Norfolk Southern, Union Pacific.

***Implications with Regard to Demand for a Tolled Route:***

Since TL operation involves single shipment and minimum coordination across hauls, it is expected that the demand for tolled routes will be lower compared to LTL- for whom coordination across terminals is a crucial requirement. Another factor is that carriers who have predominantly TL operations with medium to long hauls tend to not have fixed routes which are typically either distance or fuel-optimized and hence typically tend to avoid or exclude toll routes. However, the AECOM Report (*53*) brings up another possibility. Drivers paid on a per mile basis (about 30-42 cents per mile), would have greater incentive to take toll roads when toll costs are reimbursed and there are clear advantages in terms of higher operating speed limits, increased reliability and safety. Both of these comprise refutable hypotheses in terms of demand for toll-routes.

*Implications with Regard to Decision Making Objectives:*

With a large number of small firms comprising the TL segment, cost minimization is expected to be the relevant objective. Under such circumstances, the TL segment is much more likely to be subject to myopic decision making (bounded rationality) relative to the LTL mode. It is expected that the TL segment would be more elastic with respect to changes in fuel and toll costs, provided they meet the appropriate delivery constraints.

**LTL operation: Key Features**

- Characterized by multiple shipments from more than one shipper using a network of terminals with local pick up and delivery by smaller trucks (analogous to the Hub and Spoke network).
- In contrast to TL, the LTL carriage requires timely coordination of truck arrivals and departures at *break-bulk* facilities, large warehouses, etc.[11]
- The LTL sector is operated mostly by unionized labor in contrast to the TL counterpart.
- The intermodal drayage sector moves containers and trailers between ports, railroad, and other inter-model terminals and basically faces the derived demand from air and maritime activity. This segment relies heavily on the owner operators and has time based rate structure.
- Toll is typically paid by company (*52*).

*Some Examples:* UPS, FedEx Ground, Postal Service, Yellow Freight, Consolidated Freightways, Roadway Express, ABF Freight System, Conway Transportation Services.

[11] Nickerson mentions about the externality effects that emerge in LTL trucking because of coordination dynamics (*51).*

*Implication with Regard to Demand for Tolled Routes:*

Since LTL operations involve timely coordination, the demand for toll roads is expected to be quite high for this segment. But given that LTL operations involve multiple shipments, it is also difficult to spread the toll costs among various parties. A priori, therefore, the net effect is ambiguous. In this context, the Reebie Study indicated that LTL and cargoes requiring high level of security were less likely to divert from approved interstate routings (*35*).

*Implication with Regard to Behavioral Decision-Making Objectives*

Since "on-time-performance" is a critical requirement for LTL carriers (*53*), they are more likely to be time-minimizers. The derived demand nature of service would translate to time reliable service provision. Consequently, one can postulate trip cost minimization as the relevant objective (by choosing speed or time).We would also expect the behavioral responses of the LTL segment to be more inelastic to change in fuel prices and tolling relative to TL modes.

### 4.3.2 CLASSIFICATION BY TYPE OF OWNERSHIP

Depending on ownership, the firms can be classified based on Carrier Type (*54*):

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

*Private Carriers*

Generally, companies resort to private fleet when it involves time-sensitive and reliable service. As noted by Veras et al (*24*), private companies tend to operate in less constrained environment. If the fleet is fully utilized, shipping by private fleet would be cheaper. However, if the higher level of service comes at a cost of higher ratio of empty miles to loaded miles, then private carriage would be somewhat more costly (*8*). Typically, the driver is paid by mile and hours and toll cost is internalized by the company itself (*52*). In addition to this, as a shipper it is relatively easy to pass on toll costs to the customers. Consequently, one can expect higher willingness to pay for toll roads among private carriers.

### *For Hire Carriers*

Intended for commercial/open market, for-hire carriers are alternative to private trucking, which operate in "far more constrained" environment (*24*). These carriers face greater difficulty in allocating the toll costs over the shippers and consequently would make their decision based on cost-benefit assessment.

### *Dedicated and /or Contract Carriers*

Sometimes, the contract could be dedicated/exclusive for a *single* customer (Example: Marten Brower for McDonald's). As a consequence, dedicated service is characterized by highest utilization; predictable route and mileage. Since the toll cost will be borne by the company itself, the decision would be driven more often by company objectives. Given that highest service provision is the basic objective for this segment, willingness to pay is conjectured to be high. Examples of large carriers with dedicated fleet include J.B. Hunt, M.S. Carriers, Werner, and Schneider.

### *Owner Operator*

The owner operators are independent firms with their own customers. According to the ICF report, at the national level there are about 350,000 owner operators and most of them are leased by bigger TL companies (*8*).In terms of payment mechanism, the owner operators are paid by trip, by mile, by a percentage of the line haul charge; but rarely by the hour (*52*). We can enumerate the pros and cons in owner operator business, following Operating Cost of Trucks in Canada Report (*49*).

- Fleet capacity flexibility: Easy adaptability to short term changes in traffic volumes, without maintaining an excessive capital investment.
- Simplicity: Sometimes, the need for many administrative and maintenance functions is reduced by owner operators-"thereby eliminating the need to provide

maintenance and other services that might be required to operate a small fleet in that market location."

- Productivity: Since owner operators have greater incentive in keeping utilization high, they are often more efficient than company driven units.
- In certain instances, the carrier supplies fuel and maintenance service to the owner operator at reduced price.

Given that they are typically paid on a per-trip basis, they are likely to avoid a toll road more often (*53*). They comprise the most vulnerable segment in the event of fuel price volatility. On a similar vein, the Reebie study on Virginia truckers indicated that Owner/operators and small carriers are most likely to divert vis-à-vis larger carriers who operate company equipment (*35*).

### 4.3.3 CLASSIFICATION BY TYPE OF HAUL AND TRIP LENGTH

Private, long haul carriers form the largest segment of the trucking industry (*53*).To the extent that toll lanes yield unambiguous advantage in terms of travel time, reliability and safety, the long haul carriers would be willing to adopt them (*53*). This is in contrast to the short haul service operating within a metropolitan region (*24*). The Reebie Study however indicated the alternative plausibility- that long haulers would tend to remain on primary routes, whereas it is the local and regional truckers that could use both primary and secondary routes (*35*). The report indicated that very long haul (750 miles and up) and very short haul (less than 250 miles) were the ones most susceptible to diversion from tolling because of routing alternatives.

Veras et al (*24*) point out that carriers involved in thru-trips can bypass a tolled facility as long as they can meet the delivery constraints. While inter-regional trips might have some ability to avoid toll roads, carriers doing intra-regional trips cannot avoid them in general.

## 4.4 MULTIPLE OBJECTIVES AMONG TRUCKING FIRMS

Apart from the heterogeneity in user characteristics, another feature that merits attention is the prevalence of competing objectives. The different segments (which are characterized by different operating environments and constraints) are expected to be driven by diverse objectives. Chakraborty (*55*), for instance, differentiates trucking firms on the basis of primary marketing objectives. Parcel, processed food, and retail goods are typically characterized by on-time-performance. On the other hand, carriers which haul non- perishable items like dump-trucking, mineral ores would be characterized by "non on-time-performance route making objectives." While the LTL segment (which has to operate through timely coordination of truck arrivals and departure) is expected to have on-time-performance as an overriding objective, the TL segment might be less constrained on this account.

There is one important implication of the above discussion in terms of data analysis. One ought to *control* for differences in objectives- because even with same haul characteristics (viz. time sensitivity, route variability); the response of the firms to different policies might be different. Fact Sheet 4 in the Appendix summarizes these points and the related testable hypotheses.

## 4.5 OPERATING COST STRUCTURE

Keeping in mind the purpose of this project, it is important ascertaining whether the trucking industry makes trade offs, if any, between rising fuel costs and toll costs. To that end, the focus is shifted to the cost side now. As rightly pointed out by Bain (*1*), in addition to the time saved, truckers need to take into consideration the impact on vehicle operating costs as well. This, in turn, would define the competitiveness of a toll road in terms of its ability to save fuel costs for the truckers (*4*).

### *Components of Operating Cost*

Although total cost of travel can be decomposed into fixed cost and variable cost, we would confine ourselves to the latter. This is because, at the microscopic level, the decision to choose between a tolled and a free route is likely to be affected more by the running costs and to a lesser extent by standing costs (like license fees, taxes, insurance and interest charges).The standing costs ought to be paid irrespective of the level of operation and therefore should not affect the decision making process at the *marginal* level unless drivers are paid by the hour. It is important to note that toll costs have received mixed characteristics. While usually looked upon as a variable cost, there have been instances where it might be looked upon as a fixed cost. This is particularly the case when the route is predetermined and frequently taken, when the decision maker ought to make provision for it as a fixed cost. In economic terms, therefore, we might consider toll as an *avoidable* cost.

In order to understand how different components of costs per mile have been changing over time we refer to the following figure.

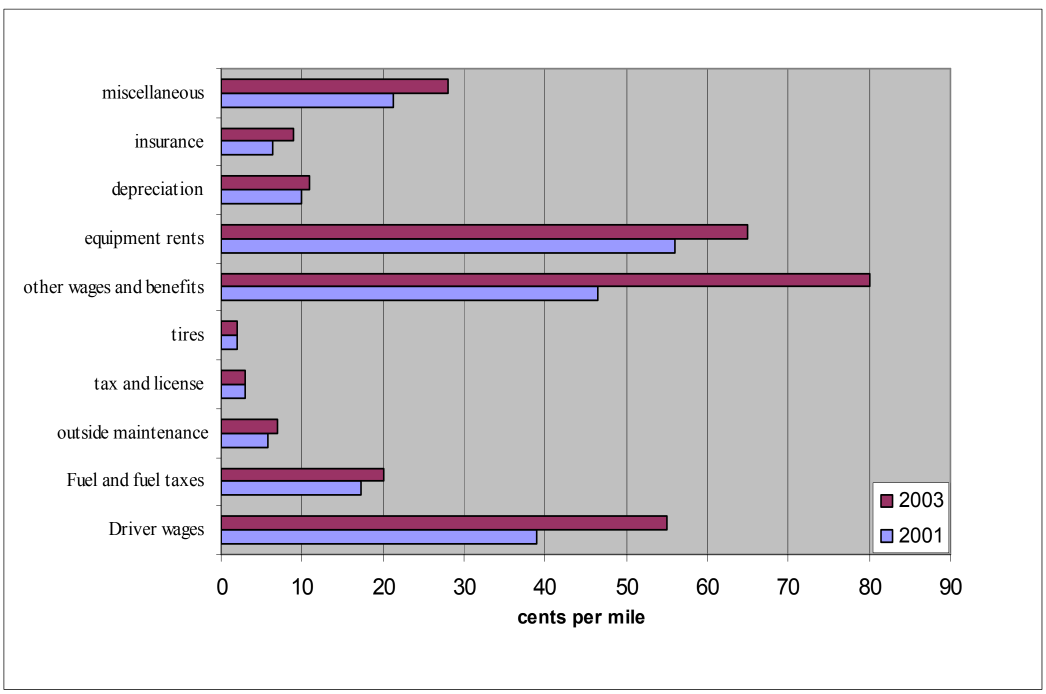


**Figure 12 Cost per Mile (2001-2003)**
Source: American Trucking Trends, 2003 and 2005

The above figure illustrates that the two categories that have experienced the largest increase in *absolute* terms are “Other wages and benefits” (72%) and “Driver wages” (41%)[12]. Expenses on fuel have registered an increase of 15.6 % over the same period. Therefore in order to stabilize their profit margin, the trucking companies must be looking for appropriate strategies in the event of escalating cost structure. The Fact Sheet 5 in the Appendix highlights these findings.

***Heterogeneity in Operating Costs***

That the industry is heterogeneous in terms of *operating* cost structure can be understood from Levinson et al.(*56*).Their survey on trucking companies in Minnesota indicates that owner operators differ significantly from non- owner operators in terms of operating cost. The apparent variability in terms of the cargo is also evident from their analysis. These are consolidated in Fact Sheet 6 of the Appendix. With the existing heterogeneity in cost structure, let us see how toll and fuel costs are looked upon by the firms.

### 4.5.1 TOLL COSTS

We reiterate that toll cost, is intrinsically different from fuel cost – in the sense that the former is an *avoidable* cost. As pointed out by Goodson (*39*), if tolls add up an extra $ 50 to the cost of a load, drivers and truckload carriers would possibly be reluctant to use the toll roads. However, the final decision ought to be made by comparing the amount of toll cost as well as the cost of out-of-route miles. The moot point is that operating cost savings need to be taken into consideration in addition to the time-toll trade-off.

One of the factors that came out of the TTAC Advisory Committee Meeting was the emotional issue of the *perceived inequity* of rates charged to trucks and cars (*40*). For instance, on SH 130 from Georgetown to south of the airport – a 40 mile distance, the toll rate is $ 6 per car, whereas it is $24 for trucks (5 axles). In addition, it is important to note the findings by Bonsall (*57*):

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[12] We note however, that the driver pay per mile may appear higher since this is an average for all carriers reporting to the U.S. Department of Transportation, including many large unionized LTL carriers. (American Trucking Trends, *48*).

- A fixed charge is preferred to one which is unknown at the start of a trip.
- A charge based on time spent in the congested conditions is unpopular.

### *Evidence on Carriers' Ability to Pass Toll Costs*

Given the above set up, it is important to understand how the toll costs are borne by the trucking industry. Roth (*34*) mentions about the limited ability of the trucking companies to pass toll costs on or spread them around to all customers. On a similar note, Veras et al. (*24*) stress that even in New York, where tolling culture is a given fact of life; only about 9 % of the carriers were able to pass on the toll increase to the customers. Nonetheless, the authors found that 70 % of the carriers *did not* exhibit any change in behavior after the 2001 PANYJ toll increase. "Customer requirements" is cited to be the underlying reason behind this. It is also attributable to the existing tolling culture, and shipper demands. However, this may not be true for a region like Texas, where there are currently so few tolled facilities that there does not pre-exist any "tolling culture." Likewise, the Reebie Associates Report (*35*) points out that while carriers do attempt to incorporate toll costs in their pricing, they are not always successful because of the contractual impediments. Specifically, when pricing is done on an annual contract basis, adjustments for newly implemented tolls are often negotiated. But all mid-contract changes in cost are borne by the carriers themselves. The mixed response to tolls evident from the above discussion needs to be analyzed with greater care in obtaining meaningful conclusions with respect to route selection. It is stressed that this is not a usual *ceteris paribus* analysis – in the sense that one key component of operating costs, viz. fuel cost is not held fixed. To understand the underlying interaction and trade offs, we refer to the following section.

### 4.5.2 ROLE OF INCREASING FUEL COSTS

Given that fuel accounts for roughly 20-25 % of the operating cost, persistent increase in fuel prices are bound to affect the trucking firms adversely. Having said that, it is important to understand how they are dealing with it. The ability to pass on the fuel costs to either side of the supply chain is far from adequate. High degree of competition does pose a problem in absorbing the fuel price rise via changes in freight rates. Fuel surcharges do exist, but tend to be characterized by some kind of *stickiness* or inability to match the price rise during the period of the contract. While anticipated changes might be taken care of by passing them on to the customers, unanticipated change in fuel prices are not easy to recoup in the presence of long term binding contracts (*8*).

As noted in Chapter 1 earlier, trucking firm bankruptcies have been correlated with fuel price increases. In particular, the smaller firms lack the bargaining power to negotiate for fuel surcharges. Like Siebert (*58*) reflects, it is difficult for the owner operators to absorb the fuel price instability and sustain a stable profit margin, thereby suggesting that this segment might have least inclination to add on tolls to their generalized cost of travel.

The concerns over fuel price hike and fuel shortages are therefore justified. How the truckers pass on the increased fuel costs depends in turn on the nature of the industry. As demonstrated in section 4.1 above, competition limits the ability to absorb the high fuel prices and yet maintain competitive freight rate. The problems get aggravated by the delay in paying the surcharge (in case it is there in the contract) which leads to cash flow problems, especially the smaller companies (*49*).

Nevertheless, fuel surcharges are common unlike toll costs pass through mechanisms. Not surprisingly, the trucking companies seem to favor fuel tax increases over the tolls (*40*). This is because the former is easier to pass on and has lower administrative costs. Fact Sheet 7 in the Appendix surmises the main issues from this discussion.

### 4.5.3 DRIVER COMPENSTATION METHODS

The contracts between drivers and firms in terms of the compensation mechanism often do play an important role behind the decision to adopt a tolled route. In this context, several observations can be made from the Reebie report (*35*):

- The independent drivers are usually paid by a) cents per mile (mileage paid) basis or b) straight percentage of freight revenue billed to the customer (piecework).The local and regional drivers are often paid by the hour.
- The piecework drivers are presumed to be most efficient, in the sense that they would evaluate the impact of tolls, distance, fuel prices and time in a *cost benefit* framework and select the route with maximum overall return.
- The mileage paid drivers, on the other hand, might be compensated either on the basis of actual miles driven or the billed (shortest route) mile. The latter induces opting for the toll road.
- As far as the owner operators are concerned, they have to bear the costs themselves. Consequently, they ought to evaluate the impact of tolls, distance, fuel price and time factors in a cost –benefit framework.
- For company drivers, however, the circumstances are different because it is the company that would absorb the fuel and toll expenses and it is more of a management decision.

The following table, adopted from Mullett and Poole (*52*), captures the heterogeneity prevalent in compensation mechanism and the broad industrial structure.

**Table 7 Driver Compensation Methods**

| *Segment* | *Industrial structure* | *Compensation method* | *Toll paid by* |
|---|---|---|---|
| TL , For Hire | Large firms dominate, few terminal facilities | By the mile | Company |
| LTL, For Hire | Large firms dominate, large terminal networks | Hourly in local operations, by mile in intercity operations. | Company |
| Owner/Operator | Independent contractors | By the mile or percentage of revenue generated | Driver |
| Local delivery | Variable depending on whether it is food, construction, supplies, etc. | Hourly | Company |
| Parcel/express | Large terminal networks | Hourly in local operations; by mile in intercity operations | Company |
| Private fleet | Company fleets moving from warehouses to retail locations | Mix of hourly and by the mile | Company |

Source: Mullett and Poole (52).

The existing variety of compensation mechanisms outlined above does pose a practical problem while conducting a survey (*49*). A single carrier might be characterized by agreements involving “$ per trip”, “$ per hour”, “cents per mile”, “$ per unit quantity hauled, or even “percentage of haul revenue.” In addition to the base pay, often there exists a variety of incentive mechanisms like flat payment per load for backhaul, plus a “cents” per mile bonus for return miles with backhaul involved. The mode of compensation does affect the cost component significantly – which in turn, impinges on the decision to take a toll road.

The heterogeneity among the trucking firms as evident from this chapter calls for adequate attention while analyzing their demand for existing as well as proposed toll road. Therefore one should refrain from obtaining generalized conclusions on “the” trucking industry with respect to their attitude towards toll roads.

# CHAPTER 5. TEXAS FOCUS GROUP ANALYSIS

The specific objectives of this chapter are to identify Texas-specific perceptions and key factors/attributes that are involved in carrier route decision making in the presence of tolling, to assess the range of trade offs that might be involved, and the type of constraints or decision making objectives guide their toll route choices. To that end, we take a *qualitative* approach here, for reasons enumerated below.

## 5.1 METHODOLOGY AND DATA

As a first step in the analysis, qualitative analysis via focus groups was identified as the appropriate starting approach to provide a basis for exploring the perceptions to tolling and nature of trade-offs involved in a route decision. Why qualitative research? It has been noted that while quantitative data deals with numbers, qualitative data deals with meanings. The former quantifies and measures constructs of interest, permitting the comparison between different sets of measurements. The latter, on the other hand, allows the researcher to look into the research setting and understand the concept itself. Thus, while the quantitative methodology permits enumeration, a qualitative approach fosters conceptualization. What seems to be ignored in these debates on choice of research paradigms is that both may be necessary to complete research projects, that without adequate conceptualization, enumeration is incomplete and vice versa (Dey *59*). Therefore, instead of an either/or proposition, researchers should attempt to achieve a balance between the two approaches. Eisenhardt (*60*) reiterates the need for multiple data sources and collection methods, asserting that triangulation achieved through such a process enhances construct validity and strengthens theoretical foundations. Additionally, she suggests the combination of qualitative data with quantitative data whenever the situation permits. Thus, in the first stage it was decided that the interview approach (or a case study method) would be used in addition to focus groups.

## 5.2 PARTICIPANTS

Several companies and participants were identified. After contacting many of them a short list of likely participants was created and finally one was selected for the Case study. The person chosen was actually involved, on a daily basis, in nearly every aspect of trucking. She is an active member of several transportation organizations in the Dallas-Fort Worth Metroplex, including the Transportation Club of Dallas. She headed an extremely successful brokerage operation, which was also involved in freight forwarding activities and was thus seen as the ideal person to talk to and gain insights into the issue of tolls, trucking operations, fuel costs and operating costs, in general.

Three focus groups were developed with representation from various segments of the industry and involved in the transport of different cargo types. The volunteers were drawn from the Transportation Clubs of Houston and Dallas, and Owner Operator Independent Operators Association (OOIDA). The Transportation Club volunteers were drawn from emails sent out by Club Presidents to their membership requesting participation. The Transportation Club of Houston (TCH) participants consisted of six representatives from the long-haul bulk carrier segments of the trucking industry with global, national, regional, local operations and intermodal/ dray operations spanning various cargo types (petroleum, hazmat, chemicals, plastics, liquid, and general freight), asset class sizes (proxy for firm size), and consisting of at least two shippers with private fleets and four for-hire companies. The Transportation Club of Dallas (TCD) participants consisted of four representatives consisting of a logistics division representative of a nationwide carrier with a fleet of company drivers and owner/operators specializing in automotive business, a transportation operations manager from a nationwide household goods movement company, an executive overseeing many aspects of transportation including operations from a household goods movement company, and lastly a marketing executive with frequent dealings with transportation service providers and 3PL service providers.

One of the themes, which emerged consistently from the Transportation Club focus groups, was that Owner-Operators need to be studied separately. Thus, a third focus group involving only Owner-Operators was also put together involving a group of six volunteer Owner-Operators with the help of Owner Operator Independent Drivers Association (OOIDA). One among the group was a company operator while the others were owner-operators.

## 5.3 QUESTIONS

A set of questions was developed for the focus group discussions. The questions follow the pattern of opening questions that draw the participants into the discussion, transition and key questions that focus on the research objective, followed by an ending question that ties the session together and brings closure (Newman, *61*). The opening question asked the participants for their name, the company they represented the nature of their freight operations, cargo transported, and scope of operations and was intended to make them feel comfortable and give everyone the chance to talk. A transition question was asked concerning the use of existing toll roads in order to move the discussion towards the issue of tolling.

The key questions asked the participants for information on factors that were important in routing and effects of fuel costs and prices. Prior to the start of each focus group discussion, the facilitator stated that the objective of the focus group was to gather information about the various trade offs involved in route selection in the presence of tolling and the effects of fuel prices on their decisions. The participants were reminded that there is no right or wrong answers and were encouraged to discuss any point raised in the group. All participants signed an informed consent form as approved by the Institutional Review Board at Texas A&M University. All discussions were audio-taped and then transcribed for analysis purpose. The following table presents the set of questions that were asked.

**Table 8 Focus Group Questions**

| No. | Question |
|---|---|
| 1 | Who makes routes? |
| 2 | Factors affecting route choice |
| 3 | Is tolling a factor? |
| 4 | Use of routing algorithms |
| 5 | Who pays for the toll? |
| 6 | What is an acceptable amount? |
| 7 | How are tolls viewed? |
| 8 | Benefits of tolling |
| 9 | Truck specific toll lanes and High-Occupancy-Toll lanes |
| 10 | Are toll costs and fuel prices jointly considered? |
| 11 | Impacts of fuel costs/prices |

## 5.4 FINDINGS FROM CASE STUDY AND FOCUS GROUPS

***Who makes the routing decision?***

The case study application and the two focus groups suggested broadly that *drivers* are the key decision makers. Notable exceptions include company drivers, and drivers with deliveries of highly time-sensitive cargo (especially concrete), which are routed in real-time. The broker case study indicated that drivers typically make the decisions, but the broker often decides the routes for her clients. However, both focus groups did draw distinctions between company drivers and noted that some larger companies adopt routing methods and route guidance tools. The tactical operations groups decide routes for their drivers and sometimes also for the fleets of owner/operators used by the companies. It was also pointed out the owner/operators typically are free to employ their own benefit/cost assessments in deciding optimal routes. Evidence from TCH discussions also suggests that for the Truckload segment, drivers also might be the key players both because of experience and because route-choice freedom is sometimes provided to drivers as a performance incentive and as part of a driver retention policy (more so for smaller asset class firms relative to larger firms).

***Factors affecting route choice***

Meeting the *customer's delivery deadline* seems to be the critical objective and was pointed out to be more important than any other factor. For owner/operators however, other factors like *revenue considerations* and desire to cut losses appeared to be overriding objectives. Additionally, economics (cost of toll versus time, distance saved, and fuel and other operating costs) of tolling, safety (especially when adverse weather is an issue), need for the shortest and fastest transit times also influence route choice.

In the case study it was noted that distance is a key factor influencing toll road choice, and the typical tendency is to route trucks the practical miles on freeways since it was felt that this tends to reduce fuel mileage and consumption due to fewer "stop and go" traffic. It was also noted that since Texas has few tolled roads, the typical tendency would be to avoid them since the alternatives would be just as fast.

***Is tolling a factor in route selection?***

Tolls were pointed out as a factor in route selection. However, it is *not* dealt with in isolation. In many situations, when origins and (or) destinations are in Chicago, IL or places in the Northeastern part of the United States, they become inevitable. Similarly New York and the Burroughs are also associated with the 'inevitability of paying tolls'.

***If an alternative to a toll road exists then…***

When no options are available, then it is not an issue. However, when alternatives to toll roads exist, the tolled route is not the "automatic" decision. Multiple factors like– safety, economics, speeds, etc. are considered before deciding which route to take. Participants noted that the decision to adopt the tolled alternative is more often a management decision made by the company and is also largely a function of the fleet sizes. For non-company decisions and for owner/operators, other factors might come into play as is evident from the following excerpt:

*"Depending on how much time they have between the shipments; if the shipment is loading today, and it has to be off just as soon as we can physically and legally get it there, they are going to do whatever they can to take the shortest route, and if that involves a toll road, then they'll take it and they can use that as a tax write-off at the end of the year. Other than that, they'll avoid them if they can; if they have time…He* [the driver] *would be responsible for paying for the toll road."*

***Who pays the toll?***

It was noted that in the case of company-owned assets, the firm pays for the tolls while in the case of Owner/Operators, the drivers pay for it. Participants were also asked if they thought this trend would continue in the future. According to the study participants, as toll roads become more widely prevalent, companies will re-evaluate their costs. Until then it will *not* be too big a factor in determining routes.

***Toll Cost Pass-Through***

The consensus in this regard appeared to be that toll costs are internalized to the entity adopting the route i.e., either a company (for a company driver) or the owner/operator. It was noted that there was no formal mechanism for building in toll surcharges as is commonly the practice in areas with extensive toll roads like the Northeast - where contracts specifically include a toll surcharge and it is ultimately passed on to the shipper. Other factors noted by Texas participants in not including toll costs were competitive market structure post-deregulation and being able to provide competitive freight rates in an effort to retain and augment the client base. Another point noted by participants was that the difficulty in allocating toll costs could be greater for less-than–truckload movements due to the way these shipments move within urban areas and load consolidation practices.

***What is an acceptable amount?***

This was an issue which raised several interesting perspectives on the cost of tolls and how companies deal with it but there was no clear cut response either. For example, a difference is made between offering dedicated services vs. random movements. In the former case, since the same routes are going to be traversed frequently for the same customer, it might be built into the contract, and the "acceptability" depends on the overall bid.

> *"Well, on our dedicated services, I'll look at it hypothetically. If I was in Chicago, and; we're in the automotive business, so we run a lot from Chicago to Detroit in our vans. Let's move Detroit over to the other side of Pennsylvania and put it in Philadelphia. I would go into the system knowing that I have to travel all the way across the entire state every time I made a move to that automotive plant. I would, at that point, actually put into the bid process of our rate levels that allow for that toll road to be there. When you are randomly running a trucking company and on a given day, you do not know where your shipments are going anywhere in the company until you actually book them with your customer, and you randomly go across Pennsylvania, you can't really do that."*

Similarly, the type of network served was noted to influence the "acceptability" of tolls and toll costs/amounts. With an increasing emphasis on decentralized networks (resulting in more facilities and hence shorter average distances), the chances of running through tolled sections is likely to increase too. This will make an impact on the transportation provider's bottom line.

Other factors affecting the *acceptable* amount of tolls were origin-destination (or lane) characteristics, backhaul revenues, and ease of freight availability. The prime reason indicated for this was the thickness of the rate structure comprised of the typical logistics costs, transportation costs including running costs, labor costs, and origin/destination charges.

It was also expressed that there is a "tipping point" with respect to toll costs. A $50 -$100 charge is considered as an issue and could not be separated from the shipment value, suggesting that there is a trade off between cargo type and toll costs.

***How are tolls viewed?***

Based on the earlier observations and interpretations of what the participants said, it is safe to state that at their current levels, tolls are seen as just another operating cost. Companies that can absorb them and still remain competitive will do so, while those that cannot do so will try to recover it from their customers. However, given the fact that the trucking industry is already taxed heavily (and disproportionately, as felt by some, when compared to other highway users) no one sees it as equitable. It is even more unfair, when the toll is paid and it does not provide any benefit such as reduced travel times etc. Some industry participants drew analogies between fuel surcharges and tolls and noted that tolls should be removed once the facility is paid for. Other participants noted that tolling options should be considered only after exploring options like mass transit especially in metro areas like Houston.

***Benefits of tolling***

According to the participants the benefits of tolling could not only extend to trucking companies and their customers (on-time deliveries etc.) but to the society as well. Trucking becomes safer and drivers get more rest and work in better conditions, thereby leading to positive effects on daily productivity.

***Truck specific toll lanes***

Types of tolling options do cause concern to trucking companies. When it was asked if trucks were to be allowed to use toll-only lane, participants were concerned with the possibility of faster moving truck drivers being frustrated by the slower moving ones and participants noted the need for both multiple lanes and easy access/egress points.

***Fuel Costs/Prices***

All participants agreed that fuel prices were having a “devastating” effect on their operations. It is even more of an issue when it cannot be recovered from customers because the agreed upon price has changed and the customer refuses to make up the difference. Hence, a certain amount of stickiness in fuel surcharges was indicated as well as non-uniformity in surcharge adoption.

Perceptions too, hurt the trucking companies. Many feel that transportation service providers use fuel surcharges to generate additional profits; instead it was noted that the opposite is true – rising fuel costs are eating away at the already slim margins that this industry sees.

Another factor that was noted to hurt the industry is the ease with which companies can 'match' competing offers. The highly competitive nature of the trucking industry (especially truckload operators) makes it difficult to *increase* rates but easier to cut rates and have everyone else follow.

***Are tolls and fuel prices jointly considered?***

-*"Never further from my mind."*

The above sentiment describes this fairly well. At first, the two factors seem to be two separate issues – but in most cases are treated similarly: as costs of doing business. While fuel is broadly accepted as an *unavoidable* cost and possibly recovered through surcharges, tolls are still very nascent in their acceptability by both carriers and shippers. As they become widely prevalent, and as more and more carriers see their profits being eroded by the high cost of tolls, they too may be treated as fuel, and toll surcharge might be a solution in the upcoming future.

## 5.5 FACTORS GENERATED FROM QUALITATIVE ANALYSIS

### 5.5.1 TCH AND TCD FOCUS GROUPS

The focus group responses were analyzed using a qualitative software QSR N6 (NVIVO software) and the transcribed texts were used to identify several 'Free Nodes' and 'Factors'. Each 'Factor' represented several 'Free Nodes', which represented a common theme between them, but were different from the others. The resulting tree diagram (with associated Free Nodes for the TCH group) is shown in Figure 13 which represents at least nine key factors that were extracted from the transcription. These include infrastructure issues, congestion, modal, product-

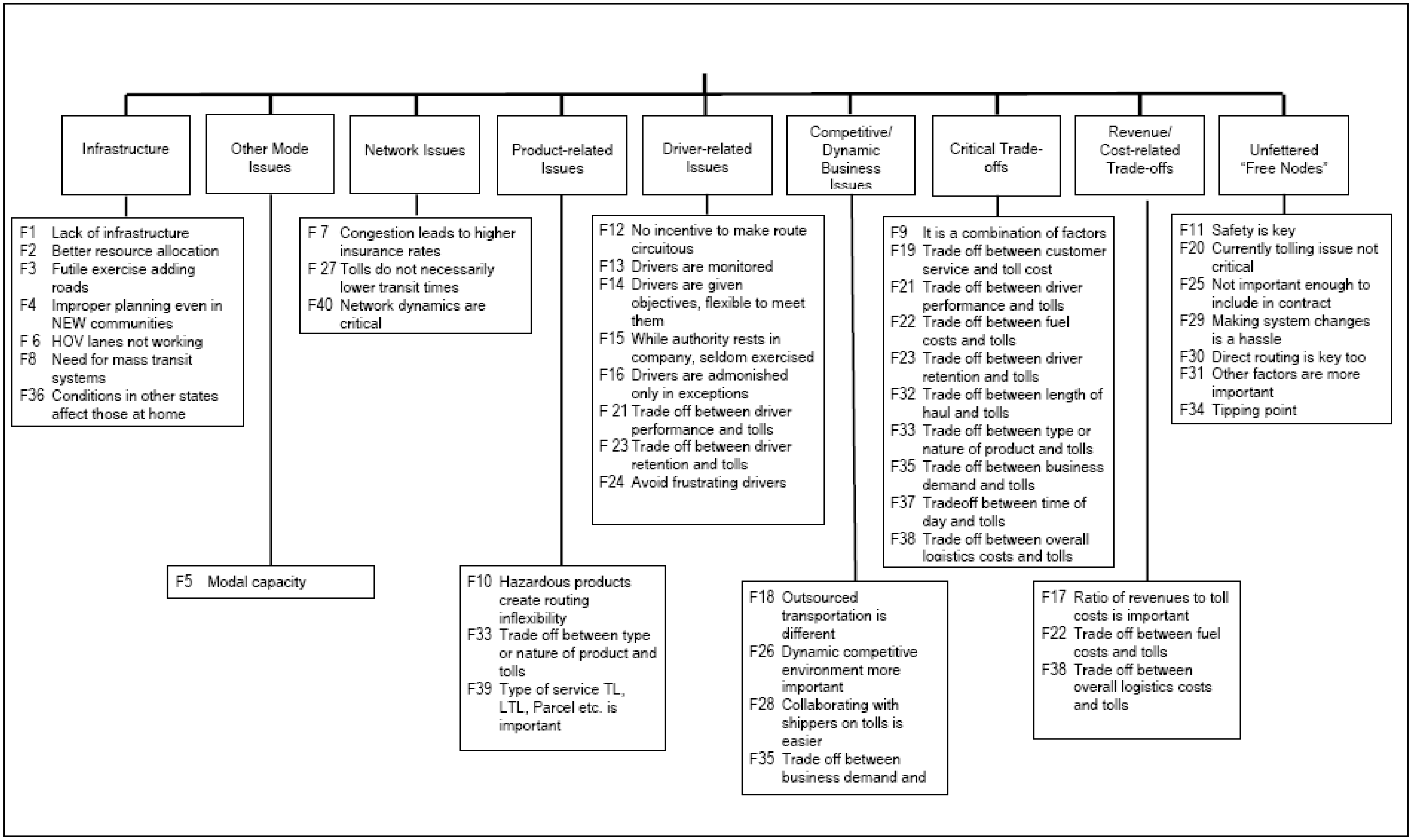



**Figure 13 The Tree Diagram**

related issues, competitive business dynamics issues, driver issues, critical trade-offs, revenue-cost trade-offs and unfettered free nodes (or those that could not be grouped within a common theme).

### 5.5.2 OOIDA FOCUS GROUP

For the focus group comprising the Owner Operators, all conversations were recorded and then transcribed. Based on careful reading of the transcribed data, textual bits were coded into 'dimensions' using QSR N6 (NVIVO). These dimensions and their associated codes are discussed below.

**Dimension: "*Operational Independence*"**

One of the most interesting aspects that emanated from this focus group was the degree of independence exercised by Owner-Operators in their operations. While this might seem natural (because they own and operate their own rigs), the intensity with which they do so was surprising.

**Dimension: *"Cash Flow Dependent"***

All participants of the 'Owner-Operator' focus group were unanimous on the importance of cash flow. They all agreed that having money on hand to pay for the tolls was an important factor in their route-selection process.

**Dimension: *"Political Resentment"***

This is a dimension which did not surface in the other two focus groups as it did among the Owner-Operators. As a group, they were unanimous in their condemnation of political influences in their industry. They all felt that tolling was unfair in the first place. Another prevailing notion among them is that politicians are "selling" the country to foreign interests:

*"My fear is that if they put these toll roads they're talking about in, in Texas, that they're going to try and sell them to somebody overseas who will then have the revenue producer for 75 years. And that will just give the legislature more money to fool away right now. And any amount of money you send often will be fooled away on something…We've learned that dealing*

*with these politicians...Look at Indiana…That money is going in his pocket or one of his buddy's pockets… There's already too much foreign control over the United States…selling our roads off to foreign control corporations."*

**Dimension: *"Effect Security"***

Another dimension that did not emerge from the other focus groups was the security factor. While most of the participants expressed concerns that the 'opening up of the borders' and allowing foreign trucking companies to do business on US highways was going to affect them, they felt that opening more toll roads would also affect security.

**Dimension: *"Aware of Importance"***

Yet another important distinction between this group and the two previous ones (members of the Transportation Clubs of Dallas and Houston) was the acute awareness of their "power".

**Dimension: *"Lack of Benefits"***

It was clear from the analysis that Owner-Operators in general feel that toll roads do not present any benefits. More importantly, this perception is not going to change even in the future. Based on this dimension and those identified earlier in this report, getting them to use toll roads may be difficult.

**Dimension: *"Cost Trade-Off"***

Finally, much like the other focus groups, Owner-Operators also look at the trade-off between the costs of using a tolled section versus its benefits especially the operator-company drivers. For instance, the trade-off between cost and urgency of delivery is evident from the following excerpt.

*"Well, as a company driver, for me I look at my deadline--when it's got to be there. Is it going to be further? A lot of times from the toll-way, it's going to be further. Sometimes it's quicker but sometimes its not, and even with it being further, and then you've got to look at the cost of the tolls. Does it outweigh the cost of the fuel?"*

As expected, fuel cost emerged as an extremely important factor. The link between fuel costs and route choice is clear from the fuel consumption and efficiency and can be seen from the following excerpts:

*"It cost me 60 cents a mile for fuel so I have to have \$2.15 to \$2.25 right now in diesel. Oil cost 89 dollars a barrel this morning on the stock market. That means that the cost of fuel is going to be up to \$3.35 a gallon. I don't get any better mileage with \$3.30 cents a gallon fuel than I do with \$2.00 fuel. The thing is I just charge for it, and if they don't want to pay it to hell with it. I don't owe it."*

*"I just negotiate the rate on every load. If they don't want to pay enough for me to make money on it then I have to have…right now about \$2.15 a mile. If they don't want to pay \$2.15 a mile I don't go. If they want to pay only that, and I have to go to the northeast I don't go to the northeast, period. Just simply because of the toll roads. It costs me more to run there… About \$2.35 actually, but it raises my cost about 15 to 20 cents a mile, and if they don't want to pay it I just don't go there."*

## 5.6 OBSERVATIONS FROM FOCUS GROUP ANALYSIS

First, this qualitative analysis indicates that there are issues that the transportation industry faces which will affect a decision to use or avoid a tolled segment. The most important of all those issues are linked to drivers. With the high turnover rate, the companies will do anything to placate them – including giving them the decision-making power to take or avoid a segment that is tolled. Hence, any study on the success of a tolled segment should include drivers as well.

Second, the study shows that the nature of the product and the state of the rest of the infrastructure are important for toll road adoption. The former is determined by the company itself, while the latter is determined by the city, state and federal governments. Here again, it is recommended that any study of tolling and its success must include these two constituents –

namely shippers (of the broadest variety of products) and city, state and federal government officials.

Many of the findings concur with the Reebie study focus groups (*35*), but there are several differences as well. For reference, a comparison with the Reebie study is shown in Table 9 below.

**Table 9 Comparison of Texas and Virginia Focus Group Findings**

| *Question* | *Reebie Study* | *Texas Study* |
|---|---|---|
| Who makes routes? | Predetermined for Company Drivers/ Third party established loads; Drivers for independent drivers and others | |
| Factors affecting route choice | Driver pay/ Company drivers focus *only* time/toll cost trade off; Independent drivers and owner operators have their own trade offs | Several trade offs including cargo type; several factors (shown in Figure 9) |
| Is tolling a factor? | - | Yes, but never considered in isolation. It is a management decision for companies. |
| Use of routing algorithms | Yes for some companies; typically least cost routing or practical miles implying staying on freeways | |
| Who pays for the toll? | Not always full cost recovery | Barely any cost recovery in Texas operations, not incorporated in rates due to highly competitive industry with thin margins. |
| What is an acceptable amount? | - | Range of responses on what is acceptable including state of network, back-haul revenues, O/D patterns; tipping point around \$50 but shipment value is critical; issue of dedicated vs. random movements |
| How are tolls viewed? | - | Perceived as double taxation and more so, because of lack of cost recovery |
| Benefits of tolling | - | Agree on benefits but need sharing in costs by shippers. |
| Truck specific toll lanes | - | Access/egress; Multiple lanes; |
| Are toll costs and fuel prices jointly considered? | - | Yes |
| Impacts of fuel costs/prices | - | Significant |
| Owner-operators | | Route choice biased against toll routes and exacerbated in the light of hike in fuel prices. |

Third, an important contribution of the focus group towards the follow-up phase or questionnaire design phase is potential inclusion of the items identified as ‘Free Nodes and Factors’ so that their validity can be ascertained on a broader scale. This sets this study apart from the Reebie analysis.

Fourth, the industry aside from the owner operators recognizes that tolling could confer some benefits. However, they are concerned with non-consideration of other transportation options, difficulty to pass on toll costs with degree of severity varying across segment groups. Finally they would support tolling options only if tolls were to be removed after the project was paid for. Owner operators also indicate that tolls would not be an issue if there was a away to recoup the costs.

Fifth, this analysis suggests that the choice to adopt a tolled route is not automatic. There are several trade-offs made at the company level for pre-determined routes. But the trade-offs faced by the company drivers (who adopt their own routes) are based on a *smaller* set consisting of time, distance, operating costs, safety, toll costs in addition to their own objectives and thus not limited to only time savings and toll costs. One key implication of this finding is that routes come with their set of relevant “attributes or hedonics”. Some of these attributes may be implicit in trade-offs that a group of truckers might consider while another set of truckers might simply ignore them. In essence, this confirms Hensher’s proposition that the truckers might adopt distinct *attribute processing strategies* in determining their willingness-to-pay (*62*).

Sixth, the focus groups reveal that since there is almost no cost recovery measure for toll costs, all segments of this industry operating in Texas are sensitive to tolling. The focus group participants suggested remedies include fuel tax rebates or fuel reimbursements drawing attention to fuel price trends as well as overall amount of taxes contributed by commercial vehicles.

Seventh, the OOIDA focus group analysis indicates that there are idiosyncratic issues that Owner-Operators as a group face while dealing with toll roads. Any Federal or State agency needs to listen carefully to these concerns and address them before embarking on strategies which institute tolled roads on a broad basis. It is clearly evident that Owner-Operators, who represent a huge segment of the overall trucking industry, is a force to be reckoned with and including them in such a decision making process is imperative.

# CHAPTER 6. ANALYSIS OF THE SURVEY DATA

## 6.1 PURPOSE

Chapters 4 and 5 provide qualitative description of the factors affecting route choice decision of the carriers, this chapter is designed to examine the perceptions using real data. To that end, a survey was conduced with the aid of American Trucking Research Institute (ATRI). The survey was deployed by ATRI to three trucking association membership groups:

- 650 Members of Texas Motor Transport Association.
- 41 Members of the American Trucking Association that are based in Texas, and
- 19 Members of the National Private Truck Council based in Texas.

The survey was pre-tested and distributed by ATRI using email, fax, and paper copy.

A total of thirty respondents responded to the survey and a discussion of their responses is provided in the ensuing section. The actual survey is included in Appendix C. These thirty respondents jointly operate a fleet of 2655 trucks.

### 6.1.1 TYPE OF CARRIER/ OWNERSHIP

Nearly half of the carriers who responded fall into the For Hire category, followed by the Private segment, as shown in Figure 14 below. At the National level, about 26 % of the carriers operate as For Hire and about 48 % are Private (*46*).

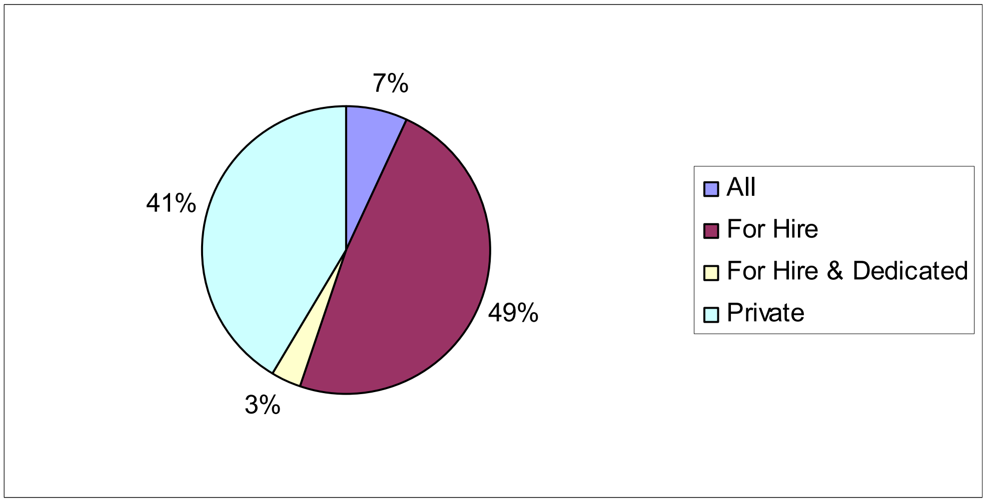
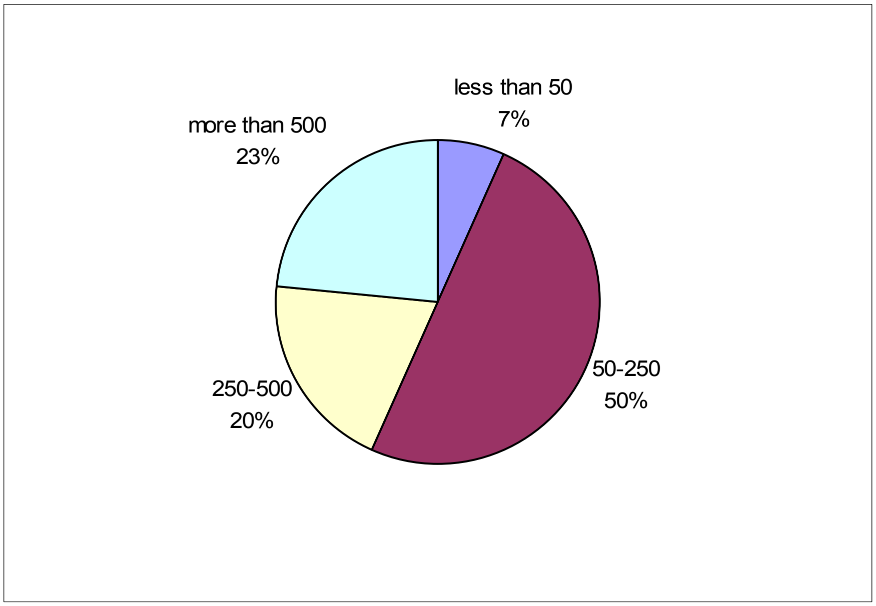



**Figure 14 Type of Carrier**

### 6.1.2 LENGTH OF THE HAUL

About half of the carriers belong to the category of medium Haul (50-250 miles), followed by very long haul (greater than 500 miles) and long haul (250-500 miles). A small segment (7%) of the companies is characterized by short haul (less than 50 miles). However, based on the total fleet size of 2655 trucks, about 17% is devoted to the very short haul (< 50 miles), 33% to medium length hauls of 50-250 miles, 17% to long hauls ( 250-500 miles) and 33% to the very long-haul (>500 miles) category. At the national level, about 52% of the trucks belong to haul length of 50 miles or less, while 24 % are between 50 and 200 miles, 8.5 % (200-500 miles) and 11.5 % run over 500 miles (*46*). Thus a comparison of the survey population with the national statistics reveals that there is an under-representation of very short haul carriers, and an over-representation of very long haul carriers. These are shown in Figure 15.



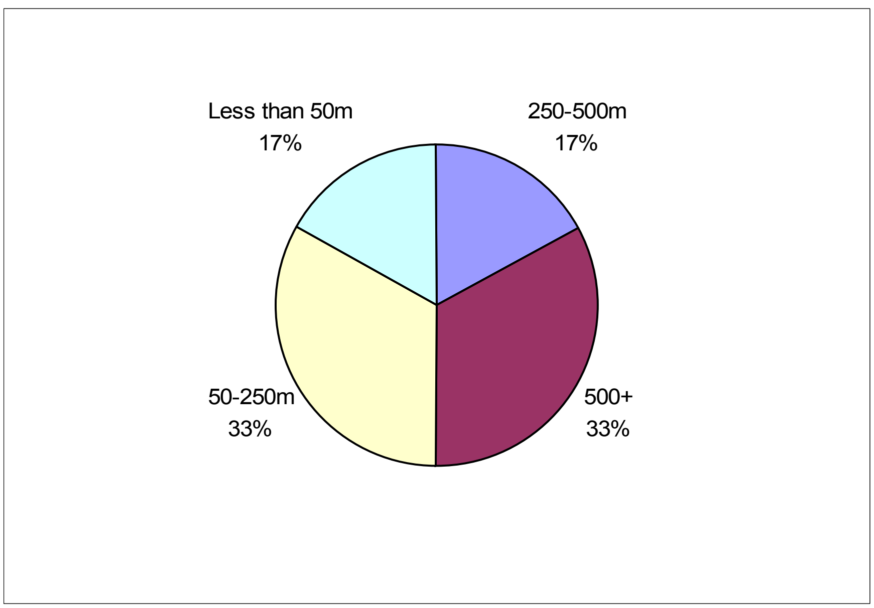




**Figure 15 a) Categorization by Length of Haul b) Haul Length by Total Respondent Fleet Size**

### 6.1.3 MODE OF OPERATION

As is evident from the following chart (Figure 16), most of the carriers (86%) are characterized by TL operation, whereas only 10 % of the total sample comprises the LTL segment. Therefore the results presented in this chapter are more reflective of the behavior of the TL segment. Furthermore, the responses to various questions are also likely to be reflective of TL segment in medium, long and very long haul operations. It is important to note that at the National level, within the For Hire category; about 52 % of the carriers belong to the TL category while 24 % are LTL (*46*).

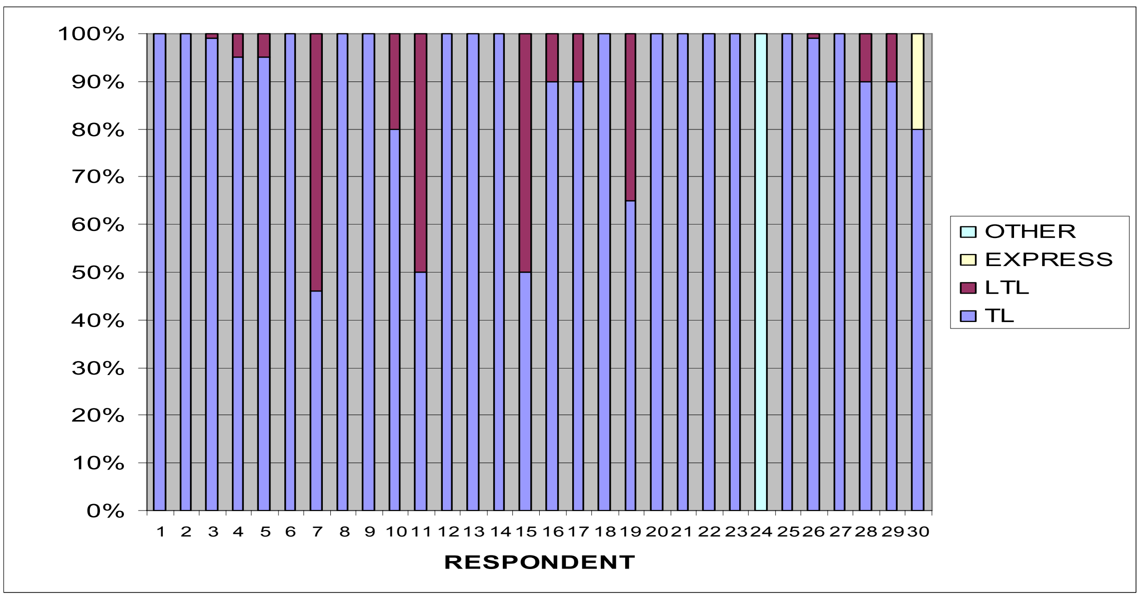



**Figure 16 Mode of Operation**

### 6.1.4 FIRM SIZE AND FUEL COSTS

The variations in firm size and the operating cost structure for the 30 carriers are demonstrated in the following table (Table 10).

**Table 10 Operational Statistics of the Companies**

| *Summary statistics* | *Power Units* | *Sales Revenue Million ($)* | *Fuel Costs (cents per mile)* | *Fuel Costs ( $ per hour)* |
|---|---|---|---|---|
| **Mean** | 89 | 21 | 55 | 63 |
| **Median** | 30 | 15 | 60 | 33 |
| **Min** | 2 | 3 | 5 | 6 |
| **Max** | 650 | 112 | 91 | 350 |

While the categorizations above provide a broad overview of the characteristics of the survey sample, there are several other structural features that dictate the behavior of the companies. A brief description of these variables is provided below.

### 6.2.1 FREIGHT DELIVERY TIME

When it comes to freight delivery times, it is the shipper or the carrier whose decision matters most. The consignees' decision might also be important in few cases, as is evident from the Figure 17. For 51 % of the companies, route choice is being made by backroom operations, for 33 % by the drivers and about 16% by the drivers.

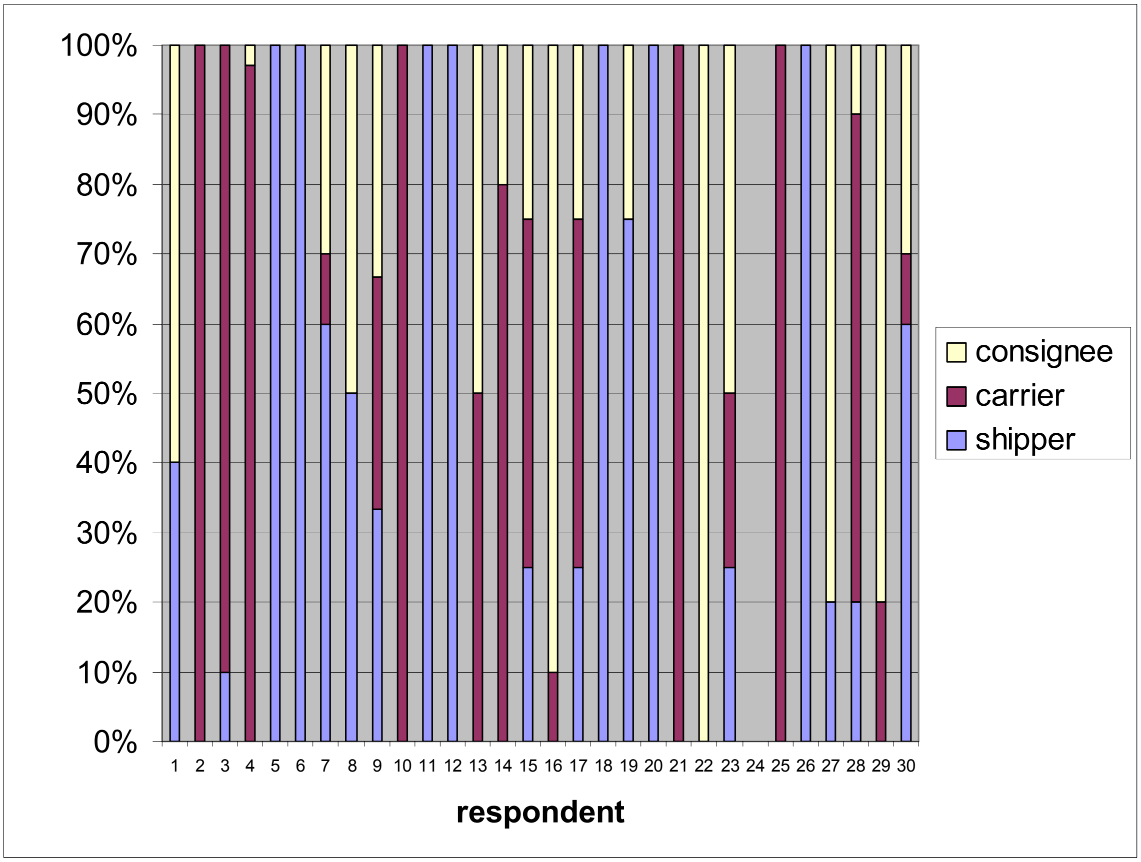



**Figure 17 Delivery Time Decision**

### 6.2.2 TOLL COST COVERAGE

When it comes to toll cost, most of the companies bear it themselves, as is evident from Figure 18. Instances where the shipper or the driver bears most of the toll cost are relatively rare.

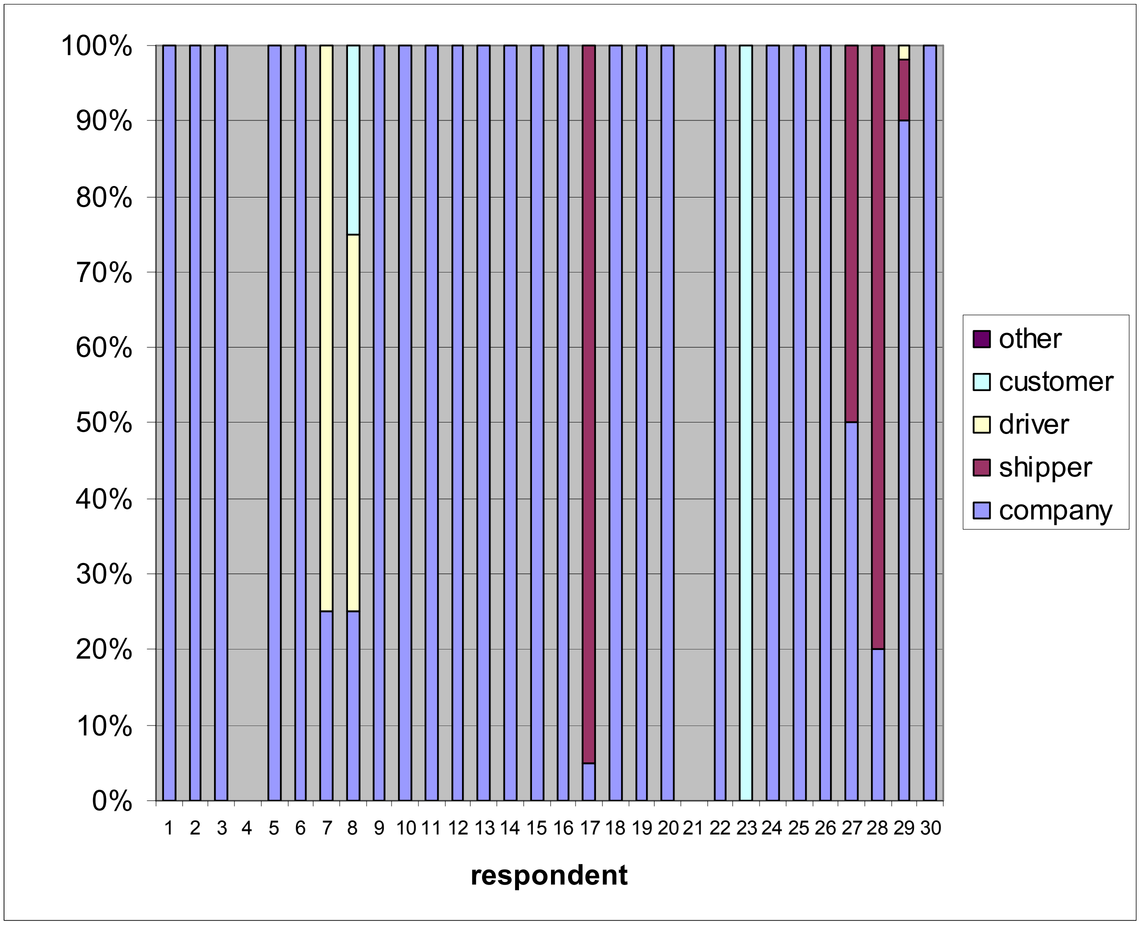



**Figure 18 Sharing of Toll Cost**

### 6.2.3 CALCULATION OF TRIP TRAVEL TIME

Figure 19 indicates that routing software is *always* used by about 30 % of the carriers, while driver experience is cited by 22% as an "always" adopted tool. It is interesting to note, that another 40% note that routing software is used sometimes and 88% point to driver experience is relied on sometimes. In general, we can say that the trip time is calculated by a combination of routing software and drivers. This is critical in the light of the present study in several aspects. It reinforces the focus group findings and perhaps more importantly, indicates first, greater opportunities for towards avoidance of toll roads. Routing software like Promiles, PC*Miler, and PCMiler are typically designed to provide choices for route optimization including options for avoiding tolled routes and also options like fuel-optimized routes, and distance and time-optimized routes for all haul lengths. Next, the reliance on driver experience is strongly reinforced by the focus group findings. This suggests that the TL sector with greater reliance on driver experience is more subject to bounded rationality in toll route choice decisions implying that choices are myopic and based on few key trade-offs. Other options like GPS/ECM, Google Earth, or even thumb rules are used by few carriers.

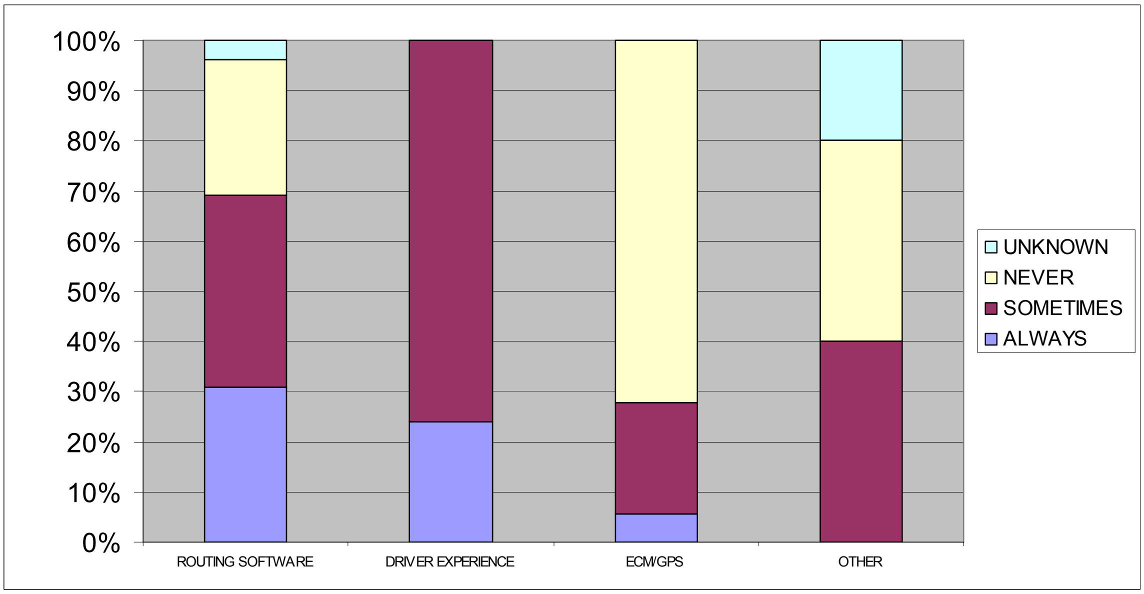



**Figure 19 Calculation of Trip Travel Time**

### 6.2.4 FUEL SURCHARGE POLICY

Rising fuel costs have been affecting the companies at all level. Consequently, as we can glean from Figure 20, most of the carriers have fuel surcharge built into the existing contracts. Nevertheless, it is interesting to note that for about 26% of the carriers, the surcharges are either low (i.e. below 25%) or even non existent. Majority of these for whom surcharges are below 25% or non-existant belong to the private category. Under these circumstances and for those, the impact of fuel costs on routing is likely to be biased against toll routes. In the case of the private carriers, this would indicate fuel cost minimization a key objective through various internal processes and via route selection that minimize costs.

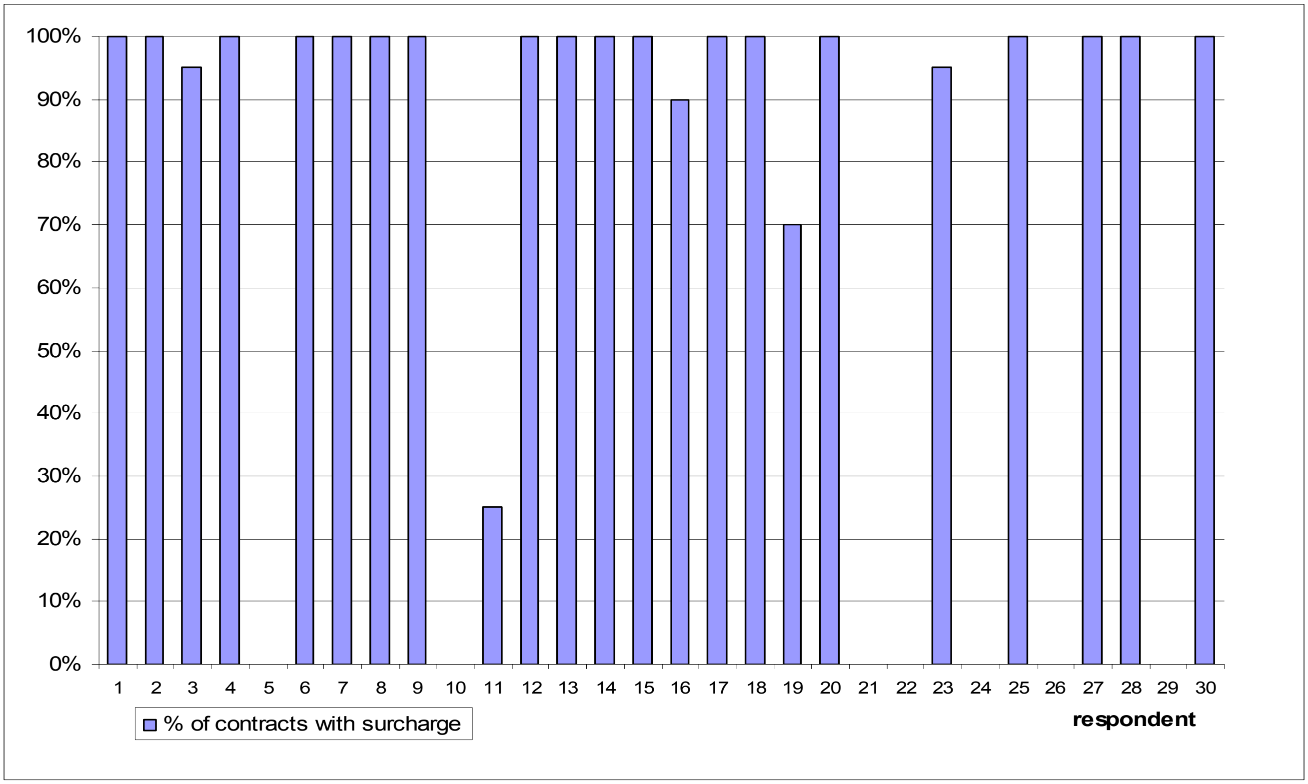



**Figure 20 Fuel Surcharge in Existing Contracts**

Although most of the carriers have fuel surcharges built into the contracts, it does not necessarily imply that all of their fuel costs get reimbursed. In fact, on an average, 52% of the costs get covered through surcharges; with the range being [0,100%] (Figure 21).This corroborates our earlier finding that there exists *stickiness* in existing contracts. In the light of this study, it is important to understand the significance of this finding. In spite of the prevalence of fuel surcharges, the costs do not uniformly get recouped and therefore, carriers which are always striving to cut down their operating costs would be reluctant to opt for toll roads. One must not forget the critical difference between fuel and toll costs- while one is an unavoidable cost, the latter is avoidable.

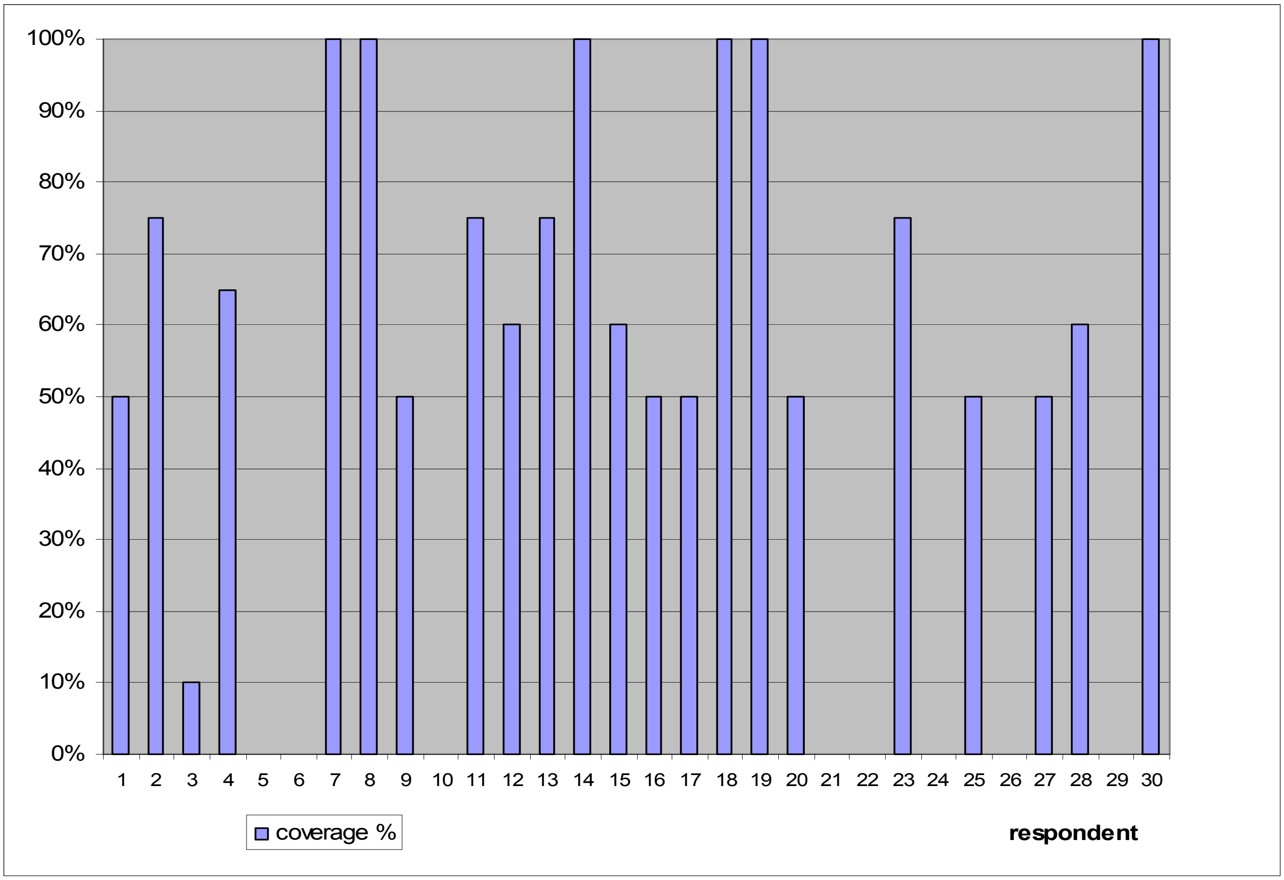



**Figure 21 Coverage of Fuel Costs Through Surcharges**

### 6.3.1 ROUTE DECISION

With the general characteristics of the carriers' operational characteristics in mind, let us shift our focus to their route choice decision in the presence of tolling. While backroom operations appear to dictate route choice decision for most of the carriers in the sample, it is important to note the importance of the drivers in this aspect (Figure 22). Although the shippers appear to be less important compared to these two categories, they do have a say in route decision. The importance of third party logistics appears to be low in this sample. Again, this reinforces the findings from the focus group that backroom operations dictated by routing tools and driver experience are the two significant groups with route decision making in TL operations.

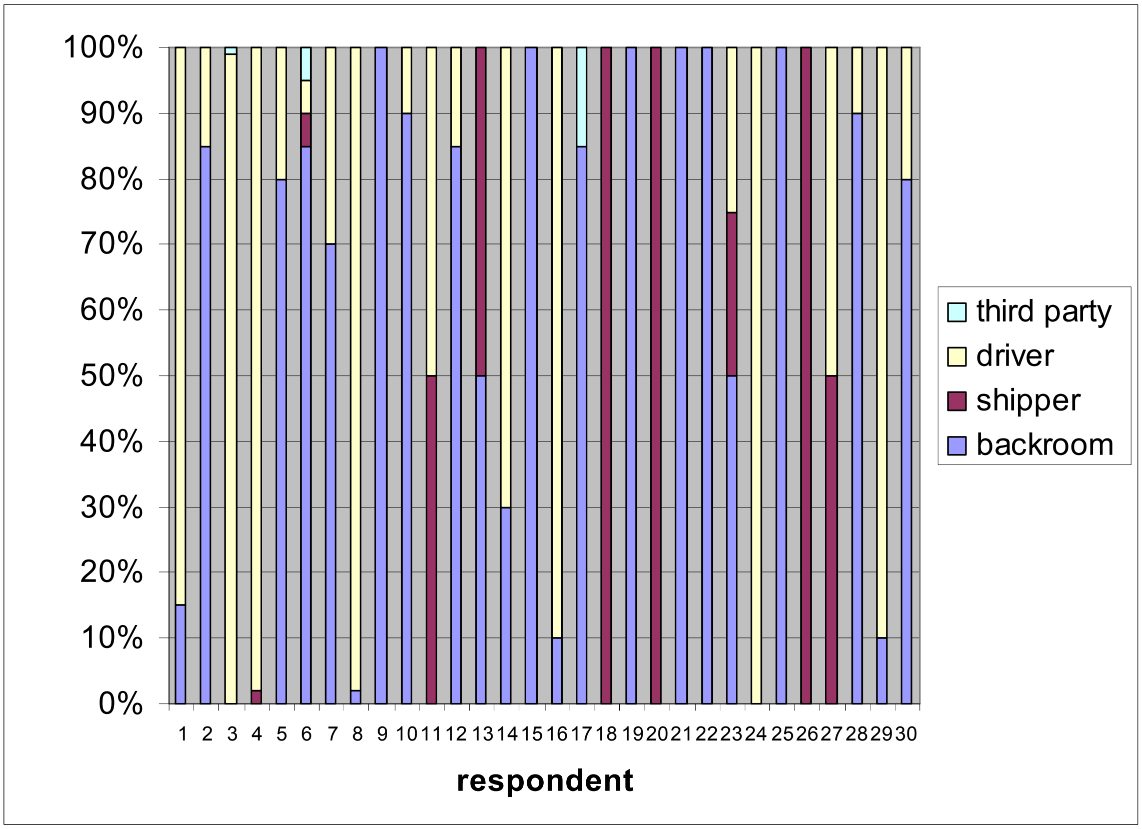



**Figure 22 Route Decision Authority**

### 6.3.2 USAGE OF TOLL ROADS

Existing toll road usage ranges from about 20% of total miles in toll routes, to no toll route miles reported by six of the carriers (i.e. 20 % of the sample) (Figure 23).

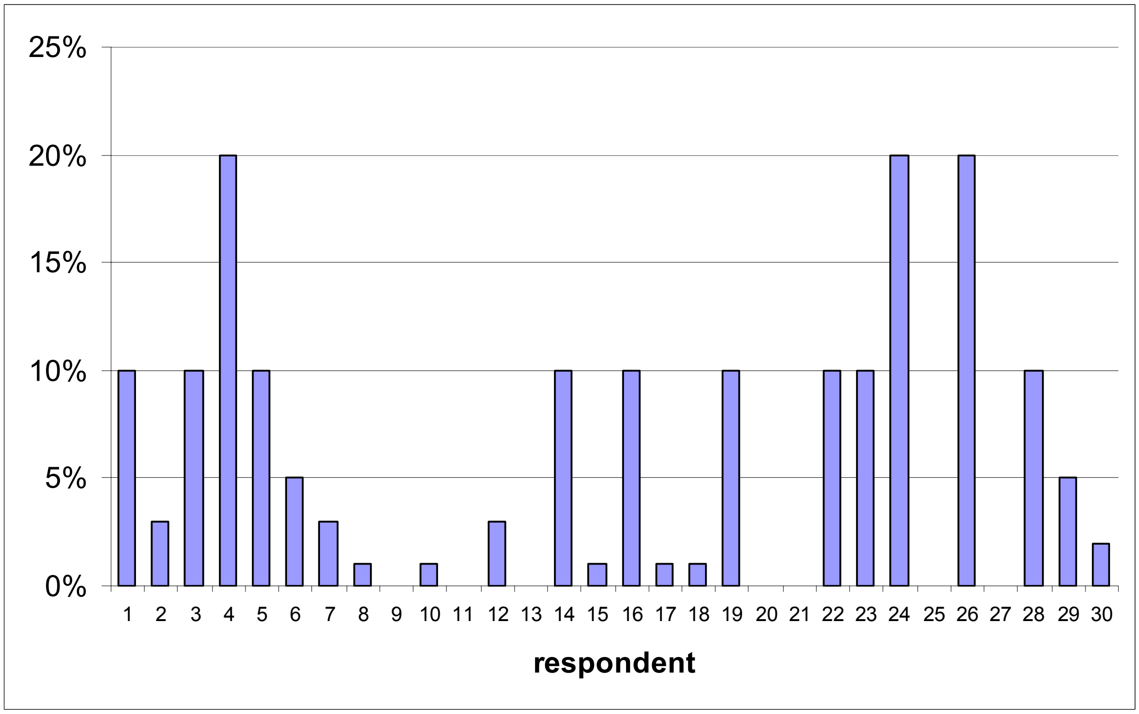



**Figure 23 Percentage of Miles Operated on Toll Roads**

### 6.3.3 POLICY TOWARDS TOLL ROADS

Figure 24 shows that while a large segment (70%) do not have a toll road policy. This may be an outcome of the relatively less number of toll roads in the state of TX.

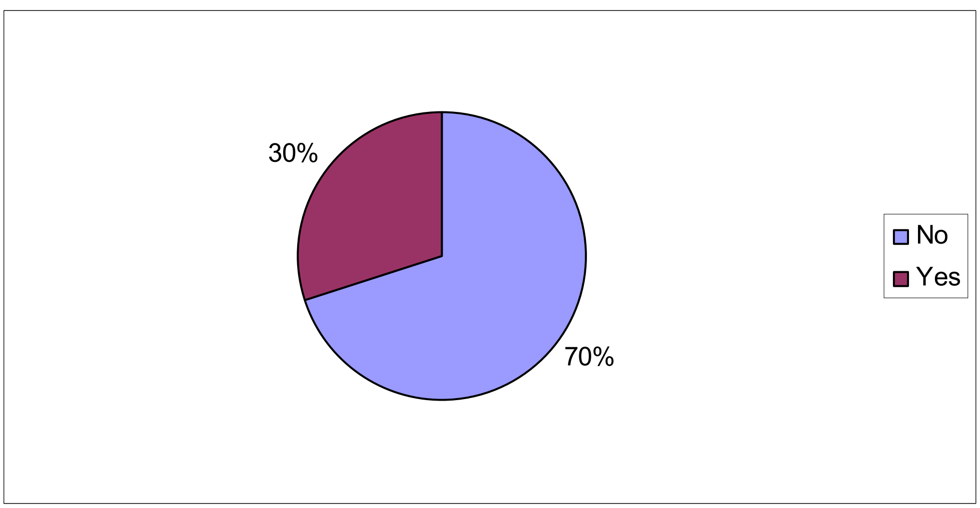



**Figure 24 Policy towards Toll Roads**

### 6.4.1 TRADE-OFFS: KEY TOLL ROAD USAGE FACTORS

This question relates to the factors that are considered important by the trucking companies if they were to take a toll road. As is evident from Figure 25, the three most important factors (captured by Rank 1) that emanated from this survey are time savings (50%), fuel costs (25%) and toll costs (18%). It is important to note that all of these form significant components of Generalized Travel Costs. Congestion on alternate routes, safety and shipper contract requirements are next in importance Driver related factors (wages, and retention) were rated rather low, less than 8%. It is however important to note that about six carriers (comprising for 20 % of the sample) would not consider the option of toll roads, irrespective of the trade-offs presented.

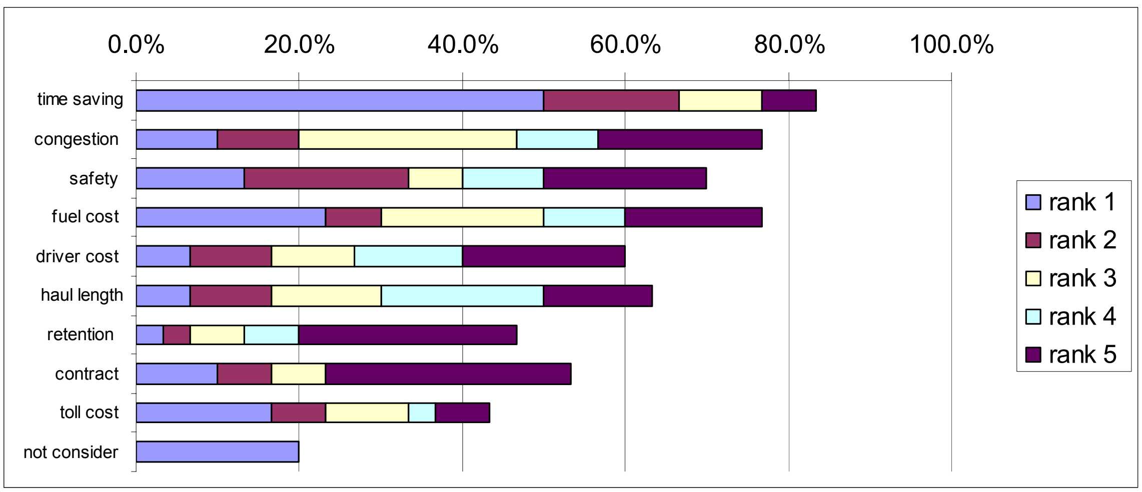



**Figure 25 Importance of Factors in Adopting a Toll Road**

### 6.4.2 IMPACT OF FUEL PRICES ON TOLL ROAD USAGE

For the given sample of observations, Figure 26 indicates that 50% of the carriers feel that fuel prices do not affect the existing usage of toll roads. Toll road usage is generally not considered along with fuel prices, except for 23 % of the carriers, who indicated that there is a clear effect. Of those 23%, 60% belong to the for-hire category, 28% to the private category and the remaining did not indicate a category. This a departure from the focus group study which indicated that fuel prices were an important factor by TL, LTL, and owner operators. Since this sample is heavily skewed towards TL mode, and use of backroom operations and routing software, this suggests that a large part of the routes may be predetermined hence not subject to an explicit “fuel price effect”.  In general, this suggests that if a greater proportion of existing route users are those with predetermined routes, there is a less likely diversion to a tolled alternative and consequently, fuel prices do not factor in explicitly.

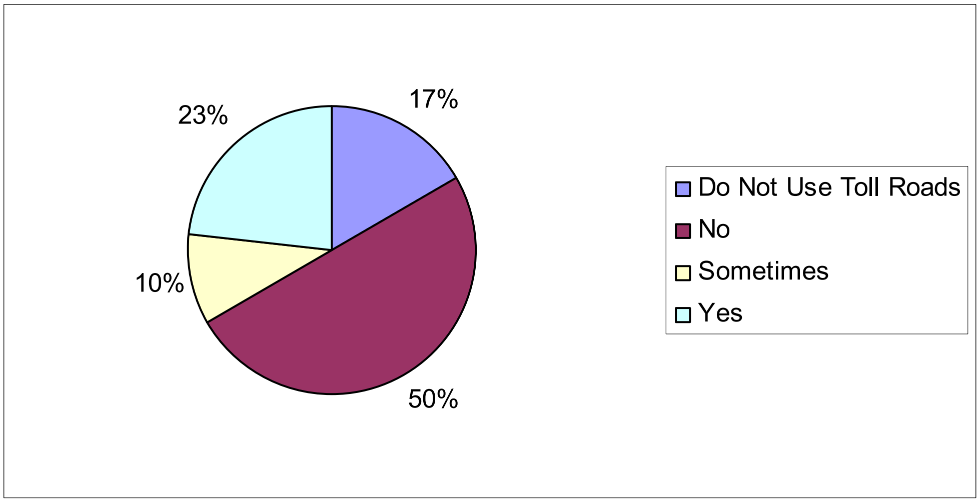



**Figure 26 Effect of Fuel Price on Toll Road Usage**

### 6.4.3 TRADE OFF: CARGO TYPE AND TRAVEL TIME

The trade-off between cargo type and decreased travel time is noteworthy. Figure 27 shows as expected that, “expedited service” would benefit the most from a reduction in travel times as offered by a toll road. Hazmat and oversized/high density/construction related cargo are also indicated to reap the benefits out of reduced travel time.

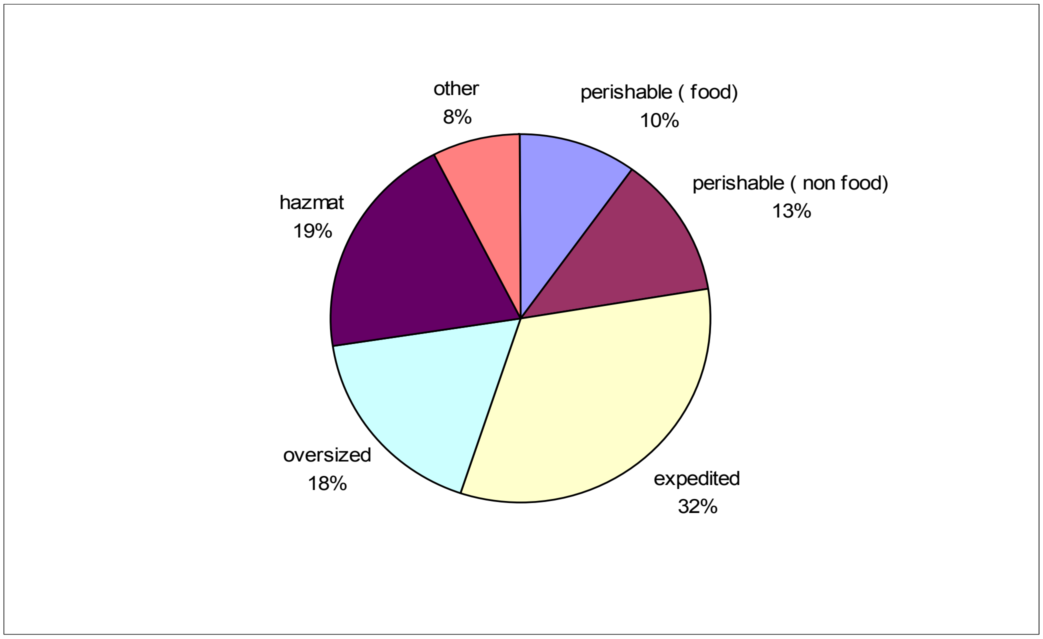



**Figure 27 Travel Time Benefit by Respondent Cargo Type**

### 6.4.4 TRADE-OFF: LENGTH OF HAUL, FUEL COSTS AND TOLL ROAD USAGE

There appears to be an important trade-off between length of haul and fuel costs and existing toll road usage. From Table 11, the effect is felt largely for short and medium haul carriers and only sometimes for long haul carriers. On the other hand, most of the long haul carriers do not consider it as an issue.

**Table 11 Haul Characteristics and Fuel Cost Impact on Existing Toll Road Usage**

| | No | Sometimes | Yes |
|---|---|---|---|
| 50-250m | 53% | 7% | 27% |
| 250-500m | 17% | | 50% |
| 500+ | 71% | 14% | |

## 6.5. ASSOCIATION ACROSS VARIABLES

In this section, several variables are analyzed jointly in order to examine if any meaningful association can be established.

**Table 12 Importance of Toll Costs by Ownership**

| *Ranking of Toll Cost to Shipment Value* | | | | | |
|---|---|---|---|---|---|
| Carrier Type | 1 | 2 | 3 | 4 | 5 |
| For Hire | 44.4% | 11.1% | 11.1% | 11.1% | 22.2% |
| Private | 33.3% | 33.3% | 33.3% | 0.0% | 0.0% |

It appears from Table 12 that for-hire companies tend to rank toll cost more highly than private firms. This is understandable given that the latter can more easily pass the toll costs on to their customers (*53*).

For-hire carriers are more likely to avoid a toll road in comparison to private carriers. This is quite expected, given that private carriers typically have toll costs built into their contracts (*53*). Table 13 indicates that the for-hire sector is more averse to toll route adoption relative to the private carriers. Furthermore, issues like driver retention are more critical for the for-hire segment (Table 14).

**Table 13 Likely Toll Road Usage by Ownership Category**

| *Carrier Type* | *Will not use toll roads* |
|---|---|
| All | 16.7% |
| For Hire | 66.7% |
| Private | 16.7% |

**Table 14 Importance of Driver Retention by Ownership**

| *Carrier Type* | *Ranking of Driver Retention* | |
|---|---|---|
| | 1 | 2 |
| All | 50.0% | 50.0% |
| For Hire | 35.7% | 64.3% |
| For Hire & Dedicated | 100.0% | |
| Private | 18.2% | 81.8% |

Table 15 indicates that private carriers tend to give higher ranking to fuel costs when compared to the For-hire segment. This can be explained as follows. Since private firms are less averse to adopting toll roads (vide Table 13 above), they might undertake a cost-benefit analysis which merits greater attention to fuel costs in route choice decisions involving tolls. On the other hand, for the For-hire carriers, fuel costs appear to be less important, since they are more likely to avoid toll routes.

**Table 15 Importance of Fuel Cost in Potential Toll Road Choice by Type of Ownership**

| ***Carrier Type*** | ***Ranking of Fuel Cost*** | |
|---|---|---|
| | 1 | 2 |
| All | 50.0% | 50.0% |
| For Hire | 50.0% | 50.0% |
| For Hire & Dedicated | 100.0% | |
| Private | 83.3% | 16.7% |

### 6.6.1 PERCEPTIONS TOWARDS MANAGED LANES

The participants were also asked about the preferred features of Truck-Only-Toll (TOT) lanes and voluntary High-Occupancy-Toll (HOT) lanes. As shown in Figure 28, the most important attributes emerged to be Electronic Toll collection, predictable toll structure, and the ability of the corridors in providing the shortest/fastest link to the key origin and destinations. Convenient access/egress points and multiple lanes come next in importance. Higher speed level was selected as a preferred option only 6% of the times.

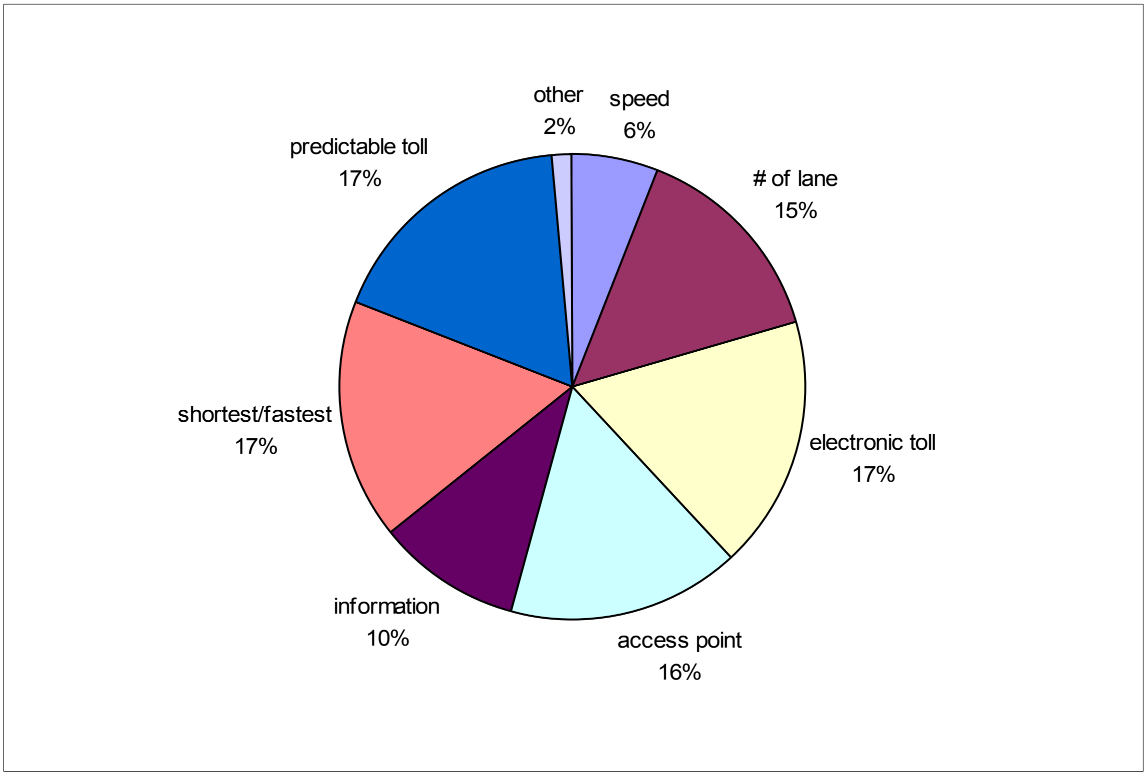



**Figure 28 Preferred Managed- Lane(s) Attributes**

When asked about the expected returns from *managed- lane options like* Truck-Only-Toll (TOT) and High Occupancy Toll (HOT) lanes, the For-Hire segment appear to be more enthusiastic about most of the attributes, like the number of lanes and the attributes like convenient access points near pick-up or delivery sites (Table 16).Attributes like predictable toll structure, electronic toll collection are equally important across segments. It is important to note that among the private carriers, the toll roads providing shortest/fastest link to key origin and destinations appear to be vital. Consequently, several of these options can be looked upon as tools to provide incentives for different segments of the industry.

**Table 16 Expected benefits from Managed Lanes**

| Expected Returns | For Hire | Private |
|---|---|---|
| Higher Speed Level | 28.60% | 18.20% |
| More than One Lane | 71.40% | 45.50% |
| Electronic Toll Collection | 78.60% | 75.00% |
| Convenient Access Points | 85.70% | 58.30% |
| Information on route | 42.90% | 41.70% |
| Predictable Toll Structure | 71.40% | 83.30% |
| Shortest/fastest link | 57.10% | 83.30% |

### 6.6.2 PERCEPTIONS TOWARDS CONGESTION

When queried about the factors that might be significantly affected by congestion, Figure 29 shows that fuel cost is the most important factor, followed by labor costs and insurance/safety costs. It is important to recognize that truckers in the sample understand that these elements of operating costs are all congestion-dependant. Driver retention also appears to be an important issue, although less severe than the other three factors.

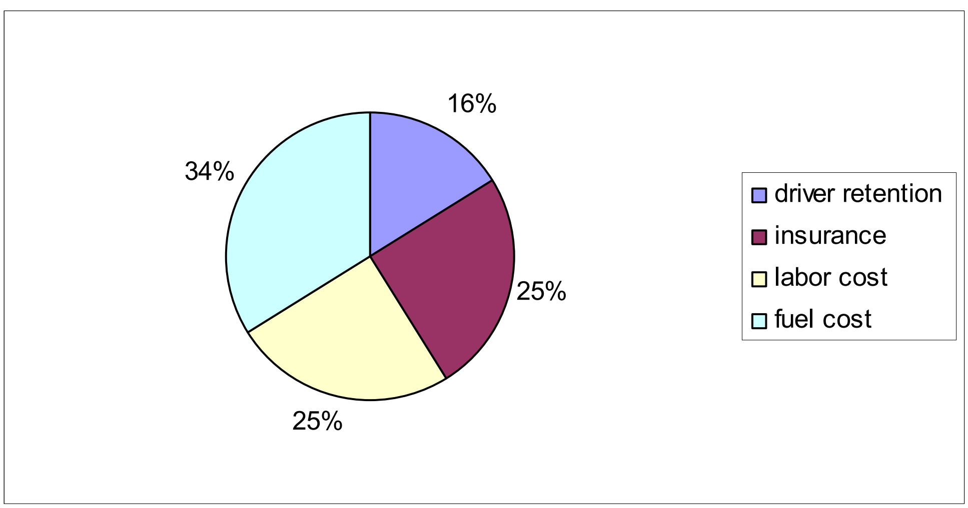



**Figure 29 Factors Impacted by Congestion**

## 6.7 WILLINGNESS TO PAY

How do trucking companies look upon toll roads in an era of rising fuel prices? Does the amount of time savings play a role in their attitude towards toll road? Which factors are deemed important while making the decisions? Three separate questions were presented in order to elicit some information about these issues. The survey uses a simple trade-off experiment with a view to identifying differences in willingness-to-pay (WTP) across groups and the key trade offs.

### 6.7.1 WHY EXPERIMENTS?

While there are several reasons for conducting an experiment, the most important factor is perhaps the inapplicability of *secondary* data on WTP. As has been stressed earlier, usage of imported data can lead to biased estimates of demand parameter. Another related reason behind conducting economic experiments is to get better information in order to evaluate proposed policies.

### 6.7.2 HYPOTHETICAL SET-UP

For the problem on hand, the respondents were presented with a hypothetical scenario involving an *extremely congested* route with a trip length of approximately 20 miles. They were presented with the option of using a toll road providing faster travel. In the first scenario, they were asked to report their *bids/willingness-to-pay when* fuel prices remain at their current level (just over $3 per gallon). Thus the problem presented was essentially of *contingent valuation* type- whereby the respondents were asked to make choices contingent upon the given scenario.

### 6.7.3 DESIGN OF THE EXPERIMENT

Travel time saved was confined to three different scenarios comprising {10, 15 and 20} minutes and toll costs were presented as a range of [$3 - $15] with an increment of $3. However, the category of responses allowed for "Other" amount that they might be willing to pay. Also, the option of not using the tolled facility was also included with an aim to provide flexibility to the respondents in making their choices. Consequently a hybrid variety of Induced vs. Homegrown Valuation was presented to the respondents.[13]

### 6.7.4 ANALYSIS

The mean WTP is presented in Table 17. While the unconditional mean is very low for all the scenarios under consideration, once we account for the non responses, the average WTP does increase. The mean WTP conditional on toll road adoption are found to be above $ 3 in all the three scenarios.

**Table 17 Mean Willingness-to-pay under Scenario I**

| | *SCENARIO I: Fuel cost = $ 3* | | |
|---|---|---|---|
| | **TTS = 10 minutes** | **TTS = 15 minutes** | **TTS = 20 minutes** |
| Unconditional Mean E[WTP] | $1.27 | $1.75 | $2.80 |
| Conditional Mean E[WTP\| Response Given] | $1.52 | $2.10 | $3.00 |
| Conditional Mean E[WTP\| Use toll road] | $3.17 | $3.50 | $4.20 |

The analysis was also done by disaggregating the choices in terms of ownership category. The results are reported for the first of the experiments, where fuel costs are held at $3. It can be readily seen from Tables 18 and 19 that the WTP among Private carriers is higher than that of the For-Hire carriers. This is in contradiction to what is found in the literature.

[13] When respondents are presented with exogenous value to choose from, it is an *induced* valuation. On the other hand, if the valuations emerge from the respondents themselves then these are said to be *homegrown*.

**Table 18 Willingness to Pay among Private Carriers**

| | *SCENARIO I: Fuel cost = $ 3* | | |
|---|---|---|---|
| | **TTS = 10 minutes** | **TTS = 15 minutes** | **TTS = 20 minutes** |
| Unconditional Mean E[WTP] | $1.92 | $2.63 | $3.50 |
| Conditional Mean E[WTP\| Response Given] | $2.09 | $2.86 | $3.82 |
| Conditional Mean E[WTP\| Use toll road] | $3.29 | $3.94 | $4.67 |

**Table 19 Willingness to Pay Among For Hire carriers**

| | *SCENARIO I: Fuel cost = $ 3* | | |
|---|---|---|---|
| | **TTS = 10 minutes** | **TTS = 15 minutes** | **TTS = 20 minutes** |
| Unconditional Mean E[WTP] | $0.64 | $0.86 | $1.93 |
| Conditional Mean E[WTP\| Response Given] | $0.90 | $1.20 | $2.08 |
| Conditional Mean E[WTP\| Use toll road] | $3.00 | $3.00 | $3.38 |

The average willingness-to-pay was also analyzed by length-of-haul. Table 20 demonstrates the variation by the four different categories. The key things to observe from the following table are as follows: the WTP among medium haul (250-500 mile) is the least, and is in fact zero unless travel time savings is very high. Very short haul (<50 miles) carriers tend to show some kind of inelasticity in terms of their stated choices. Very long haul (>500 miles) carriers exhibit some kind of *flat* WTP when TTS is modest (i.e. below 15 minutes). Lastly, WTP appears to be highest among the short haul carriers (50-250 mile). This suggests that tollways in urban congested conditions would appeal to those involved primarily short-haul movements.

**Table 20 WTP by Length of Haul**

| Length of Haul | | TTS=10 minutes | TTS=25 minutes | TTS=20 minutes |
|---|---|---|---|---|
| Very Short Haul Less than 50m | Unconditional Mean E[WTP] | $3.00 | $3.00 | $3.00 |
| | Conditional Mean E[WTP\| Response Given] | $3.00 | $3.00 | $3.00 |
| | Conditional Mean E[WTP\| Use toll road] | $3.00 | $3.00 | $3.00 |
| Short haul 50-250m | Unconditional Mean E[WTP] | $1.73 | $2.70 | $3.80 |
| | Conditional Mean E[WTP\| Response Given] | $1.86 | $2.89 | $4.07 |
| | Conditional Mean E[WTP\| Use toll road] | $3.25 | $3.68 | $4.75 |
| Medium Haul 250-500m | Unconditional Mean E[WTP] | $0.00 | $0.00 | $1.00 |
| | Conditional Mean E[WTP\| Response Given] | $0.00 | $0.00 | $1.00 |
| | Conditional Mean E[WTP\| Use toll road] | $0.00 | $0.00 | $3.00 |
| Very Long Haul 500+ | Unconditional Mean E[WTP] | $0.86 | $0.86 | $2.14 |
| | Conditional Mean E[WTP\| Response Given] | $1.20 | $1.20 | $2.50 |
| | Conditional Mean E[WTP\| Use toll road] | $3.00 | $3.00 | $3.75 |

Although these figures represent average demand structure among the group of respondents, we can say something more about the "aggregate" willingness-to-pay. This is represented in Figure 30, which plots the frequency of observations across the chosen WTP. In the broad sense, this curve represents a demand curve for improved travel time. It is important to note that the demand tapers off at $9, which may be regarded as the *choke-off* price for the given sample of carriers. We fit a linear trend to the observed choices under the three different scenarios and observe that the behavior appears to be consistent with theory. With an increase in travel time saved, the *aggregate* demand curve incurs a rightward shift. That is, at a given toll cost, more companies are willing to adopt the hypothetical toll road.

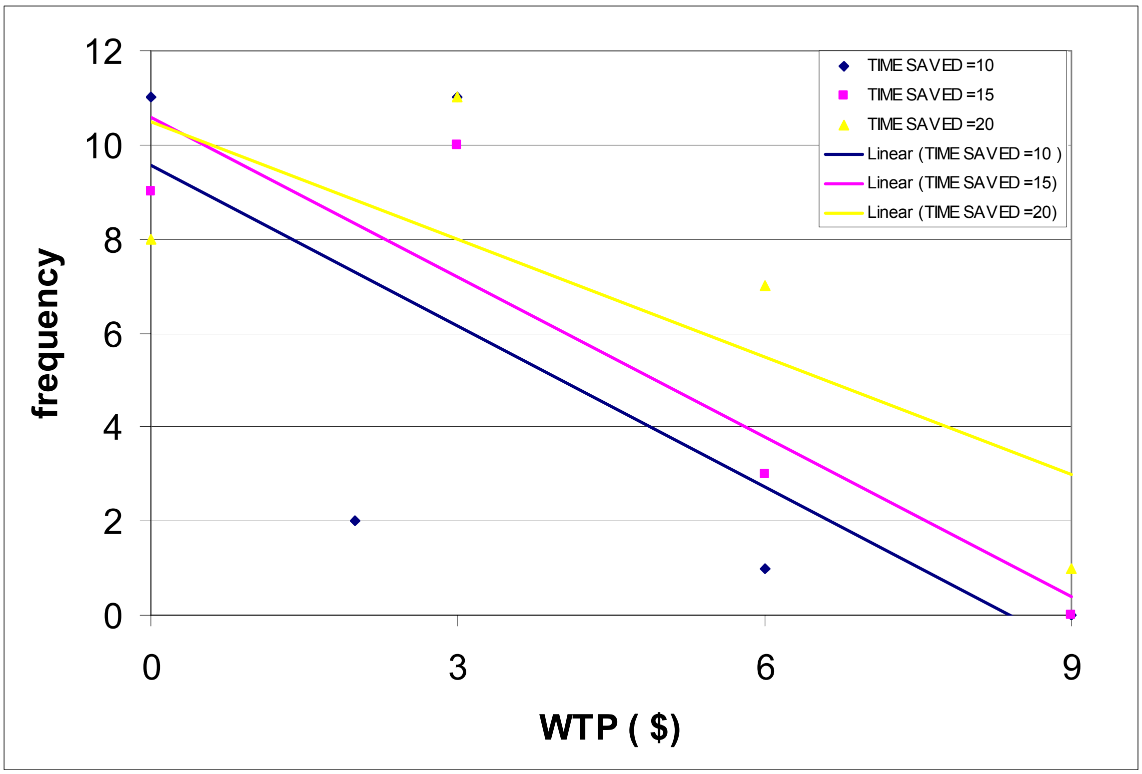



**Figure 30 Aggregate Demand Curve under Scenario I**

***Effect of fuel cost changes***

The hypothetical scenario presented above was slightly modified to examine the effect of fuel cost on toll road usage, which is one of the primary motivations behind this study. As before, we present the summary statistics of the responses in the following table.

**Table 21 Willingness to Pay under Scenario II**

| | *SCENARIO II: Fuel cost = $2.50* | | |
|---|---|---|---|
| | **TTS = 10 minutes** | **TTS = 15 minutes** | **TTS = 20 minutes** |
| Unconditional Mean E[WTP] | $1.43 | $1.82 | $2.80 |
| Conditional Mean E[WTP\| Response Given] | $1.72 | $2.27 | $3.11 |
| Conditional Mean E[WTP\| Use toll road] | $3.07 | $3.63 | $4.42 |

The aggregate demand curves associated with the reduced fuel cost scenario are presented in the following figure. The general statement that demand for toll road would increase with reduced trip time remains valid in this situation also.

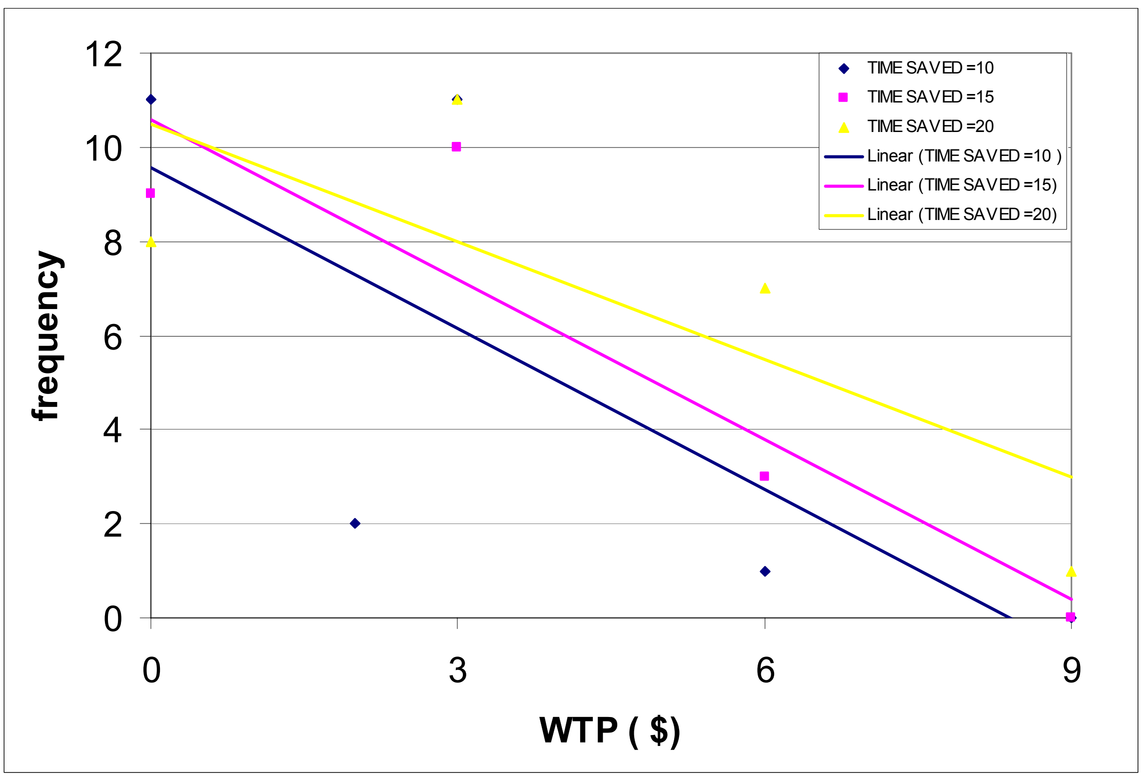



**Figure 31 Aggregate Demand Curve under Scenario II**

*Ceteris paribus*, as fuel prices increase, one might expect a demand reducing effect for toll roads.

The explanation runs as follows. Since fuel comprises unavoidable cost, the companies would seek to minimize their total operating cost by limiting avoidable costs like toll costs. Therefore it is expected that the aggregate demand curve will incur an inward shift as a response to this exogenous fuel price shock. A comparison of the choices under the two different scenarios is presented in Figure 32. There is indeed a shift of the demand curve with a change in the fuel cost for a given time saving and demand curves are more elastic with higher fuel prices. The differences tend to diminish as time savings increase, clearly implying that time savings have to be significant in order to elicit a positive response from the industry. Toll lanes that offer marginal to low time savings, may capture a much smaller portion of truckers particularly those who make en-route decisions, and/or rely on driver experience.

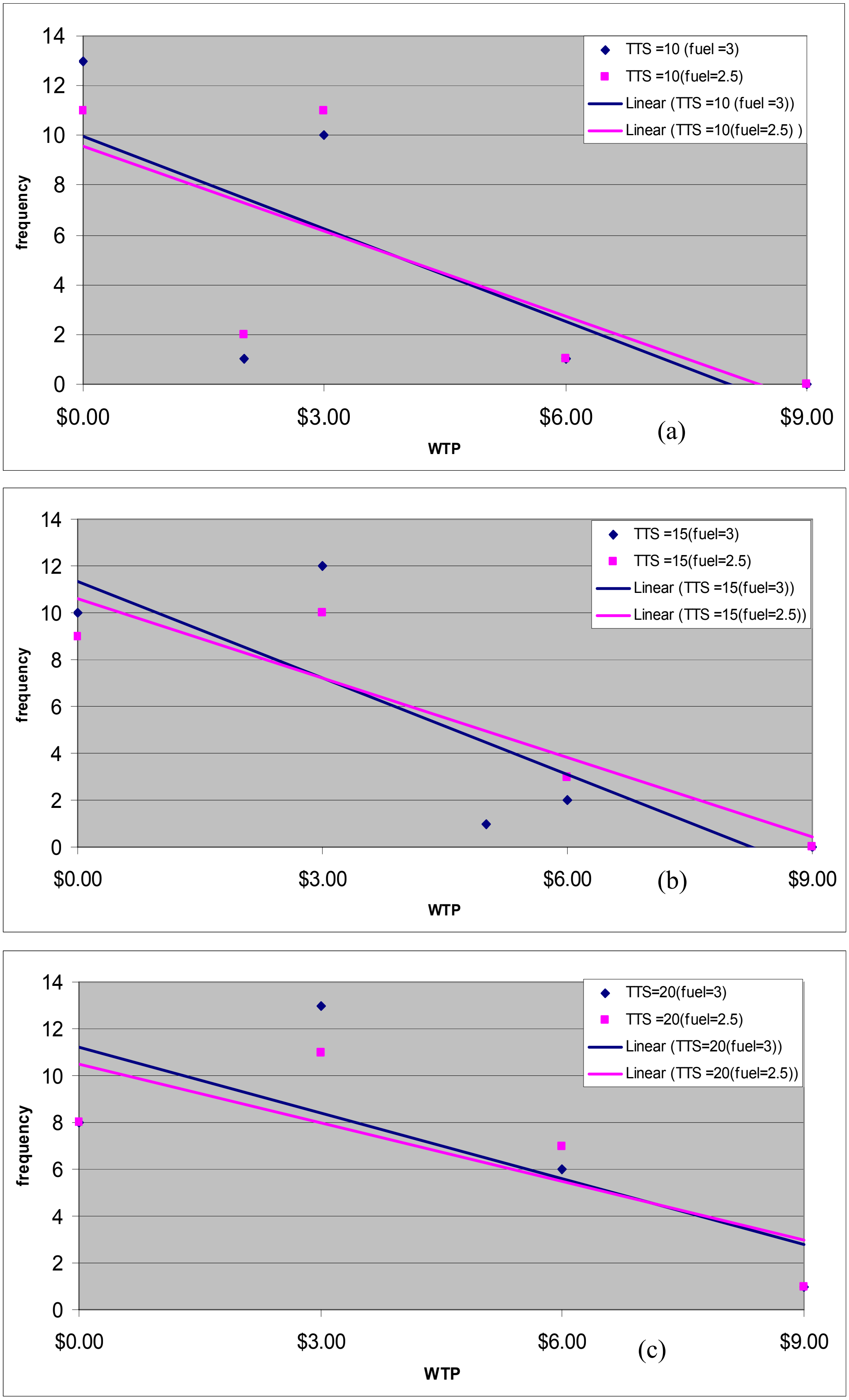



**Figure 32 Effect of Fuel Price Increase on the Demand Curve a) TTS 10 minutes b) TTS 15 minutes c) TTS 20 minutes**

### 6.7.5 FACTORS AFFECTING TOLL ROAD DEMAND: ATTRIBUTE PROCESSING STRATEGY

One important aspect that merits attention is how the stated choices are being made by the respondents. Specifically, what are the factors that they considered important while making their choices? The third question in the experimental section of the survey helps us in addressing this issue.

The respondents were asked to rank several factors which they considered important while stating their willingness to pay for tolls. The most important factors (characterized by Rank=1) as indicated by the carriers are increased scheduling issues due to reliability; fuel costs; cargo type and insurance costs. Rank 1 and 2 taken jointly reveals that the most important factor is fuel costs, followed by cargo hauled, reliability (scheduling) and insurance costs. These are shown in Figure 33. Keeping in mind, the sample is predominantly TL operations, these factors represent the key trade-offs made by this segment when selecting routes.

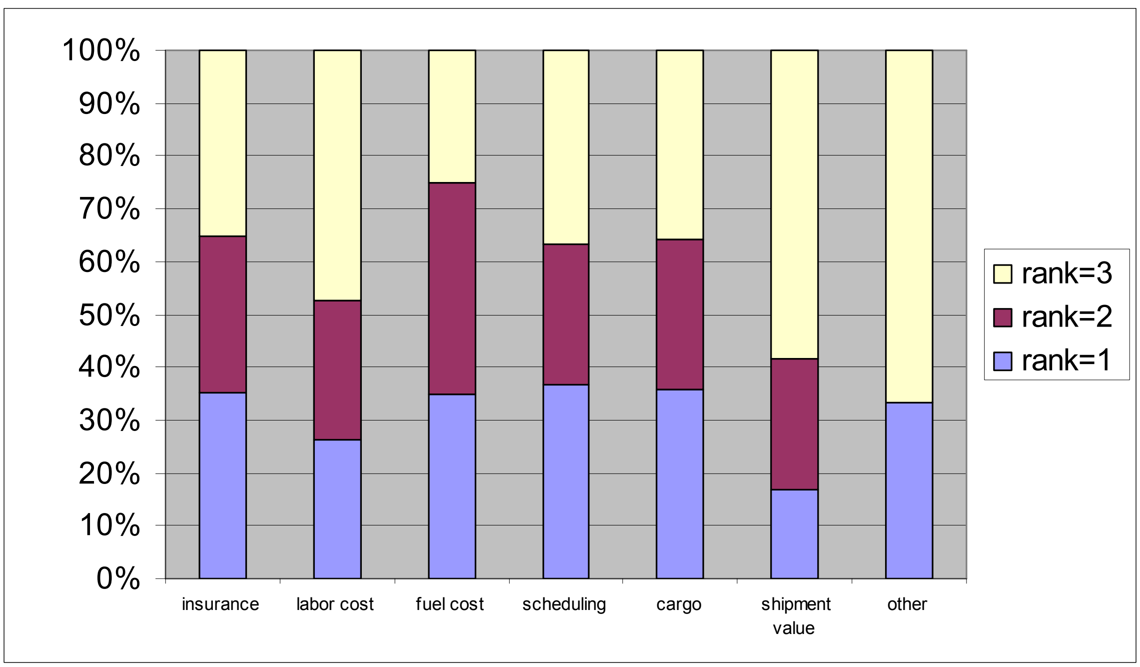



**Figure 33 Importance of Factors while making Stated Choices**

Apparently, there exist differences across private and for hire segment of the trucking industry in terms of their behavioral responses towards toll roads. This can be seen from the following table.

**Table 22 Importance of Fuel costs in Willingness to Pay by Ownership Category**

| | *Ranking of Fuel Costs* | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| For Hire | 62.5% | 25.0% | 12.5% |
| Private | 11.1% | 55.6% | 33.3% |

Interestingly, fuel cost turned out to be really important factor among the For Hire carriers. This is much in contrast to their response to Question 16, where the Private carriers indicated that fuel cost is more important while choosing a tolled route. The difference might be explained as follows. Private carriers have their own fleets and in this sample, majority of private carriers also have only partial fuel surcharge coverage to no fuel surcharges (25% - 0 coverage) Thus the goal would be to keep fuel cost across the fleet at a minimum. The response to survey question (16) tells us how fuel costs play a role in pre-selected routes while the latter indicates the importance of fuel costs as an attribute when one has to select a route.

Among other variables, increased reliability and scheduling also turned out to be critical among For-Hire segment, as can be seen from the following table.

**Table 23 Importance of Scheduling Issues**

| | *Ranking of increased scheduling issues/reliability* | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| For Hire | 57.1% | 28.6% | 14.3% |
| Private | 11.1% | 33.3% | 55.6% |

### 6.8.1 POLICY TOWARDS TOLL ROADS

The respondents provided valuable insight in terms of their policies towards toll roads, which are enumerated below.

- The general perception towards toll roads is succinctly put by one of the respondents as follows. If a toll road produces negligible effect on distance, time and cost, they would avoid it. When the toll cost is offset by the benefits, then toll roads are considered as a viable option and driver is reimbursed. Most importantly, the cost is ultimately passed on to the customer.
- One of the respondents indicated that the policy is to use other route if that is *practical*.
- At least three carriers indicated that they use toll roads only when there are no other options, i.e. no other *substitutes.*
- Use a toll road only if it is mandatory, or *predetermined* by the company.
- Yet another carrier pointed to the fact that most of the toll roads do not allow *permit loads*. The use of toll roads when available makes it more convenient for their drivers to carry the longer loads.
- One of the respondents cited the role of delivery time and the length of the alternate non-tolled route. In both of these cases, the drivers are *allowed* to adopt a toll road- the ultimate decision being taken by the dispatcher.
- Another carrier stated that unauthorized use of toll roads is paid for by the drivers themselves.
- It is important to note that at least one of the respondents indicated that their policy to use a toll road depends on the time *and* fuel cost savings offered by a toll road.
- Finally, one of the respondents belonging to the very long haul category indicated, however, that although their company does not have any policy as such, toll road might be used if it is available.

### 6.8.2GENERAL PERCEPTIONS OF THE PARTICIPANTS TOWARDS TOLL ROADS

The opinions provided by the respondents provide great insight regarding their attitude towards toll roads. For instance, one of the participants indicated that if new toll roads can be built without any new transportation taxes, it might be taken into consideration. Conversion of existing roads to toll roads would however be opposed.

One a similar note, one of the participants explained the reason behind their opposition as follows. If the highway and fuel taxes paid were used for the maintenance of existing roads and building new roads, there would have been no requirement of toll roads in the first place. Yet another participant explained their opposition to toll roads as mere revenue generators. Toll roads might be supported if those were *revenue neutral* – i.e. involving toll cost equal to the amount of savings generated.

Given that fuel surcharges are not rare, it is not surprising that some of the participants favored fuel tax over tolls. While toll roads were felt to "not solve the problem", these are looked upon as revenue generators. Some of indicted suggestions include elimination of overhead costs and improving the allocation of fuel tax revenues towards highway construction projects.
The attributes of the competing/alternate route also emanated as an important factor. Toll road would not be considered unless the alternative is dangerous or hazardous. Sometimes toll roads might be out-of-route or not within the area of business. For these instances, it is sensible not to take a toll road.

An interesting factor that emerged from one of the participants relates to the issue of accounting inconvenience. While toll roads might involve time *as well as* fuel cost savings, it might be offset by accounting hassles. This was echoed within the focus group respondents as well. However, the focus group participants were of the opinion that this was not so significant at this point in Texas.

One of the participants provided an interesting suggestion related to *standardized electronic pass (interoperable toll tags)* on existing and future toll roads nationwide. It is believed that this would decrease the transaction costs by reducing fuel costs. Another suggestion is to increase the number of toll plazas for trucks with electronic passes. In order to enhance usage of toll roads among the drivers, several measures were suggested- including additional parking for overnight rest areas, adequate lighting, security and restrooms.

## 6.9 CONCLUSIONS

Can we use this sample of responses to infer anything about the population of truckers? Given the set up of the experiment, the respondents were asked to report their WTP based on a hypothetical situation. There are some well known biases with such experiments like hypothetical bias, strategic (like groups who will not adopt a toll route under any circumstance) and information bias (extent to which the carriers comprehend the situation and information). Notwithstanding these biases, there are several aspects gleaned from this study. First, the critical trade-offs emanating from this survey and focus groups are not only time and toll costs but also fuel costs, length of the haul and cargo characteristics. While these trade-offs are typically ignored in the literature (vide Table 4), in the light of this study, it is imperative that they be included in future studies for a better understanding of the demand structure of the trucking companies. Future research should consider appropriately designed experiments when reaching out to target populations.

The absolute WTP values produced by this study are trivial in comparison to the patterns and trends revealed. The sample indicates that average WTP among private carriers emerged to be higher than that of the For Hire carriers. While short haul carriers are characterized by highest WTP, the medium haul carriers exhibit lowest WTP than all other categories by haul classification. Additionally, some of the other key factors that emerged in regard to tolling include:

- Private carriers in the sample had low or no fuel surcharges in place. Fuel costs therefore play an important role which can manifest in route selection process. Hence, WTP for private carriers appears lower than for hire since the fuel decision is more important. On the other hand, the survey also indicates that if a route has a substantial impact on fuel consumption, then the private carriers would be supportive. The for-hire sector WTP is higher than the private sector.
- Both private carriers and for hire carriers are inclined to using routing software and/or driver experience in route selection. Routes selected pre-trip may be set according to carrier's prime objectives. The large percentage relying on driver experience suggests that instantaneous decisions to adopt a toll route might be made a subset of drivers on a road.

- General perception towards toll roads and factors that might incentivize their use like interoperable toll tags, well equipped rest areas, number of truck toll plazas.
- Preferred features/options for TOT lane options.
- Ranking of factors involved in choice of a tolled route.

Finally, it is important to note that the *pseudo* experimental design demonstrated here is only a preliminary step. It should spawn better design for future research and reach out to a much larger sample of carriers.

# CHAPTER 7. A SIMULATION STUDY TO ASSESS UNCERTAINTY IN TRUCK TOLL FORECASTS

## 7.1 BACKGROUND

At the strategic level of planning or for investment grade studies, project evaluations are a crucial first step. Better decision making involves some key issues from the perspective of bondholders, practitioners and researchers. For instance, in terms of a proposed toll facility one ought to have reliable information on expected toll revenue and costs over a specified planning horizon. At the initial stage of planning, however, not all of this information is available. This leads to considerable amount of uncertainty in terms of decision making. Existing models of revenue and traffic forecast try to incorporate uncertainty through conservative assumptions on model inputs and varying them *one at a time* (*4*). From a practical standpoint, it is better to obtain probabilistic forecasts by including risk explicitly into the model. Obtaining simulated distributions is a methodological advancement over sensitivity analysis, whereby it is possible to consider numerous "what if" scenarios to examine the impact of uncertainty on the variables of interest. It can be done using Monte Carlo simulation techniques, whereby the *scenario analysis* could be built in[14]. This chapter therefore proposes the implementation of risk analysis via Monte Carlo simulation as an approach to deal with the uncertainty in demand responses early in the planning stages. Secondly, this chapter also proposes the use of the full distribution of preferences to account for within group variation in responses.

Although the superiority of simulation has been pointed out in the literature (*4*), actual applications of simulation with respect to truck toll forecasts have been rare. One exception is Kawamura (*32*) where stochastic simulation is applied in the context of dollar benefits from truck congestion pricing. However, even simulated distributions require some objective criterion in order to compare the risk associated with different alternatives. Stochastic dominance is one such approach, whereby simulated distributions can be ranked objectively in terms of the underlying risk.

[14] A note of caution: Although toll road and traffic revenue forecasts using a probabilistic framework through Monte Carlo techniques is an advancement over deterministic framework, some kind of project uncertainties lie *external* to the traffic modeling environment. Bain (*1*) notes that uncertainties of these kinds might not be fully captured by *within model* probability analysis.

Economic and financial feasibility analysis on toll lanes, as done in the literature, typically involves estimation of agency costs and user benefits in terms of travel time and vehicle operating costs savings (*15*). While analyses of these kinds are conducted at the *aggregate* level, it's worthwhile to investigate the issue of optimism bias by considering it as a *demand* side problem since demand uncertainty gets transmitted to both revenue and traffic forecasts (*4*). This, in turn, requires careful attention to user heterogeneity. For a highly fragmented industry of this kind, the predictive capability of any study would depend on recognizing the underlying demand characteristics and industry segmentation. To control for the demand side variation in terms of operational and financial characteristics is therefore deemed to be useful (*17*).

While user group heterogeneity is acknowledged as a crucial factor, its link to the risk associated with revenue yield is not well documented. It is important to understand and incorporate the demand uncertainty from various sources. The toll rate, travel time savings, and user heterogeneity (usage patterns and within-group variation) – each of them can affect the demand for toll roads. Also, the importance of operating cost in relation to the toll costs as a demand side factor has not received its due attention. This is particularly important when a tolled route significantly impacts generalized travel costs in addition to time savings.

The principal objectives of this chapter are thus threefold. First, we demonstrate the demand side effect of operating cost on VOT. Second, we examine the consequences of ignoring user heterogeneity (emanating from operating cost differentials and demand structure) on the risk associated with toll revenue forecasts. Finally, we present a better way of quantifying the risk associated with toll revenue forecasts. In doing so, stochastic dominance analysis is adopted as a tool to aid decision making at the strategic level.

## 7.2 METHODOLOGY

A methodological framework is developed here for decision making at the strategic and planning level. This involves three distinct steps: First, a simple model is presented to incorporate the effect of vehicle operating cost savings on the demand side along the lines of Adkins et al (*63*). Next, simulated distributions of the uncertain variables (VOT and toll revenue) are obtained. Finally, stochastic dominance analysis is used in order to assess the risk associated with these variables. The simulation study is based on a hypothetical corridor, much in line with Veras et al (*15*).

We consider cost benefit analysis as the basic behavioral postulate of the decision maker. In terms of benefits for the trucking industry, the economic significance of toll lanes comprise of productivity gains through time saved and potential changes in operating costs in addition to improved safety and reliability. Carriers therefore need to consider vehicle operating costs in addition to time savings while making route choices (*1, 4*). To help fix ideas, let us consider a hypothetical tolled route (of length $D$ miles) which saves time ($\Delta t$) as well as operating cost ($\Delta c_i$) for the $i^{th}$ user-group, however at a toll cost equal to $\tau$. For now, let us assume that cost savings include only the distance dependent portion. Thus user $i$, characterized by value of time $v_i$ would be willing to take the tolled route only when the following condition holds good:

$$v_i \cdot \Delta t + \Delta c_i \cdot D \geq \tau \cdot D \tag{9}$$

In equilibrium, when this holds with equality, the threshold value point for user $i$ is given by [E2].

$$v_i = \frac{(\tau - \Delta c_i) \cdot D}{\Delta t} \tag{10}$$

Thus, for a toll road that involves operating cost savings, the threshold value of time and consequently demand for toll roads would depend on the cost savings. Equation (10) is worth taking a closer look. It incorporates the difference between the state of the practice and the proposed method in imputing VOT. Going by tradition, if we ignore operating cost changes, VOT is simply a ratio of toll cost and time savings. Therefore ignorance of operating costs and cost heterogeneity can lead to biased estimates of VOT. To the extent that the tolled route leads to operational cost savings (dis-savings), this bias will be in the upward (downward) direction. This leads to the following proposition:

**Proposition 1**: *Ignorance of operating cost savings of the user group would lead to an upward bias in the implied (boundary) Value of Time distribution. For a scenario where operating costs are likely higher on the tolled route, this bias will be in the downward direction.*

The probability that the Value of Time of a user sampled at random will exceed a pre- specified threshold level is given by equation (11), which also captures the probability of diversion to the tolled route.

$$\Pr ob(\tilde{v}_i \geq v_i^{threshold}) = \int_{v_i^{threshold}}^{\infty} f(\tilde{v}_i) d\tilde{v}_i \tag{11}$$

Thus, as pointed out by Hensher, the usage of *mean* VOT to approximate a skewed distribution would yield a biased number of users adopting the tolled route (*17*). For this hypothetical segment, the expected toll revenue (R) can now be expressed as

$$\tilde{R} = \sum_{i=1}^{n} N_i \cdot \Pr ob\left(\tilde{v}_i \geq v_i^{threshold}\right) \cdot \tilde{\tau} \cdot D \tag{12}$$

where $N_i$ denotes the truck volumes in $i^{th}$ user group; $v_i^{threshold}$ captures the threshold value of time and (~ ) is reflective of the fact that the underlying variables are stochastic.
The *scaled* revenue for a total of N ($=\sum N_i$) trucks can thus be expressed as

$$\frac{\tilde{R}}{N} = \sum_{i=1}^{n} \left(\frac{N_i}{N}\right) \cdot \Pr ob\left(\tilde{v}_i \geq v_i^{threshold}\right) \cdot \tilde{\tau} \cdot D \tag{13}$$

Denoting the proportion of trucks in $i^{\text{th}}$ group by $\theta_i$, equation (13) can be rewritten as

$$\frac{\tilde{R}}{N} = \sum_{i=1}^{n} \theta_i \cdot \Pr ob\left(\tilde{v}_i \geq v_i^{threshold}\right) \cdot \tilde{\tau} \cdot D \tag{14}$$

Given the pedagogical purpose of this paper, without any loss of generality, we restrict the number of splits to Private/For Hire. In principle, the splits would depend on the categorization of corridor users, say by number of axles and should also include owner-operators. However, due to dearth of VOT parameters for the latter, we do not consider them here. Thus for the assumed splits, equation (14) becomes

$$\frac{\widetilde{R}}{N} = \left[\theta_{private} \cdot \Pr ob\left(\widetilde{v}_{private} \geq v_{private}^{threshold}\right) + \theta_{for-hire} \cdot \Pr ob\left(\widetilde{v}_{for-hire} \geq v_{for-hire}^{threshold}\right)\right] \cdot \widetilde{\tau} \cdot D \qquad (15)$$

This equation will be applied while simulating the (scaled) toll revenue.[15] In this format, the revenue equation recognizes response variability across user groups. In contrast, if we ignore user heterogeneity, the expected toll revenue from all the trucks would be given by

$$\frac{\widetilde{R}}{N} = \Pr ob\left(\widetilde{v} \geq v^{threshold}\right) \cdot \widetilde{\tau} \cdot D \qquad (16)$$

With these basic formulations in the background, let us see how we can implement them in a simulation based study.

### 7.3 SIMULATION AND STOCHASTIC DOMINANCE ANALYSIS

As noted earlier, the financial viability of proposed toll road relies on a host of factors. While improved revenue forecasts do rely on better data to capture user heterogeneity, this data may not be readily available in early stages. Simulation becomes particularly useful in this context. The risk associated with the simulated distributions of uncertain variables can be further analyzed by using stochastic dominance analysis. Typically, there are two criteria to choose from- First and Second Order Dominance (FSD and SSD). Stated simply, when one distribution yields unambiguously *higher returns*, then it is said to First Order Stochastically dominate the other distribution. On the other hand, if a distribution is *less risky* then it is said to dominate the other distribution in a second order sense.

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[15] Equation (15)is directly comparable to the general equation for estimating Truck toll revenue, where:

$$Truck\_toll\_revenue_t = Average\_daily\_volume_t * truck\%_t * Assumed\_diversion\_rate_t * toll\_rate_t$$
$$* Dis\tan ce * Annual\_revenue\_days$$

As a methodological advancement, our method directly incorporates the effect of a) demand characteristics, b) segmentation by user groups and c) usage propensities. A period wise treatment of this equation could allow us to differentiate other factors like short and longer term variations in usage.

The policy implications of dominance analysis are noteworthy. While higher realizations are preferable to risk-averse decision makers, they would also prefer a distribution which is less risky. It is this ranking that would provide valuable insight while conducting feasibility analysis. For instance, it might be the case that even in the presence of much uncertainty in the input variables, the risk associated with toll revenue is within acceptable bounds to get it financed. Alternatively a huge variability in toll revenue would indicate the possibility of *optimism bias*. A priori, without making quantitative assessment of risk, the decision maker cannot predict which one will happen. It is in this sense that simulation provides analytically superior results in comparison to simple *ceteris paribus* sensitivity analyses.

The two Dominance criteria are used in order to rank the risk associated with the state of practice vis-à-vis the proposed method outlined in this paper. Specifically, two sets of exercises are conducted:

*Exercise 1*: VOT distributions are simulated from equation (10) by incorporating a) only time savings and b) both time and operating cost savings. The resultant simulated probability distributions are then ranked by using appropriate criterion (FSD or SSD) to assess degree of risk associated with the threshold VOT distributions.

*Exercise 2*: Probability distributions of toll revenue are obtained a) with and b) without considering user heterogeneity by using equations (15) and (16) respectively. In particular, the risk associated with toll revenue is compared by assuming a) a single VOT distribution for the entire trucking industry and b) separate VOT distributions for the assumed splits (Private/For-Hire).

The basic steps for obtaining the simulated distributions are enumerated first, after which we provide a detailed description of the model inputs in the ensuing section.

*Step 1*: Given that accurate prediction of toll revenue is an extremely daunting task, the most important step is to isolate the uncertain factors captured in equation 10(for threshold VOT) and equations 15,16(for revenue).

*Step 2*: Workable assumptions are made with respect to each of the uncertain variables. These are the key input variables of the model.

*Step 3*: Key output variables (KOV in the parlance of simulation) are obtained as function of the uncertain input variables.

*Step 4*: Simulation stage: The KOV's are simulated for a thousand iterations, using Latin Hypercube Sampling technique.[16]

*Step 5*: Probability distributions of the KOV's are obtained. Using appropriate decision criteria (FSD or SSD), a ranking is developed over these probability distributions.
With these fundamental principles in background, let us now focus on the variables that are relevant to truck diversion.

**Description of the Variables/Input Data**

For the two sets of exercises outlined above, the working assumptions with respect to the key input variables are consolidated in the following tables.

**Table 24 Key Input Variables to Simulate Value of Time**

| *Variable* | *Scenario* 1 | *Scenario* 2 |
|---|---|---|
| *Toll rate* <br> *($ per mile)* | Uniform [0.10,0.50] | Uniform [0.10,0.50] |
| *Travel Time Savings* <br> *(minutes)* | Uniform [5,25] | Triangle (5,10,25) |
| *Operating Cost Savings* <br> *($ per mile)* | Uniform [ 0.10,0.25] | Uniform [ 0.10,0.25] |
| *Distance ( miles)* | 50 | 50 |

[16] By virtue of using stratified random sampling, Latin Hypercube ensures additional accuracy at the tails in comparison to Monte Carlo technique.

**Table 25 Key Input Variables to Simulate Toll Revenue**

| *Variable* | *Scenario* 1 | *Scenario* 2 |
|---|---|---|
| *Toll rate($ per mile)* | Uniform [0.10,0.50] | Uniform [0.10,0.50] |
| *Travel Time Savings (minutes)* | Uniform [5,25] | Triangle (5,10,25) |
| *Operating Cost Savings ($ per mile)* | Uniform [ 0.10,0.25] | Uniform [ 0.10,0.25] |
| *Distance(miles)* | 50 | 50 |
| *For Hire –Private Split* | $\theta_{private}$ ~ Uniform [0,1]<br>$\theta_{for\ hire} = 1 - \theta_{private}$ | $\theta_{private}$ ~ Uniform [0,1]<br>$\theta_{for\ hire} = 1 - \theta_{private}$ |
| *Value of Time* | For Hire ( $v_{for\ hire}$) ~ Log Normal ( -1.187, 0.924 )<br>Private ($v_{private}$) ~ Log Normal ( -1.78, 1.053)<br>Industry ( $v$ ) ~ Log Normal ( -1.467, 1.027)<br>Source: Kawamura (*32*) | |

Following the literature, VOT is specified as Log Normal (*31, 32*)*,* given that it is non-negative. While it is best to obtain localized VOT distributions for different segments of the trucking industry, one might resort to "imported parameters" from other comparable studies (*1*). This would entail, however, a source of optimism bias. Nevertheless, for the exploratory purpose of this paper, we obtain the parameters from Kawamura (*32*).

Travel time savings (henceforth, TTS) is also subject to uncertainty. As shown in Table 24, we have two different scenarios contingent on how TTS is modeled. One can capture the variation by assuming simple Uniform distribution (Scenario1) or Triangular distribution (Scenario 2). The motivation behind using two different scenarios is to check the robustness of the rankings, discussed at length in the following section. One can justify the usage of Triangular distribution on the following grounds. First, TTS typically follow *finite* range continuous distribution. Second, at the strategic level of planning, when *limited* information/data are available, it is difficult to specify the true underlying distribution of the travel time saved. The triangular distribution is intuitively appealing to the planner/analyst because it requires just three pieces of information - the minimum, modal and maximum values in order to derive an approximate distribution (*64*).

In terms of additional demand variation with respect to user group, the level of disaggregation considered here involves two kinds of splits: For Hire/ Private. The heterogeneity in terms of vehicle operating cost is captured from the existing literature (see for instance*, 56, and 65*). However, since these documents provide data at *levels*, it remains an important task for the analyst to make reasonable assumptions with respect to the cost savings. Given the exploratory purpose of this analysis, we incorporate heterogeneity by drawing random numbers from an assumed range of 10 to 25 cents per mile.

Toll rates are assumed to follow a uniform distribution within the range of parameters specific to the trucking industry. Finally, we take the distance of our hypothetical corridor to be 50 miles.

### 7.4 RESULTS

For the first set of exercises, equation (10) is used in generating VOT. We considered both the state of the practice and the proposed methodology (of incorporating time as well as operating cost savings). The Cumulative Distribution Functions (henceforth, CDF) as shown in Figure 31 provide a succinct way of depicting and comparing the risk associated with these distributions.

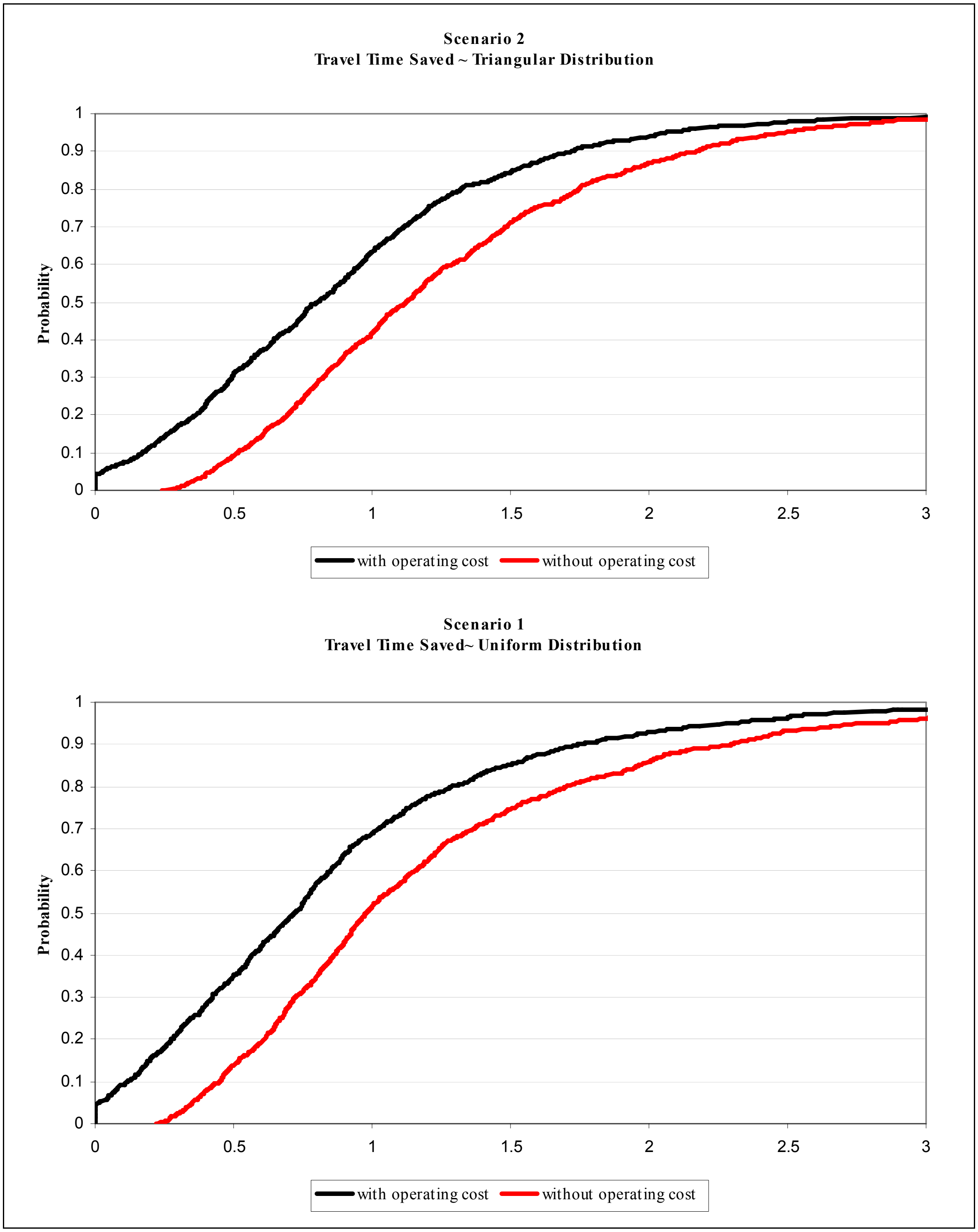



**Figure 34 Cumulative Distribution Functions of Value of Time**

The two panels in Figure 34 correspond to the two different scenarios pertaining to TTS. From the CDF's one can see that exclusion of operating cost leads to higher realization of VOT at each probability.

"Stoplight Charts", as shown in Figure 35, are insightful in comparing two risky distributions.[17] The two panels correspond to the two scenarios with respect to TTS.


**Figure 35 Stoplight Charts for the Simulated VOT Distributions (Using Lower Cut off 0.5 and Upper Cut off 1.5).**

[17] Two target values (Lower and Upper Target) need to be specified while obtaining the Stoplight Charts. For the subjective thresholds, these charts give the probabilities of (a) exceeding the upper target (green), (b) being less than the lower target(red), and (c) observing values between the targets (yellow). Detailed description is available in Richardson (*66*).

In the first panel we can see that by incorporating the cost savings, there is a 15 % probability of exceeding a pre-specified upper threshold (1.5) and a 35 % chance of being below the lower threshold (0.5). In contrast, ignorance of operating cost savings leads to 25 % probability of exceeding the higher threshold, and a 14 % chance of falling short of the lower threshold. Thus the state-of-practice is likely to give higher probability to higher values and at the same time lower probability to lower values. In other words, it yields a VOT distribution which tends to underestimate the revenue risk. This result remains valid for Scenario 2, which is depicted in the second panel of Figure 35.

While Cumulative Distribution Functions and Stoplight charts are useful graphical tools, for analytical purpose one ought to use an objective criteria to choose between the two risky distributions. Dominance analysis indicates that VOT distribution obtained by ignoring operating cost differentials *First Orde*r Stochastically dominates the distribution where operating cost has been accounted for. In the light of these findings, we make the following proposition:

**Proposition 2**: *Value of Time thresholds obtained by ignoring operating cost would First Order stochastically dominate the distribution when operating cost savings is accounted for. In other words, the state of the practice methodology would tend to underestimate the true risk.*

For the second exercise, we use Equations (15) and (16) to generate the (scaled) probability distributions of toll revenue, which is the KOV this time. In line with the previous exercise, revenue is first generated under the distributional assumptions of the input variables. The resultant probability distribution functions are shown in Figure 36; with the two panels corresponding to the two scenarios for TTS.[18]

[18] We stress that the horizontal axes relate to scaled revenue which can be multiplied by actual traffic volume to get the aggregate revenue. The probability distribution and the ranking would however remain unaffected by this rescaling.

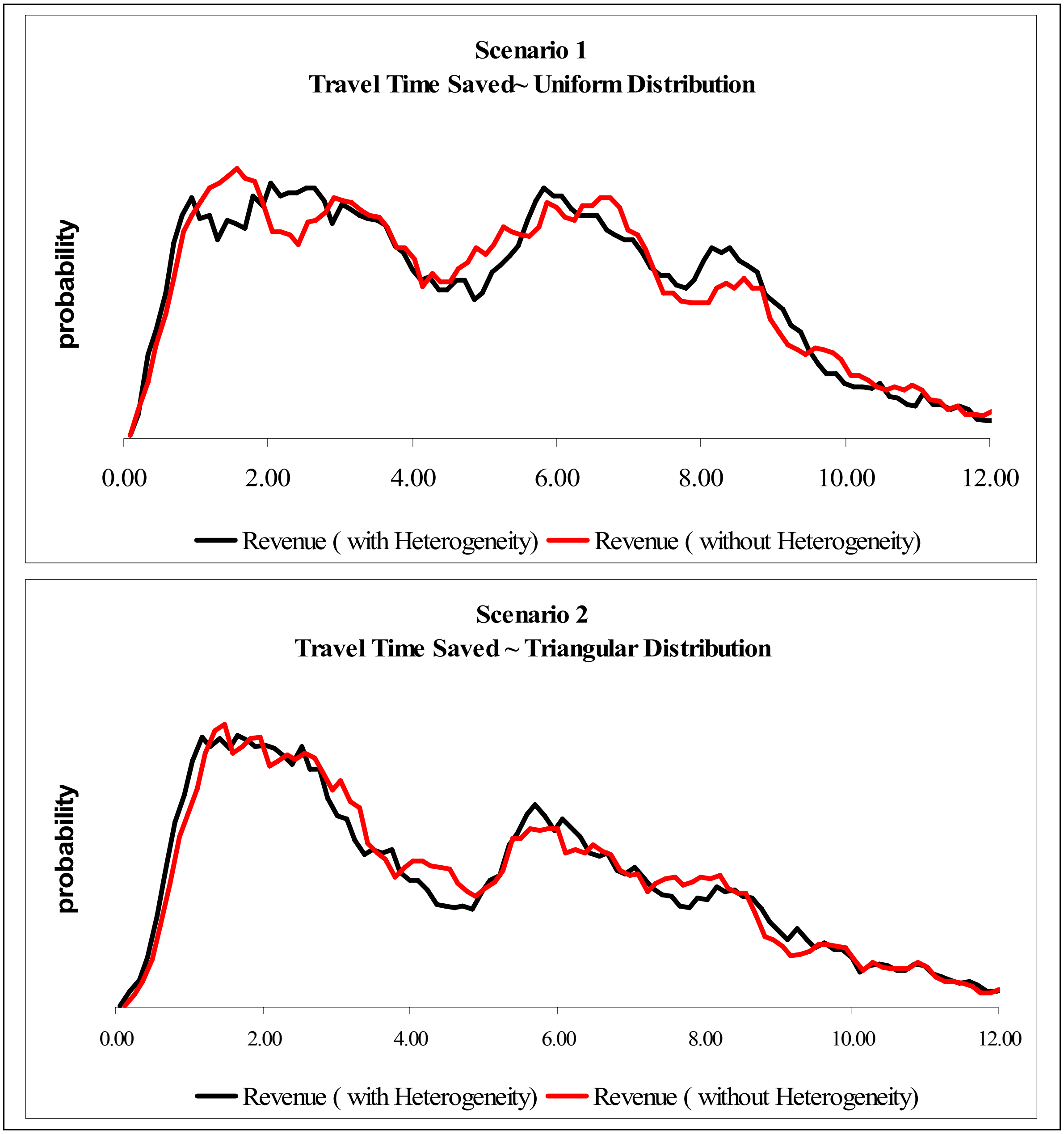



**Figure 36 Probability Distribution Functions of Revenue**

The Stoplight charts associated with the probability distributions are presented in Figure 37.

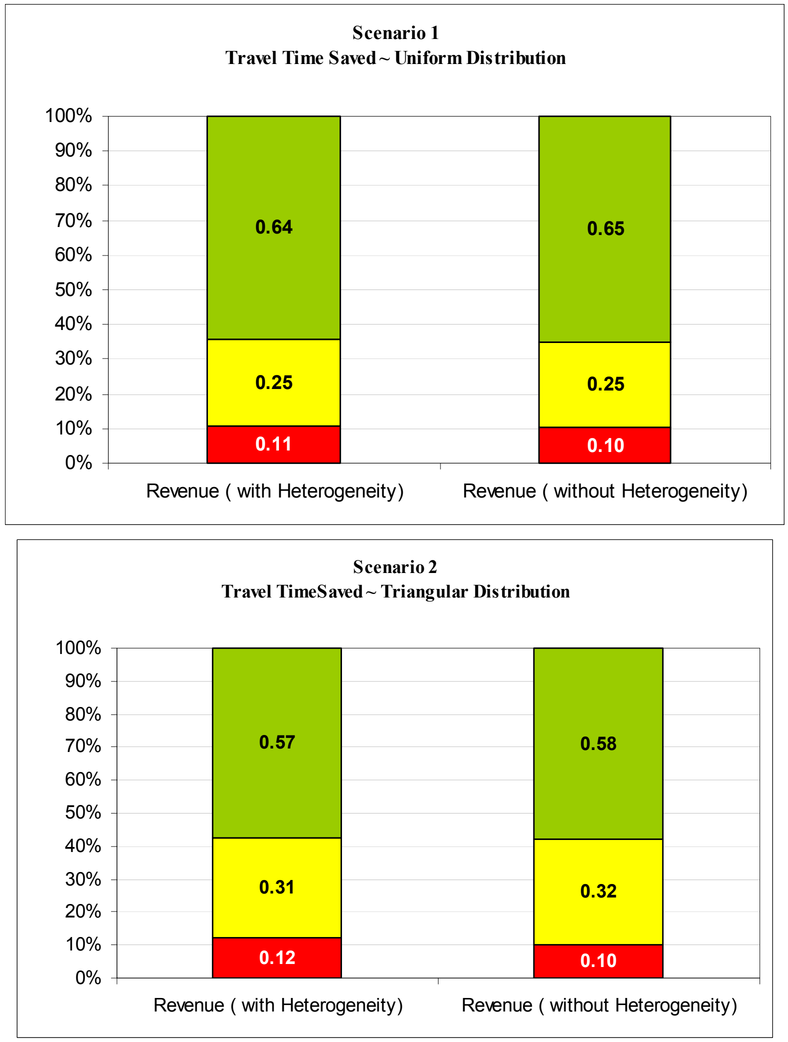



**Figure 37 Stoplight Charts for the Simulated Revenue Distributions (Using Lower Cut off 1 and Upper Cut off 3)**

The revenue distribution without user heterogeneity *second order* stochastically dominates the distribution obtained by incorporating user heterogeneity. Irrespective of the two scenarios considered, the conclusion remains robust that ignorance of heterogeneity is tantamount to lowering of risk associated with expected revenue distribution. This in turn, explains the other source of optimism bias stemming from usage patterns. Consequently we have the third and final proposition from this analysis:

**Proposition 3**: *Ignorance of underlying heterogeneity of the potential user groups (in terms of operating cost and value of time parameters) would lead to lower risk associated with projected* *toll revenue. With Value of Time varying across different users, adopting a "single" value of time parameter for the entire industry would lead to optimism bias in truck toll forecasts.*

## 7.5 DISCUSSION OF RESULTS

There are important messages that can be gleaned from this Chapter. First, stochastic dominance analysis can be particularly insightful in conducting feasibility studies associated with toll revenue forecasting. Consistent with the exploratory objectives of this research study, an application of this method to assess the risk associated with truck toll forecasts is demonstrated. The approach outlined here could very well be applied to a real life scenario and could be expanded to include other variables. For instance, several parameters enumerated in Tables 24 and 25 can be taken as close approximations of highly congested I35 and its alternative tolled route SH130. Exhaustive analysis would however require localized parameters with respect to the splits, VOT and operating cost savings of the potential user groups. Going by "industry wide averages" is of less use, as suggested by Hensher (*17*) and Kawamura (*32*).

Second, from a planning perspective, since truck related projects are also subject to high degree of optimism bias (*1*), this research would imply that the candidate corridors be thoroughly examined for various freight movement types (TL/LTL), ownership of users and the distribution of owner operators. Also, since cargo can be a significant source of variation in route decision and that operating costs do vary by cargo type (*56*), it is advisable to include them into the analysis. The Reebie study (*35*), for instance, found significant diversion for coal. It is noted that extremely bulky commodities with specific production–consumption locations would tend to be relatively inelastic and exhibit "all or nothing" type diversion. It is important to note, however, that the propensity of diversion by commodity type is an empirical question and requires further research. Currently, the only known approaches to accomplish these goals are to obtain the parameters from a) nationally available data sources like REEBIE Transearch, FHWA-Freight Analysis Framework (FAF), Census Vehicle Inventory and Use Survey (VIUS), b) Commercial vehicle surveys and c) local corridor studies. National data suffer from limitations in that they can at best provide county level first-cut assessments of user heterogeneity for some aspects of freight movement. When possible, localized truck origin-destination studies are a superior alternative.

Third, even though the simulation was conducted with limited number of user groups (driven by knowledge of VOT parameters) the results can be generalized to accommodate more user groups as long as enough information exists with respect to their willingness to pay. The scenario assumed here is a typical case where the existing roadway is characterized by a mix of users.

Fourth, the bias in toll revenue emanating from the two factors explored in this paper might get dampened under certain circumstances. Travel time reliability, for instance, sometimes becomes an overriding factor behind route decision. This may or may not be correlated to VOT of the user (*4*). The methodology outlined in this paper can accommodate this through a reduction in the variance of TTS. Other empirical characteristics, such as a higher proportion of trucks carrying time sensitive goods, can also reduce the bias. This only corroborates our earlier point that understanding usage patterns and traffic composition in terms of user groups can go a long way in improving the forecasts.

# CHAPTER 8. RECOMMENDATIONS, CONCLUSIONS, AND FUTURE RESEARCH

Direct user fees based options are gaining further momentum all over US and particularly in TX. This requires proper assessment of demand for toll roads among the potential user groups. However, there is too little information about the trucking industry as far as their attitude towards toll roads is concerned. Inadequate attention to a vital industry segment can bring about severe optimism bias with respect to truck toll forecasts. On the flip side, another consequence is the potential ineffectiveness of truck tolling options in providing the desired congestion relief. Based on the research findings we present several recommendations that would aid truck toll planning efforts for various segments of the community. These recommendations are made based on a study of the effect of toll perceptions, route choice decisions in the presence of tolling, and the effect of the fuel prices on the demand side.

### *Toll Forecasts Recommendations*

Exogenous shocks like a consistent rise in fuel prices can affect route decision and in turn, forecasts in the following ways.

a) Typically, the *steady state* forecast of gross average daily traffic (ADT) traffic volumes do not account for economic shocks/ fluctuations. While these base volumes form the basis of almost all projections, ignoring the possible adverse effect of fuel costs might introduce bias in the final projections.

b) Rising fuel costs may lead to toll road avoidance, particularly for medium to long- haul routes because these are typically fuel optimized. Presumably, there could be short and long term differences in behavior towards toll roads. Truckers might take substantial time in adjusting their behavior towards toll roads. This would elongate the ramp up risk associated with new toll roads. The extent of ramp up risk would depend on how fast the users in general and truckers in particular, adapt their behavior towards toll roads. Thus the (non) existence of a *tolling culture* may affect the scale and duration of ramp up risk. Typically the ramp up duration is about one to five years. Behavioral models do not capture this information and typical toll forecasts rarely adjust for this adjustment lag. Factors such as fuel price increases could impact the length of the ramp up on the demand side. These issues might be approached in some of the following ways:

***I.*** One should examine for short and long run differences in demand parameter estimates. This calls for thorough assessment of key model input parameters (as enumerated in Chapter 2). It is however possible when a project is tracked for sufficiently long time.

***II.*** To the extent possible, one should also adjust the diversion rates implicit in the model in the immediate short term, right after opening of the facility. Greenfield type projects might warrant more adjustment in terms of the lag length as well as diversion parameters.

***III.*** Better understanding of the users in terms of their operational characteristics (and therefore heterogeneity) is required at the corridor level of analysis.

***IV.*** Fuel costs influences need to considered on the cost side of the revenue forecast equation as well. This report has focused primarily on the impact on the demand side; however, shocks like fuel price effects should be accommodated both on the cost side and demand side. Risk analysis in conjunction with stochastic dominance provides an effective way to deal with shocks as well as general uncertainty.

***Information Provision***

In order to enhance demand for toll roads, it is recommended that information with respect to potential benefits of toll roads be provided to the trucking community early on. Information provision with respect to productivity gains via improved a) reliability and time savings and b) reduced operating costs can garner long term support from the trucking community.[19]This is particularly important in the light of the Focus Group and the Survey findings. Given that operating costs (especially fuel costs) was indicated several times as an important factor in route choice, these must be included in assessing toll road usage propensities. Another possibility might involve information provision with respect to travel time reductions to the key destination points on the network, break-bulk facilities and distribution centers from the key origin points. With fuel as a big component of operating costs, this kind of information provision can guide truckers to assess the economic value of a toll route in true optimization terms. At present, while a large segment of the industry might be making their decision premised

[19]With that said, future research is needed in this area since the effect of reduction in congestion on energy usage is unclear.

on bounded rationality, better information can help them assess the pros and cons of re-routing and to conduct independent cost-benefit analysis. It is important that candidate future projects be studied for their potential for impacting time and cost savings so that these may be communicated to the community early on.

***Future Research***

- As a long term research goal one might consider building better models of truck route choice behavior. One may consider the possibility of including bounded rationality both as a limitation as well as an opportunity.
- More research is warranted in order to obtain localized parameters with respect to, say, willingness to pay/value of time of the truckers, potential travel time saved, accurate highway speed, operating cost differentials between a tolled route and its alternative "free" route. To that end, while designing surveys, future studies should also include the drivers since their decision is often critical when it comes to route choice in presence of tolling
- As far as designing better models are concerned, one might also think of improving the route assignment models, which typically are based on shortest path algorithms. These should include Generalized Trip Cost to the extent feasible. There have been some recent efforts that are beginning to acknowledge the role of operating costs within model structure on accounting for influences of GTC on the supply side and sensitivity to tolling. Examples include Gossain et al. (*67*), who illustrate the application of generalized Cost Function (GCF) as an alternative to toll diversion curves.
- The possibility of conducting *risk analysis* and simulation techniques must be considered in order to capture the role of uncertainty in model inputs on the demand and cost side of the revenue equation. Stochastic dominance is especially useful when factors may be related and useful when used in conjunction with risk analysis.

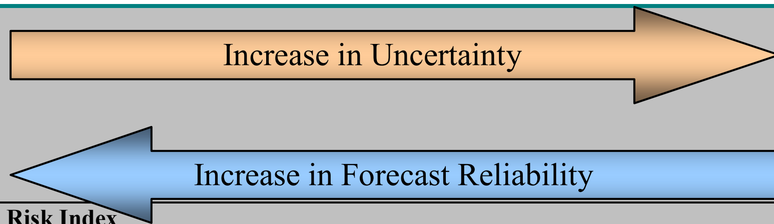
***Fuel Rebates and Other Incentives to Promote Toll Routes***

Options like increasing the freight limit might warrant research given that the trucking industry looks upon this measure as a way to increase productivity (*9*). Another recommendation relates to the short term aspect of the problem. A policy like fuel tax rebate is a possibility especially for the additional miles traversed on toll roads that might leave the trucking companies with more disposable income. Some states like Massachusetts have a fuel tax rebate program to incentivize the trucking community (http://www.turnpikerebate.com, *68*). This is particularly important for those truckers and carriers who do not have fuel surcharges in place. Several other preferred options for tolled routes were indicated by survey group participants which include standardized electronic tags, improved rest areas, increased number truck toll plazas, predictable rate structures, multiple truck toll lanes and easy access/egress from and to tolled options. In the longer term, shipper and receiver policies should be explored given that a large percentage of respondents indicate delivery schedules that are set by shippers or consignees. Since driver experience was reported in addition to routing software for setting trip time, information provided early on in the process and at critical junctures along congested roadways would be helpful. This information should at a minimum include time savings on the route and alternate route conditions.

***Hierarchy of Key Corridors***

- An interesting and practically useful strategy would be to develop a *hierarchy* of corridors for potential truck tolling applications based on the known risk and usage factors. For a given zone, a risk profile for each of the corridors based on how they serve the key connectivity points might prove beneficial towards designing intelligent policies. Future studies might aim at developing *performance metrics* of potential candidate corridors in terms of i) potential time savings, ii) trip time to key destinations iii) impact on operating costs, etc. An adapted version of the risk index developed by Bain (*1*) is provided below that might aid future studies. This is shown in Table 26.

**Table 26 Computation of Risk Index of Candidate Toll Roads**




| **Project Attributes** | **Risk Index** | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| *Toll Facility details* | Already existing facility | | | At the Planning Stage | |
| *Forecast Horizon* | Short term | | | Long term | |
| *Competing Roads* | Few | | | Many | |
| *Level of Congestion* | Highly congested | | | Limited congestion | |
| *Demand Profile* | Relatively flat demand | | | Characterized by seasonality | |
| *Toll structure* | Simple | | | Complex (local discounts, variable pricing, etc.) | |
| *Existence of Tolling Culture* | Ability to pass on toll costs to the shippers | | | Inability to pass on toll costs to the shippers | |
| *Input Data* | Up to date | | | Historical | |
| *Model Parameters* | Locally Calibrated | | | Imported from existing studies | |
| *Who pays the Toll* | Fleet Operator | | | Driver / Owner operator | |
| *Vehicle Operating Cost Savings* | Significant | | | Insignificant / very low | |
| *Willingness to pay by load type* | LTL | | | TL | |
| *Ownership*[20] | Private | For Hire | | Owner Operator | |
| *Trip Type* | Intra –regional | Inter-regional/city | | Through Trips | |
| *Haul characteristics*[21] | Medium Haul | Long Haul | very short haul | Short Haul | |
| *Cargo Characteristics* | Just in Time | Perishable | | Bulk/non time sensitive | |
| *Driver Compensation Mechanism* | Paid by hour (Example- Parcel, private fleet) | | | Paid by mile / load (Example-TL, Owner Operators) | |
| *Other: Fuel Price sensitivity* | LTL | | | TL | |

*Source: Adapted from Bain (1)*

### *Freight Data on Key Candidate Corridors*

In order to operationalize a risk index, it is important to have freight data on key aspects and for candidate corridors along the lines suggested by Meyer et al. (*69*) such as:

- Trip type (intra-regional, through, intra-city, pickup/delivery, parcel)
- Operational and ownership characteristics of users to the extent possible
- Willingness to pay
- Typical cargo transported

[20] This was obtained from the survey.
[21] Ibid.

# APPENDIX A. FACT SHEETS

## A.1 ISSUES WITH TRUCK TOLL FORECASTS

***Optimism bias***

Internationally, toll revenue estimates have been overestimated by an average of 20-30 % (Bain (*1-3*)).

Variability in truck forecast is higher compared to passenger vehicles.

***Causes of Optimism Bias***

Model input assumptions
Structure, development and application of models
Ramp up risk
Event risk
Level of service ex post
Usage of *average* Value of Time as an approximation of skewed distribution
Lack of user heterogeneity as a demand side factor

***How to deal with the Problem?***

Identify variability, relationships and trends in all model inputs and output
Obtain *expected* changes in the uncertain variables, like fuel prices
Incorporate user heterogeneity in terms of demand or potential usage
Use demand distributions, as localized as possible
Establish *trip purpose specific* value of time savings
Account for the effect of exogenous shocks like fuel prices on the *demand* side and cost side.
Potential for Stochastic Dominance Analysis in assessing the risk associated with truck toll forecasts.

## A. 2 INDUSTRY STRUCTURE

***Distribution by segment*** (FHWA Statistics, *46*)

| | |
|---|---|
| Private: | 48 % |
| For Hire: | 26 % |
| Other: | 26% |

***Distribution of For Hire Interstate carriers*** (American Trucking Trends, *48*)

Truckload : 52%
Less- Than-Truckload 24.2 %
Other specialized: 9.6 %
Household goods: 5.2%
Refrigerated: 4.1 %
Tank: 3.3%
Bulk: 1.7%

*According to FHWA statistics* (*48*),
Among the for-hire carriers, approximately 50% operate primarily in the truckload sector, 25% in the Less-than-truckload sector, and 25% operate in other segments (tanker, refrigerated, hazmat).

***Implications***

The TL sector appears to be more competitive when compared to the LTL sector

With a large number of small firms comprising the TL segment, cost minimization tends to be the relevant objective. Under such circumstances, the TL segment is much more likely to be subject to myopic decision making (bounded rationality) relative to the LTL mode.

TL operations in medium /long haul movements typically do not have fixed routes.
- Conform to primary routes primarily
- Rely on driver experience (from survey) for route choice
- More susceptible to bounded rationality.
- Knowledge regarding the extent of use of an existing roadway by TL for long haul movements would be important for adjusting tollway demand.

### A.3 Competitive nature of the industry

More than 579,000 U.S. Interstate motor carriers (American Trucking Trends, *48*)
(It was less than 20,000 prior to the deregulation of 1980)

***Distribution by type of load*** (ICF Report, *8*)

53000 Truckload firms - out of which 40000 are very small (with five or fewer tractors)
About 1000 less-than-truckload firms -35 companies account for 85 % of revenue

***Implications for freight rates***

Highly competitive and fragmented market structure- leading to both price and non- price competition.

In order to remain competitive, freight rates have to be kept low and it is often difficult to pass the toll cost on to the shippers.

Recouping toll costs would be a bigger issue for Texas, in the absence of a "tolling culture."

## A.4 COMPETING OBJECTIVES

Given that the industry is highly competitive and driven by pull logistics, a firm could have multiple objectives:

***General objectives***

- ✓ Cost minimization
- ✓ Profit maximization
- ✓ Customer oriented
- ✓ Fuel efficiency
- ✓ Distance minimization

***Marketing objectives***

- ✓ On time performance
- ✓ Lowest freight rates
- ✓ Safety of performance
- ✓ Availability of specialized equipment

***Implications***

The LTL segment, which requires timely coordination, would tend to have time minimization (on time performance) as the principal objective. This is in addition to cost minimization which is an outcome of the competitive industry.

For the TL segment, cost minimization would be the dominant objective.

Marketing objective would determine, among others, the propensity to use modern information technologies.

## A. 5 COMPONENTS OF OPERATING COST

| ***Costs In Cents Per Mile*** (American Trucking Trends, *48)* | | |
|---|---|---|
| | **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 Regional Case Studies*** *(Operating Costs of Trucks in Canada,49)* | | |
|---|---|---|
| | Cost Share (%) | |
| Driver | 36 | |
| Fuel | 18 | |
| Administration | 14 | |
| Equipment Ownership | 12 | |
| Repairs | 7 | |
| Insurance | 3 | |
| Tires | 2 | |
| Miscellaneous(Licenses, | 3 | |

***Observations***

Labor costs are a significant cost component.

The significant rise in wages is probably triggered by the driver shortage phenomenon.

Fuel costs rank second in terms of importance, accounting for around 25% of the total operating costs.

## A.6 OPERATING COST HETEROGENEITY

| ***Per Mile Operating Cost Variation by Ownership*** (Levinson,*56)* | | | |
|---|---|---|---|
| | Average | Median | Standard Deviation |
| Owner Operator | $0.84 | $0.50 | $0.69 |
| Non Owner Operator | $0.67 | $0.61 | $0.39 |

| ***Operating Cost Variation by Cargo*** (Levinson, *56)* | | |
|---|---|---|
| | Average | Standard Deviation |
| Overall | $0.69 | $0.44 |
| Rubbish | $1.54 | $1.30 |
| Dairy | $1.03 | $0.47 |
| Food Products | $0.90 | $0.66 |
| Paper | $0.85 | $0.29 |
| Petroleum | $0.81 | $0.62 |
| Timber | $0.76 | $0.40 |
| Aggregate | $0.70 | $0.37 |
| Industrial Supplies | $0.68 | $0.43 |
| Construction | $0.67 | $0.35 |
| Ag Chemical | $0.62 | $0.45 |
| Agricultural | $0.61 | $0.32 |
| General Products | $0.60 | $0.29 |
| Beverages | $0.50 | $0.54 |

***Implications***

The heterogeneity in operating cost could affect toll road demand.

Given that the industry is highly competitive, cost cutting is primary motive of the trucking firms. To what extent they can adopt/avoid a toll road would depend on their operating cost structure.

Also, the extent to which the carriers get affected by rising operating costs (triggered by fuel costs) would depend on their underlying heterogeneity in terms of costs.

## A.7 COST PASS THROUGH MECHANISM

***Fuel Cost***

Fuel typically accounts for 25 % of operating costs.

70 % of the higher fuel cost is recouped through surcharges (*6*).

Fuel surcharges do not apply to out-of-route miles or fuel burned during engine idling.

Stickiness in contracts:
There is however, a lag between fuel price changes and fuel surcharge receipt.

***Toll Cost***

There exists geographic division with respect to tolling culture. For instance in North East and Midwest, toll surcharges are often built-in, which is indicative of toll network density.

While toll costs are often negotiated in annual contracts, any mid year cost changes are absorbed by the carrier itself.

***Implications***

Fuel represents *unavoidable* cost while toll costs are generally *avoidable.*

Carriers make strategic decision on how to:
a) Economize the costs –both fuel and toll costs
b) Recoup the costs through surcharges
c) Resort to alternative strategies viz. hedging, practice of fuel economy

Smaller carriers and the independent owner operators are likely to be impacted most by rising fuel prices.

The historical correlation between high fuel prices and bankruptcies of small and mid-sized carriers is indicative of their inability to bargain on surcharges.

# APPENDIX B. FOCUS GROUP ANALYSIS

## B.1 P J ERICSSON INTERVIEW ANALYSIS (DYNASTY TRANSPORTATION)

*(F 1) Routing decision made by...*

PJ: "Decision maker. Drivers many times for example if they leave Dallas and have to go through Austin to get to San Antonio or something like that, are they going to by-pass the toll-road. Well, it depends on how much the toll is so I think with the whole answer, the whole key to it, is how much is they toll and how many miles are they going to have to run to get around it. Keeping in mind that the national average is $2.50 a gallon and most tractor trailers get 6 miles to the gallon so you know, that is going to be the qualifier there because most of the time you ant to go the shortest route".

*(F 2) Toll cost versus distance saved*

PJ: "Decision maker. Drivers many times for example, if they leave Dallas and have to go through Austin to get to San Antonio or something like that, are they going to by-pass the toll-road. Well, it depends on how much the toll is so I think with the whole answer, the whole key to it, is how much is they toll and how many miles are they going to have to run to get around it. Keeping in mind that the national average is $2.50 a gallon and most tractor trailers get 6 miles to the gallon so you know, that is going to be the qualifier there because most of the time you want to go the shortest route".

*(F 3) Fuel costs*

PJ: "With fuel the way it is, it's actually the least miles that you have to burn. Now, that's hard for example. You are going to burn more fuel going through a metropolitan area, but maybe not. If you are going through Dallas, if you go through I-30 versus I-20, are you going to burn that much more gas if you have a few little slow downs. You know, that is probably negligible because it would take you, you know you have to go so far down to get to I-20. Generally, you route trucks the practical route for a truck. And of course that would be different than a car. You have to keep that in mind so they are going to stay on freeways as much as possible because that cuts fuel mileage. I think that the Northeast, you have so many toll-roads that it's kind of a regular thing and I think companies just, once those toll-roads are in place, they just make a decision as far as policy goes whether they are going to run that toll-road or when they are or when they're not. They just either do or they don't. They get toll passes or whatever the case is. You will find that a lot of the toll-roads for example in the Dallas area, you probably aren't going to find a truck on the toll-way. I don't see trucks very often on the Bush. If they would turn 635 into a toll-way that would be a different matter however, you are not ever going to get trucks off of a loop around a city because they are going to have to go on that road because they are going to be avoiding the city. I think the impact of the toll road is probably depending on the circumstance, but if it's in a metropolitan area, it's really going to be negligible".

...

Lady: “Coming back to the discussion on fuel prices, you mentioned that you do have clients that you serve outside Texas and somewhere in the Northeast and other areas. Have you seen any change in the way that they have responded to the toll-roads because of increasing fuel prices or has everything been the same?”

...

PJ: Everything has basically been the same.

PJ: I don’t think there are enough toll-roads out there that have really impacted any area. I mean new toll-roads that really make any impact anywhere.

...

PJ: “Yes. There is a fuel surcharge. The Department of Energy every Monday releases a national average for diesel and for regular car fuel and they do a national average, they do it by geographic region as well and what most people do, it depends on the contract, I have several different things, but generally, it’s a percentage of your bill. Right now, most people are running between 16% and 25% sir charge on the total bill. For example, to go from Dallas to Houston, I charge a customer a $400 minimum and then fuel on top of that and then any stops or other charges on top of that. And that scale slides and changes every Monday”.

*(F 4) Toll way convenience*

PJ: “And another thing too, for example. I don’t know if you are familiar with the Houston area but Beltway 8. Trucks don’t use Beltway 8 really and the reason that they don’t is not because it’s a toll-road but because it’s really too far out and it really doesn’t benefit them in any way. It doesn’t make anything quicker. It doesn’t save miles, it doesn’t save money”.

*(F 5) How are tolls perceived?*

PJ: “They know. For example, in the Northeast, getting onto Long Island or into Manhattan, they know that you have to pay tolls from $150 to $250. Pennsylvania turnpike is another thing, Jersey turnpike. It’s a very common thing. Down in Florida you have to pay to go across certain bridges. That is just part of doing business”.

*(F 6) Shippers don't get to select the route*

Pappu: When you look at Texas, especially when you are looking at that specific link that bypasses Austin. If the shipper knew that there was an alternative…Say it may take a few hours more, but you’d rather go through Austin. In that case, what do you recommend, do you give them 2 prices where one includes the tolls and one excludes the tolls?

PJ: No, they don’t get to route my trucks.

*(F 7) What is an acceptable toll charge?*

Pappu: So how would you deal with that situation? Would you send it through the city?

PJ: Well, it depends on how much the toll is going to be. How much is it going to cost my truck to get through Austin on that toll? If it's $10 I'm not going to worry about it. If it's $100, then it becomes an issue.

Pappu: How about $50?

PJ: That's an issue.

Lady: You are talking about 20 cents a mile roughly.

PJ: 20 cents a mile for a toll, you mean?

Lady: Yes. For a specific segment that bypasses Interstate 35.

PJ: If you are talking about $5, nobody is going to care. They are going to go that way, if it is quicker and if the miles are shorter and that is probably going to be the decision maker.

*(F 8) Who pays for the toll?*

PJ: As far as the truck goes, I give them the rate for that particular run and that would be part of their rate and ask me the question again, I'm sorry.

...

PJ: Well, you know, I don't think your shipper even thinks about it. They just hire a trucking company and it never crosses their mind how that guy gets there or what roads or types of roads he is on.

...

PJ: It depends on your customer base. And again it's going to go back to what is economical as far as the cost of riding the truck and is that $5 toll going to save $5 in gas or cost you $5 in gas. It's all going to boil down to that and that's what they are going to look at.

*(F 9) Toll cost versus fuel cost trade off*

PJ: It would depend on that particular route and if it became necessary for them to use the toll road in order to affect their schedule on time then I'm sure they would look at it. But what you are going to see most people doing is avoiding tolls at the beginning at all costs. And then as this culture gets into place of more and more toll roads then you are going to see people doing things, but it's still going to boil down to money and to fuel. Time is fuel, fuel is time. It's fuel. You can make that the ultimate, final common denominator. Everyone is going to make their decision based on the fuel that they are burning.

...

Lady: Would you say that this kind of a trade off that you are talking about is pretty much universal regardless of what types of commodities category the shipper specializes in?

PJ: The only exception to that of course would be hazardous cargo carriers who have to run certain routes no matter what. That comes in very different pricing structure anyway. Those are the only people and your oversized on flatbed loads. You have to route them a certain way and again those are, when that kind of thing happens, all of that is taken into consideration and rolls into that price.

*(F 10) Participant Info*

PJ: My largest customer is here in the Dallas-Fort Worth area and their largest customer is Home Depot. I probably deliver to, on a weekly basis, an excess of 100 Home Depot stores. And those stores are in Louisiana, throughout Texas, sometimes Oklahoma, New Mexico, Arizona, and California.

Lady: Are independent owner/operators also among the list of carriers you would contract for?

PJ: Yes, I do use owner/operators but I really don't like the single guy, one man operation. Most of my carriers are the little guys with 5 trucks or less. That's the kind of companies I deal with.

*(F 11) Any difference in reaction to tolls based on service provider?*

Lady: Going back to the trade off kind of decision making, would you expect to see any differences across the carrier segments? Like truck load, less than truck load, owner/operators, any differences in how they would perceive tolling?

PJ: No.

Lady: And with the impact of fuel prices?

PJ: I think that you are going to see anybody who is an owner/operator or even a small guy it is still "how am I going to burn the least fuel." And that's going to be the common denominator again for everyone.

## B.2 FOCUS GROUP ANALYSIS: OWNER-OPERATORS

**Factors involved in route making involve meeting deadlines, getting it their quicker, and trade-off in terms of costs of doing so:** *"Well, as a company driver, for me I look at my deadline--when it's got to be there. Is it going to be further? A lot of times from the toll-way, it's going to be further. Sometimes it's quicker but sometimes its not, and even with it being further, and then you've got to look at the cost of the tolls. Does it outweigh the cost of the fuel?"*

**Cash is important:** *"because owner operators, most of them they have to have the cash available to do it…"*

**Road conditions might deter their usage:** *"sometimes up there you don't have a choice because some of the roads up there are still made for horse and buggy. They're not made for a 53 foot truck that's nothing but a big wind sail at times…"*

**Limit usage in the first place; if however it has to be used then time saved is important:** *"…being an owner-operator and the independent, the shipper usually doesn't want to pay the extra for the toll roads so I just simply don't go where there are any. And the only time I'll use one is when I just have to, like in Ohio if it's quicker to go the I-80 toll road to get to a certain place to load. If it saves me time, sometimes I'll run one for a few goods, but not many, and I try to avoid them at all cost. That's why I mostly run west of the Mississippi where there are less toll roads."*

**Avoid toll roads completely; avoidance becomes more appropriate when backhaul is not available:** *"I pick where I'm going to go. I usually try to run from Texas to the Pacific Northwest. There are no toll roads out there. I try to run California from Texas. I run to Florida. Sometimes I'll have to run down into Florida because there are Florida toll roads. There are several toll roads but I don't run them. If a load has to go down there to Miami, forget it. I'm not going to haul it unless it pays a ridiculous amount of money. I'll go to Tampa, I may go to Lake City, I may go to Jacksonville, but I don't go down deep into Florida for two reasons: one of them being that there's nothing coming back for a …, and the other one being that it costs to run toll roads. I-95, I don't run the east coast just simply because of the toll roads."*

**Owner operators need to have cash in hand to pay for tolls, which becomes a problem when cash flows are tight:** *"They are for me because the people that I haul for don't want to add money to the load to pay for it. Now I have leased to people in the past, and they always just include it if it's less miles to run the toll roads. They just bill the customer for it, and then they reimburse me. I have to pay for it in cash but I get reimbursed."*

**Yet another indication of why cash flow is important to Owner-Operators and why they would like to avoid them if possible:** *"Certainly, you can run more miles, and I can't afford to do that. And they always tried to pay me on zip code to zip code miles, or household goods miles, or postal miles, because B line miles, it's straight line miles from where I am to where I go; so I have to cut the miles out as much as I can if that involves me having to run the toll road and spend another 50 to 75 to 200 dollars. When I used to run the east coast I would* *have to carry another 200 dollars just for the tolls, and unless the companies will pay that I don't go there."*

**Indication that there might be an up-side to toll roads – they provide convenient services (fuel, food and rest areas):** *"…when we go through the eastern part of Oklahoma we do have to run the toll roads because of the time factor, and it's really not maintained very well, but the one thing I like about it is you got one… as you get off and you got to stop when you get off…The way Ohio has theirs set up they've got fairly nice rest areas in there. They're kind of on the expensive side, but they're nice."*

**Another indication of important cost is: "***I do not use toll roads because I cannot afford them."*

**Another reason is that people (O/O's) already pay highway tax, so why should they pay again to use toll roads: "***Here's my buck, and I'm not going to spend it on that because I'm already spending way too much money in highway fuel taxes, and they're not being spent correctly. They are being diverted for other uses…. You pay to use that road; then you pay to use it again… Actually, we're being taxed on the roads three times. We're paying fuel tax, registration on the vehicles, and then the tolls. That's three times taxation right there."*

**Toll road avoidance:** *"Okay, I take primarily jobs that do not require toll roads, and if I take a job I will go out of my way to avoid the toll roads... I'm going to be part of a traffic jam on I-35. Highway 8 around Houston. No way. Shippers aren't going to pay for it; I'm not going to pay for it. Not going to happen."*

**Cost trade-off:** *"It was only 2 miles difference in time restraints, and it saved me what 3 bucks to run across it."*

**Being re-routed on a non-toll route is cheaper than the cost of going 140 miles on a toll road:** *"I want to say it was like 60 bucks or 70 bucks right across that 140 miles, and it's not very well maintained."*

**No matter the size of the company (Schneider is one of the nation's largest trucking companies) nor they type of ownership (owner/operator or company-owned) the reaction to toll roads is the same:** *"Yeah, when I worked for Schneider we would try to get around the toll road because that's where you're money comes from. It doesn't matter if you're owner operator or company driver if you look at it from a business standpoint. If you spend too much on fuel and too much on tolls you're just not making any money…"*

**Perceptions of what a toll should be vary, but common sense will prevail:** *"I-88 up in Illinois, them tolls are higher than they should be, and our company will reroute us… Unless its, you know, you give them a good reason you've got bad weather and the primary roads are the only ones that's been clean."*

**Cost of congestion is less than the cost of a toll (or at least as perceived by Owner/Operators:** *"Not for me. Not for my part. As far as the congestion goes, I take that over* *the toll road as an owner operator any day…I will ease my way through congestion before I'll take a toll road just simply because of the higher cost. Now if we got a rebate on our fuel tax on our income tax for using toll roads it might be different, but we don't."*

**Owner/Operators tend to be strongly 'Nationalistic' and distrust politicians, which might be reasons they are skeptical on the fairness of toll roads:** *"My fear is that if they put these toll roads they're talking about in, in Texas, that they're going to try and sell them to somebody overseas who will then have the revenue producer for 75 years. And that will just give the legislature more money to fool away right now. And any amount of money you send often will be fooled away on something…We've learned that dealing with these politicians...Look at Indiana…That money is going in his pocket or one of his buddy's pockets… There's already too much foreign control over the United States…selling our roads off to foreign control corporations."*

**Feelings that toll roads might result in national-security situations:** *"Well, I went through that inspection station twice one day when I was down in Laredo. I made the wrong turn and went through it. The guy looked at me and goes, knowing that I'd done been through there within a 30 minute time frame, and you know he didn't even question it. Didn't even question it as to why I was back through there. I could have been smuggling God knows what through there, and never even questioned it. Our border…is a joke. Toll roads make it worse… that's right because on the toll roads they wouldn't have to stop and get inspected. They would just go get 20 miles up the road, take off wherever the heck they wanted to go, and they're good"*

**More on the link between security and toll roads:** *"The part I look at is all the hazmat material that goes to Mexico. .. ."*

**Compensation for hauled loads:** *"I just negotiate the rate on every load. If they don't want to pay enough for me to make money on it then I have to have…right now about \$2.15 a mile. If they don't want to pay \$2.15 a mile I don't go. If they want to pay only that, and I have to go to the northeast I don't go to the northeast, period. Just simply because of the toll roads. It costs me more to run there… About \$2.35 actually, but it raises my cost about 15 to 20 cents a mile, and if they don't want to pay it I just don't go there."*

**Feeling is that there is no need for toll roads in the first place, therefore it is a moot point:** *"You take the tax money that was diverted away from road maintenance and put it back where it belongs there is no need for tolls."*

**Perception is that tolling (the way it is currently done) is unfair:** *The toll roads get built, and the law that enables them to be done is passed by the legislature says that the road itself will revert to the state after the initial cost of building it is…that I wouldn't have any particular argument with, but the fact is, is that if the money that we pay in road taxes is then diverted, and they're doing this as a scam or a …in order to get where they can spend more money right now. That is unconstitutional, and I think should be illegal."*

**The general feeling is that no matter what paying to use any road (a toll road) is not ever justified; i.e., there is no happy medium between the cost of a toll and the 'benefits' it**

**can provide – there is no 'tipping point':** *"Well speaking for myself here in Houston, I don't foresee any tipping point."*

**Alternatives such as 'truck-only-lane' etc:** *"Then you've got an enforcement nightmare that's going to cost you a ton of money…That's going to be a headache from hell right there."*

**'Creative' alternatives if use of toll roads is to be encouraged:** *"The only way I would consider it is if we were able to charge* [the customer/shipper] *double the toll road or time and a half for the toll road."*

**The reason Owner/Operators can afford to be picky and choosy:** *"Well, one thing for a truck driver that you've got to realize, now there's some drivers out there they get paid hourly. They get paid a mile and then they get paid hourly. We don't get paid hourly. If this truck ain't rolling down the road we don't get paid."*

**Example of 'cost analysis':** *"I called on a load that was going from Texarkana, Texas to Fort Louis, Washington. It weighs 16,800 pounds and its…I asked them what it paid, and they said it paid 3,400 dollars. Well if I haul that load it pays 4,700, and I will not haul it for any less because it cost me 1,500 dollars and about 1,550 dollars in fuel to go out there at least, and then there's some road tax and everything else. If I can't clear enough to make money on it, if I can't make like $1.40 or $1.50 a mile after fuel it's a waste of time for me to put a load on the truck, and I won't do it."*

*"It cost me 60 cents a mile for fuel so I have to have $2.15 to $2.25 right now in diesel. Oil cost 89 dollars a barrel this morning on the stock market. That means that the cost of fuel is going to be up to $3.35 a gallon. <u>I don't get any better mileage with $3.30 cents a gallon fuel than I do with $2.00 fuel</u>. The thing is I just charge for it, and if they don't want to pay it to hell with it. I don't owe it."*

**Owner/Operators know how important they are to the country's economy:** *"They think that the air traffic controller strike was bad. If the trucking industry ever shut down, that would look like a picnic compared to what would happen."*

**The effect of fuel price increases has affected operating costs:** *"Yeah I have to charge more. Have to* [pass on the increases to the shipper/customer]. *That's the only way you can do it."*

# APPENDIX C. SURVEY OF TRUCKING COMPANIES ON TOLL ROAD OPINIONS

**1. Please indicate name and/or company:** (*optional)*

______________________________________

**2. Please indicate your title within the company:**

______________________________________

**3. Type of Carrier/ Business:** ***(Check all that apply)***

| | |
|---|---|
| Private | |
| For Hire | |
| Other (Please specify:________________) | |

**4. What is your typical length of haul? (Check One)**

| | |
|---|---|
| Less than 50 Miles | |
| 50 – 250 Miles | |
| 250 - 500 Miles | |
| 500 + Miles | |

**5. Please indicate the approximate percentages for each mode of your operation. (Total should equal to 100 %)**

| **Operations** | **%** |
|---|---|
| Truckload | |
| Less than Truckload | |
| Express / Parcel service | |
| Other : | |

**6. How many power units does your company operate, including owner-operator units?**

**7. What is the approximate annual sales revenue of your company? (*OPTIONAL*)**

| |
|---|
| |

**8. Please list the top three commodities that your company transports:**

**#1**______________________________________

**#2**______________________________________

**#3**______________________________________

**9. Who decides which routes to take?** ***(Please indicate a percentage)***

| **Decision Maker** | **%** |
|---|---|
| Back-room Operations | |
| Shipper | |
| Driver | |
| Third Party | |

**10. Who sets the freight delivery times?** ***(Please indicate a percentage)***

| | **%** |
|---|---|
| Shipper | |
| Carrier | |
| Consignee | |

**11. What percentage of your operating miles are on toll roads?**

_______________%

**12. Do fuel prices impact your use of toll roads?**

***(Please check one)***

| | |
|---|---|
| Yes | |
| Sometimes | |
| No | |
| Do Not Use Toll Roads | |

**13. When you do pay a toll, who ultimately covers the cost?**
***(Please indicate a percentage)***

| | |
|---|---|
| Our Company | % |
| Shipper | % |
| Driver | % |
| Customer | % |
| Other: ________________ | % |

**14. Does your company have a policy towards toll road use?**
❑ Yes ❑ No
***If yes, please explain in the comment box below:.***

| |
|---|
| |

**15. How does your company calculate trip travel times?** ***(Check one box for each option.)***

| | **Always** | **Sometimes** | **Never** | **Unknown** |
|---|---|---|---|---|
| Using Routing Software | | | | |
| Using Driver Experience | | | | |
| Using ECM / GPS Data | | | | |
| Other (Please specify) : | | | | |

**16. If you were to consider toll road usage, how important are the following factors? Please rank order, from 1 to 5, those factors most important to your company.** ***(1=Most Important, 2 = next most important, etc.)***

| | **Top 5 Rank** |
|---|---|
| Time savings | |
| Congestion on alternate routes | |
| Level of safety on alternate routes | |
| Fuel costs | |
| Driver costs | |
| Length of haul | |
| Driver retention | |
| Shipper contract requirement | |
| Overall toll cost relative to shipment value | |
| Other: | |
| Will not consider use of toll roads *(check box)* | ❑ |

**17. Please indicate cargo that you carry that may benefit from decreased travel times.** ***(Check all that apply)***

| | |
|---|---|
| Perishable (food items only) | |
| Perishable (non-food items) | |
| "Expedited" Service | |
| Oversized / High density / Construction-related | |
| Hazardous materials | |
| Other : | |

**18. Among the following issues, are any significantly affected by <u>congestion</u>?** (*Circle all that apply)*

| | |
|---|---|
| Driver Retention | Insurance / Safety Costs |
| Labor Costs | Fuel Costs |

**19. Please indicate the cost of fuel during operations, either in cents per mile or $s per hour:**

***(Please indicate in space provided)***

| What is your fuel cost, for a typical truck, in cents per mile? | What is your typical fuel cost for operating a truck, in $'s per hour? |
|---|---|
| | |

**20. Fuel surcharge policy:**

| | |
|---|---|
| What % of existing contracts include a fuel surcharge? | % |
| What % of these fuel surcharges adequately cover your actual fuel costs? | % |

**21. The Texas Department of Transportation is researching the following types of "managed lane" scenarios for improving traffic flow and providing improved service:**

***A) Voluntary Truck Only Toll (TOT) lanes, and;***
***B) Option to pay/travel on High-Occupancy-Toll (HOT) Lanes.***

**If paying for such lanes, what would you expect in return?** ***(Check all that apply)***

| | |
|---|---|
| Higher speed levels | |
| More than one lane (for TOT lane scenarios) | |
| Electronic Toll Collection | |
| Convenient access points near pick-up / delivery sites | |
| Information on driving and route conditions | |
| Toll routes / corridors that provide the shortest / fastest link to key origins and destinations | |
| Predictable / stable toll fee structures | |
| Other: | |

**22. Consider a scenario involving an EXTREMELY CONGESTED route with a <u>trip length of approximately 20 miles.</u> You have the option of using a toll lane for a faster trip. Assume that the fuel prices are at their current level (just over $3 per gallon). How much would you be willing to pay for potential time savings on the toll facility *(Please check one box per Scenario)***

| Scenario | $3 | $6 | $9 | $12 | $15 | Other (please specify $ amount) | Would not use toll facility |
|---|---|---|---|---|---|---|---|
| You can save 10 min | | | | | | | |
| You can save 15 min | | | | | | | |
| You can save 20 min | | | | | | | |

**23. In the same scenario, but with lower fuel prices (around $2.50 per gallon) what would be your willingness to pay for the express service associated with such a lane(s)? *(Please check one box per Scenario)***

| Scenario | $3 | $6 | $9 | $12 | $15 | Other (please specify $ amount) | Would not use toll facility |
|---|---|---|---|---|---|---|---|
| You can save 10 min | | | | | | | |
| You can save 15 min | | | | | | | |
| You can save 20 min | | | | | | | |

**24. Considering your responses in Questions 22 and 23, please rank the importance of the factors you used to make your selections.(Please rank 1-3** with **1 = most influential**. Use each number only once)

| | Rank from 1 to 3 |
|---|---|
| Insurance and safety costs | |
| Labor costs | |
| Fuel costs | |
| Increased scheduling issues due to improved reliability | |
| Cargo type (e.g. Hazmat, concrete, high tech) | |
| Shipment value | |
| Other (please specify) | |

**25. Please use the following space for any additional comments.**

# REFERENCES


1. Bain, R. *Credit Implications of Traffic Risk in Start-Up Toll Facilities.* Infrastructure Finance, Standard & Poor's, London, 2002.

2. Bain, R. *Infrastructure Finance: Traffic Forecasting Risk: Study Update,* 2004. http://www.people.hbs.edu/besty/projfinportal/articles.htm. Accessed July 1, 2007.

3. Bain, R. *Traffic Forecasting Risk Study Update 2004 – Through Ramp-up and Beyond.* London: Standard & Poor's, 2005.

4. Estimating Toll Road Demand and Revenue. NCRHP Synthesis 364.Transportation Research Board. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_364.pdf. Accessed September 30, 2007.

5. *Top Industry Issues.* American Trucking Research Institute, Presented to American Trucking Association. 2005. http://atri-online.org/research/results/economicanalysis/index.htm. Accessed July 1, 2007.

6. Stinson, C. "Rising Fuel Prices Hurting Trucking Industry", http://ezinearticles.com, Accessed July 1, 2007.

7. Kilcarr, S. "Fuel's Wide Ride", obtained from http://www.highbeam.com/doc/1G1-120132488.html. 2004.

8. ICF Consulting. "Evaluation of U.S. Commercial Motor Carrier Industry Challenges and Opportunities", Freight Management and Operations, 2003.

9. Lynch, T.P. *The impact of rising gas prices on America's small businesses.* The American Trucking Associations, 2007.

10. Higgs, L. "N.J. Turnpike Authority reports lower revenue for its two highways", obtained from http://www.app.com. 2006.

11. http://www.landlinemag.com/todays_news/Daily/2007/Nov07/111207/111607-01.htm Accessed on November 30, 2007.

12. Patch.D., *Traffic decline stalls Ohio Turnpike work*: http://www.toledoblade.com Accessed November 15, 2007

13. Costello, S. "Gas price impact on toll toads feared", obtained from http://salcostello.blogspot.com. 2006. Accessed November 15, 2007.

14. Baez, G., *Investment-Quality Surveys*, Texas Turnpike Authority, Austin, 2004.

15. Veras, J.H., Sackey, D., Hussain, S., and Ochieng,V. Economic and Financial Feasibility of Truck Toll Lanes. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1833,* TRB, National Research Council, Washington, D.C., 2003, pp. 66-72.

16. *Central Texas Turnpike System: Traffic and Revenue Forecast Update.*URS CorporationVollmerAssociates,L.L.P. <ww.centraltexasturnpike.org/pdf/Continuing%20Disclosure%202005%20Exhibit%20H%20TR%202005%20Update.pdf>, 2005.Accessed July 1, 2007.

17. Hensher, D.A., and P. Goodwin. Using Values of Travel Time Savings for Toll Roads: Avoiding Some Common Errors. *Transport Policy,* 11, 2004, pp.171–181.

18. Fitch Ratings, *Bliss, Heartburn, and Toll Road Forecasts*, November 12, 2003.

19. *S&P continues critique of forecasts-update finds further faults.* http://tollroadsnews.info/artman/publish/article_1030.shtml. Accessed November 15, 2007.

20. Goodwin,P. Review of New Demand Elasticities With Special Reference to Short and Long Run Effects of Price Changes. *Journal of Transport Economics*, Vol. 26, No. 2, May 1992, pp. 155-171.

21. *Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior.* TDM encyclopedia. http://www.Vtpi.org/tdm/tdm11.htm. Accessed 10/1/2007

22. Goodwin,P. *Empirical evidence on Induced Traffic.* Transportation.1996, Vol. 23, No. 1, pp. 35-54.

23. Lee, D. *Demand elasticities for Highway Travel.* HERS Technical Documents, FHWA. www.fhwa.dot.gov. Accessed 12/1/2007.

24. Veras, J.H., Q.Wang., N. Xu., K. Ozbay., M. cetin., J. Polimeni. Impacts on Time-of-day Pricing on the Behavior of Freight Traffic in a Congested Urban Area: Implications to Road Pricing, *Transportation Research, A: Policy and Practice,* 2006.

25. De Jong, G. C. *Value of freight travel time savings*, in: D. A. Hensher and K. J. Button (Eds) Handbook of Transport Modeling, pp. 553–563 .Oxford: Pergamon. 2000.

26. McKinnon, A. C. *The contribution of road construction to economic development*. Paper presented at the T&E Workshop on 'Roads and the Economy', Brussels, Belgium, 8 December 1995.

27. Zamparini, L, Reggiani, A. *Meta-Analysis and the Value of Travel Time Savings: A Transatlantic Perspective in Passenger Transport*. Networks and Spatial Economics. Volume 7, Number 4, December, 2007, 377-396.

28. Knorring, J.H., He, R., and Kornhauser, A.L. "Analysis of Route Choice Decisions by Long-Haul Truck Drivers", Proceedings of Transportation Research Board Annual Meeting, 2005.

29. Zyl, N.J.W.V. and M. Raza.*In Search of the Value of Time: From South Africa to India.* Travel Survey Methods: Quality and Future Directions. Edited by Peter Stopher and Cheryl Stecher. Elsevier Science, pp.457-484. September 2006.

30. Yalcin, A., Hashiuchi, J. and Mizokami, S. "A Study on Expressway Toll Pricing based on the results of Social Experiment", TRB 85th Annual Meeting CD ROM, 2005.

31. Smalkoski, B. and D. Levinson.*Value of Time for Commercial Vehicle Operators.* Working Papers 200501, University of Minnesota: Nexus Research Group, 2005.

32. Kawamura, K., *Commercial Vehicle Value of Time and Perceived Benefit of Congestion Pricing*. University of California Transportation Center, Berkeley, 1999.

33. *Categories of Travel Time*. Obtained from http://www.dot.ca.gov/. Accessed 08/01/2007.

34. Roth, D. "International Symposium on Road Pricing", (PowerPoint presentation), American Trucking Associations, 2003. http://www.trb.org/Conferences/RoadPricing/Presentations/Roth.ppt. Accessed July 1, 2007.

35. Reebie Associates. *The Impact of Tolls on Freight Movement for I81 in Virginia.* Final Report, Department of Rail and Public Transportation, Virginia, 2004.

36. Taft, B., "Northern Ohio Freight Strategy: Recommendations to Improve Traffic Safety and Congestion", 2004. http://www.dot.state.oh.us/news/2004/10-11-04Gov.htm. Accessed July 1, 2007.

37. Lake ,D.M. and Ferreira, L. "Demand for Toll Roads: A Summary of Elasticities, Travel Time Values and Modeling Approaches", Physical Infrastructure Center Research Report 02-01, School of Civil Engineering, Queensland University of Technology, Brisbane,2002.

38. Bonsall, P., J. Shires, J. Maule, B. Matthews and J. Beale. Responses to complex pricing signals: Theory, evidence and implications for road pricing. *Transportation Research Part A: Policy and Practice*. Volume 41, Issue 7, August 2007, Pages 672-683.

39. Goodson, D., *Do tolls really take a toll?* http://www.etrucker.com/apps/news/article.asp?id=24441. Accessed July 1, 2007.

40. Trans Texas Corridor Advisory Committee Meeting Summary # 5.www.keeptexasmoving.org. Accessed July 1, 2007.

41. H. Williams and J. Ortuzar, Behavioral theories of dispersion and the miss-specification of travel demand models, *Transportation Research B* 16, 167-219, 1982.

42. The TIOGA Group Study, "Goods Movement Truck & Rail Study," obtained from http://www.scag.ca.gov/goodsmove/pdf/truckrail/ch3.pdf. Accessed November 30, 2007.

43. Vadali, S.R. *Refinement of the TxDOT Economic Opportunity Index*. Technical Memorandum, 2007.

44. Federal Highway Administration Report. *Business Logistics: From Push to Pull Logistics*,http://ops.fhwa.dot.gov/freight/theme_papers/final_thm3_v3.htm. Accessed July 1, 2007.

45. U.S. Census Bureau. "Truck Transportation", Economic Census, Industry Series, 2002.

46. http://www.fhwa.dot.gov/policy/ohim/hs05/htm/mv9.htm. Accessed November, 30, 2007.

47. Winston, C. "U.S. Industry Adjustment to Economic Deregulation", *The Journal of Economic Perspectives*, Vol. 12, No. 3, 1998, pp. 89-110.

48. *American Trucking Trends.* American Trucking Association, Washington, D.C., 2005-06.

49. "Operating Costs of Trucks in Canada", Prepared for the Economic Analysis Directorate, Transport Canada, 2005.

50. "The Wisconsin Trucking Industry Perspective", prepared by the Wisconsin MotorCarriersAssociation,2002.http://www.witruck.org/2005%20DC%20paper.pdf Accessed July 1, 2007.

51. Nickerson, J.A., and Silverman, B.S. "Why Aren't All Truck Drivers Owner-Operators? Asset Ownership and the Employment Relation in Interstate for-Hire Trucking", *Journal of Economics & Management Strategy*, Volume 12, Number 1, Spring 2003, 91–118.

52. Mullett, R. and Poole, R. *Road Pricing and Trucking: Framing the Issues:* Mapping the Future. Tollways.Volume 3, Number 1, IBTTA, 2006.

53. AECOM Consult, Inc. *Issues and Options for Increasing the Use of Tolling and Pricing to Finance Transportation Improvements*. FHWA, Office of Transportation Policy Studies, 2006.

54. Golob, T.G. and Regan, A.C. "Impacts of Highway Congestion on Freight Operations: Perceptions of Trucking Industry Managers", Transportation Research Part A 35, 2001, pp.577-599.

55. Chakraborty, A. and Kazarosian, M. "Product Differentiation and the Use of Information Technology: New Evidence from the Trucking Industry", NBER Working Paper No. W7222, 1999.

56. Levinson, D., M. Corbett, and M. Hashami. *Operating Costs for Trucks*. University of Minnesota: Nexus Research Group, Working Series Number 000024, 2004.

57. Bonsall, P., Cho, H-J., Palmer, I and Thorpe, N. "Experiments To Determine Drivers' Response to Road User Charges", *Proceedings of the European Transport conference*, PTRC, Cambridge, UK, 1999.

58. Siebert, J.H. "The Impact of Traffic Congestion on Owner Operators", TRB Annual Meeting, 2001.

59. Dey, I. Qualitative Data Analysis: A User-Friendly Guide for Social Scientists, Routledge, NY, 1993.

60. Eisenhardt, K. M. Building Theories from Case Study Research," *Academy of Management Review*, 1989: 14(4), 532-550.

61. Newman, L. C. Macroergonomic Methods: Interviews and Focus Groups. In Proceedings of the Human Factors, 2002.

62. Hensher, D. How do Respondents Process Stated Choice Experiments? Attribute Consideration Under Varying Information Load, *Journal of Applied Econometrics,* 21, 2006: 861-878.

63. Adkins, G.A., A.W. Ward and W.F. McFarland. *Values of Time Savings of Commercial Vehicles.* NCHRP Report 33, 1967.

64. Williams, T. M. Practical use of distributions in network analysis. *Ops Res. Soc.,* 43, 1992, 265-270.

65. Barnes, G., and P. Langworthy. *The Per-Mile Costs of Operating Automobiles and Trucks*. Minnesota Department of Transportation, 2003.

66. Richardson, J.W. *Simulation for Applied Risk Management*, Department of Agricultural Economics, Agricultural and Food Policy Center, Texas A & M University, 2006.

67. Gossain, V., Williams, T.A., Savage, J.P., Mwalwanda, C.E. *Analyzing the Effects of Tolls and Operating Costs on Statewide Travel Patterns.* Wilbur Smith Associates. http://www.trb-appcon.org/TRB-Presentations/Session%209/6_Analyzing%20the%20Effects%20of%20Tolls%20and%20Operating%20Costs.ppt. Accessed December 15, 2007.

68. http://www.turnpikerebate.com. Accessed November 30, 2007.

69. Meyer, M., L. Saben, W. Shephard, and E. Steavens. Feasibility of Truck-only-Toll Lane Network in Atlanta, Georgia. *Transportation Research Record*, Journal of the Transportation Research Board, National Research Council, 1960, 2006.