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16. ABSTRACT

The problem of truck routing and the choices associated with it is a major focus of concern in transportation agencies throughout the world. Unfortunately, there has been a minimal amount of value of time (VOT) and value of reliability (VOR) oriented research relating to this problem. This research initiation grant project is intended to fill the gap in the literature surrounding this problem. The purpose is to evaluate characteristics used by owner-operated trucks in Southern California when choosing from two or more different types of roads such as interstate freeways, state freeways, toll roads, and local roads. The ultimate goal is to contribute the body of knowledge necessary for comprehensive benefit-cost analyses concerning toll roads. This report documents the development of a full research design based on six tasks such as the critical literature review on stated preference survey methods, clear and detailed statement of objectives for the stated preference survey, development of a survey instrument, identification of the sample population, proposed methodology for generating a representative sample of respondents, and pilot test of the survey instrument. When developing the full research design based on the factor analysis results, the project team explores the number of alternatives and specific examples such as Interstates 110 and 710 during peak gate hours. Route choice attributes are considered using cost measure, reliability measure, travel time measure, safety measure, weather measure, time of day measure, scheduled delivery time measure, truck cargo price measure, truck gas mileage measure, and truck comfort measure. The project team designed and provided a number of scenarios with each respondent for their route choices.

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Abstract

The problem of truck routing and the choices associated with it is a major focus of concern in transportation agencies throughout the world. Unfortunately, there has been a minimal amount of value of time (VOT) and value of reliability (VOR) oriented research relating to this problem. This research initiation grant project is intended to fill the gap in the literature surrounding this problem. The purpose is to evaluate characteristics used by owner-operated trucks in Southern California when choosing from two or more different types of roads such as interstate freeways, state freeways, toll roads, and local roads. The ultimate goal is to contribute the body of knowledge necessary for comprehensive benefit-cost analyses concerning toll roads. This report documents the development of a full research design based on six tasks such as the critical literature review on stated preference survey methods, clear and detailed statement of objectives for the stated preference survey, development of a survey instrument, identification of the sample population, proposed methodology for generating a representative sample of respondents, and pilot test of the survey instrument. When developing the full research design based on the factor analysis results, the project team explores the number of alternatives and specific examples such as Interstates 110 and 710 during peak gate hours. Route choice attributes are considered using cost measure, reliability measure, travel time measure, safety measure, weather measure, time of day measure, scheduled delivery time measure, truck cargo price measure, truck gas mileage measure, and truck comfort measure. The project team designed and provided a number of scenarios with each respondent for their route choices.

Route Choice Characteristics of Owner-Operated Trucks on Southern California Freeways

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Executive Summary

The PI proposed to develop a full research design to evaluate the route choices of owner-operated truck drivers operating in Southern California freeways. The primary goal of this research initiative is to enhance private decision-making regarding the route choices of owner-operated truck drivers, while the secondary goal is to provide agencies and truck operators with useful information for benefit-cost analysis of public investment or tolling projects so that current road options can be considered such as high-occupancy toll roads. In order to achieve the objective of this research initiation grant project, the PI and the project team members consisting one graduate student and one undergraduate student worked on the six tasks, including: 1) critical literature review on stated preference survey methods; 2) clear and detailed statement of objectives for the stated preference survey; 3) development of a survey instrument; 4) identification of the sample population; 5) proposed methodology for generating a representative sample of respondents; and 6) pilot test of the survey instrument.

The research team conducted critical literature review on stated preference survey methods and the truck route choice characteristics. Existing studies on the factors such as value of time (VOT), value of reliability (VOR), travel cost, safety, comfort, convenience, income, ownership, congestion, vehicle class, and others are examined. Then, the team defined clear and detailed statement of objectives for the stated preference (SP) survey, followed by the analytic hierarchy process (AHP) technique for a survey instrument, which played a vital role in develop a SP survey design. Since the research boundaries vary in traffic volume, travel cost, travel time, and reliability due to traffic congestion, it was necessary to determine the most significant factors, while eliminating other factors which are difficult to examine the usefulness for an accurate VOT estimation using a regression analysis.

As a result of this effort, the project team documents evaluation results on key factors that affect route choice characteristics of owner-operated trucks in Southern California freeways. Unlike truck drivers who work for a company, owner-operated truck drivers need to make decisions when considering the best possible route for a particular trip since they have the liberty of choosing their own route and their value of time is dependent on numerous factors, rather than being dependent on their hourly wage. Surveys were conducted with owner-operated truck drivers who use Southern California highway systems routinely, including all truck classes and cargo types. The team identified the sample population in Southern California boundary, especially ports of Los Angeles and Long Beach. Fuzzy AHP was designed and applied to identify and evaluate the most important contemporary factors from the perspective of owner operated truck drivers. It was found that the three most important factors were travel time, price of the cargo per unit, and the level of experience of the driver. The results not only provide insight in deciding whether certain projects will be economically beneficial for society, but also contribute an evaluation method for multi-criteria decision making in order to help researchers and managers to determine the drawbacks and opportunities. The evaluation results are used when developing the full research design. The project team explored the number of alternatives and specific examples such as Interstates 110 and 710 during peak gate hours. The team designed a SP survey with different scenarios in Southern California freeways and the survey provides an opportunity with each respondent to express their route choices.

1.0 Introduction

The U.S. highway system comprises approximately 3.9 million miles of highways, including high-capacity, multilane freeways, urban streets, and unpaved rural roads. The nation's highway system also carries approximately 29% of all intercity ton-miles of freight, which generates 75% of intercity freight revenue (1). Depending on the truck size, ownership, and use, the truck population is very diverse and causes severe traffic congestion. For example, truck transportation from the Ports of Los Angeles and Long Beach is often bottlenecked due to the heavy traffic demands in a limited capacity. Small et al. (2) presented the valuation of travel-time savings and predictability in congested conditions for highway user-cost estimation. Thus, shipper responses to travel cost, reliability on-time arrival, comfort, convenience, safety, and ownership are important to understand shipper behaviors with respect to these parameters, which will aid in developing appropriate strategies and incentives for better managing shared systems.

In the ever growing population of Southern California, the freeway congestion is becoming a severe problem. The increasing number of people using freeways has contributed to a number of problems including an increase in the frequency of traffic jams and the frequency of accidents. These problems make a large impact on the fluidity and efficiency of heavy truck operations, giving them a higher overall costs, which in-turn affects the costs of the goods that they transport. In recent years there has been an increase in the amount of research aimed at solving the problem of congestion, and this research is aimed at contributing to that by focusing on truck drivers and the costs that can be reduced for them, as well as for society as a whole.

More importantly, the economic feasibility study for a new road is useful in determining if a new road can be built and how much economic worth can be obtained if the consumed resources are invested in other development projects. Therefore, it is vital to evaluate various factors with equal criteria and methods in order to ensure impartiality. At present, the Federal Highway Administration requires a feasibility study for the federal-aid funds by including benefit-cost analysis, non-monetary but quantifiable considerations, non-quantifiable considerations, and base case and sensitivity analysis (3). In conducting the feasibility study, a value of time (VOT) for truck travels is one of the critical factors among various cost and benefit items for the economic feasibility study of a new road. The VOT is defined as a monetary value that travelers are willing to pay to reduce travel time. The estimation methods for VOT vary depending on the researchers.

Truck drivers almost always face dilemmas which require them to make decisions for best route choice. They frequently ask themselves that should I proceed through downtown or avoid it? Should I choose this freeway over the other? Should I pay to use a toll road that may save time or wait in traffic? Daily trips having the same origin and destination often differ a great deal from each other. The presence of regular lanes, toll lanes, HOV lanes, and navigation devices offer truck drivers the option of several routes to choose from. A route choice preference study proposed in this research is one of the demand analysis processes which determine the number or percentage of preferences between zones made by owner-operated truck drivers. The selection of truck routes is very complex, depending on factors such as the owner truck driver's income, the availability of transit service, and the relative advantages of each mode in terms of travel time, cost, comfort, convenience, and safety. Therefore, a driver's route choice model to be developed in this research will attempt to replicate the relevant characteristics of the truck operators, the transportation system, and the trip itself in order to obtain a realistic estimate of the number of trips by each mode for each zone pair. The VOT of trucks, which constitutes a considerable portion of the benefit items in the economic feasibility study for a new road, needs to be validated by going beyond a typical academic discussion.

2.0 Critical Literature Review on Stated Preference Survey Methods

The project team has completed critical literature review and summarized key information to show how the existing studies relate to the project work. A comprehensive list of all the key definitions were made to help readers understand the terminologies used in the work. Using GIS software, Google maps, and Caltrans website information, the freeways of interest and various distribution centers from the ports of Long Beach and Los Angeles were visualized to look closely at all interstate and state routes in Los Angeles County with their starting and ending locations associated their total distances.

Table 1 summarized the existing studies on variables for truck routing choice characteristics. In order to avoid redundancy and for uniformity purposes, a single variable is used for indistinguishable variables. For example, for traffic density and congestion, traffic density is used. Travel cost, travel price, and expense are taken to be as travel cost. Travel time, travel costs, reliability, congestion, fuel stations, truck lanes, safety, trip length, trip time of day, setbacks at origin, unexpected delays, scheduled delivery, flexibility of schedule, delivery location, cargo price per unit, cargo volume, commodity type, special service, truck classification, gas mileage, comfort, truck ownership, driver income, cost bearer, driver age, drivers' experience are the variables found from the literature surveys. Travel time, travel cost, and reliability are the most frequently used variables among others, as shown in Table 1.

Table 1: Variables for Truck Routing Choice

Author (Year) (Ref.)	Title	Variables	VOT
Winston. (1981) [4]	A disaggregate model of the demand for intercity freight transportation	Volume of shipment Cost of shipment	
Bovy and Stern. (1990) [5]	Route choice way finding in transport networks	Traffic density Expected weather Travel time Reliability Number of lanes and lane width	
Fowkes. (1998) [6]	The development of stated preference techniques in transport planning	Travel cost Travel time Reliability	
F.B.T.C. (1999) [7]	Fehmarn belt traffic demand study	Travel cost Travel time	$21/hr
Kawamura (2000) [8]	Commercial vehicle value of time and perceived benefit of congestion pricing	Travel cost Toll	$23.40-26.80/hr
De Jong (2000) [9]	Value of freight travel-time savings	Travel cost Travel time Probability of delay,	$4.16-8.82/hr

		Frequency of shipment	
Fowkes et al. (2001) [10]	Freight road user valuation of three different aspects of delay	Cost Door to door Travel time Spread schedule delay	Shipper: $32.37/hr, Truck manager: $134.96/hr, Own vehicle: $32.37/hr
DFT(2002) [11]	Economic assessment of road schemes: The COBA manual		Light goods vehicle: $14.64/hr Other goods vehicle: $12.21/hr
Fowkes and Shinghal. (2002) [12]	The leeds adaptive stated preference methodology	Travel cost Travel time Reliability of service Frequency of service	
Knorring. (2003) [13]	Basic human decision making: an analysis of route choice decisions by long-haul truckers	Income and education Risk aversion Traffic information Time of day Traffic density Number of rest areas	
ODOT (2004) [14]	The value of travel-time: estimates of the hourly value of time for vehicles in Oregon 2003		Light truck: $18.92/hr, Heavy truck: $25.49/hr
Fosgerau and Karlstrom (2004) [15]	Value of reliability		380/hr
Sekiya, Kobayashi, Nambu, and Uesaka. (2007) [16]	Factors influencing freight truck route selection	Travel distance Delivery time Facility type Freight volume	
Antoniou, Matsoukis, and Roussi. (2007) [17]	A methodology for the estimation of value-of-time using state-of-the-art econometric models	Travel time Travel cost	7.2/hr (linear) 6.9/hr (Logit) 8.1/hr (Binary Logit)
Buethe and Bouffioux. (2008) [18]	Analyzing qualitative attributes of freight transport from stated orders of preference experiment	Frequency Travel time Reliability Flexibility Travel cost Travel damages	
Arentze, Feng, Timmermans, and Robroeks (2012) [19]	Context-dependent influence of road attributes and pricing policies on route choice behavior of truck drivers: Results of a conjoint choice experiment	Traffic density Road category Route facilities Travel time Time of day Size of truck Travel distance Time since rest Driver age	
Sun (2013) [20]	Decision making process and factors affecting truck routing	Frequency of fuel stations & fuel price Travel time reliability Truck parking Toll prices Travel distance Travel time Predictability Travel cost Toll characteristics	$21/hr – $78/hr

Toledo (2014) [21]	Key decision factors for toll road usage by trucks	Travel time reliability Refrigerated container
Davidson, Teye, and Culley (2014) [22]	Developing a successful stated preference methodology for determining destination choice coefficients and using it to investigate its empirical structural relationship with toll route choice	Time of day Travel time Travel cost
Hess, Quddus, Rieser-Schussler, and Daly (2014) [23]	Developing advanced route choice models for heavy goods vehicles using GPS data	Number of links Travel distance Travel time Fuel cost

Notes:

- In order to avoid redundancy and for uniformity purposes a single variable is used for indistinguishable variables
- For Traffic density and congestion, Traffic density is used.
- Travel cost, Travel price and expense are taken to be as Travel Cost
- Detailed reviews for these existing studies are available in Appendix II.

3.0 Clear and Detailed Statement of Objectives for Stated Preference Survey

The project team designed and administered a preliminary questionnaire that provided us with useful information about truck drivers, and more specifically, the population of interest, while acting as a preliminary training session for student assistants who will administer a full scale questionnaire and/or survey. More importantly, the project team has analyzed the objectives for the stated preference survey and the key factors that truck drivers consider when deciding which route to take through the literature on the subject matter. The preliminary questionnaire consists of eleven questions, as follows:

1 Do you own and operate your own vehicle?
2 How many axles does your vehicle have?
3 Is the starting or ending location for any of your trips the Port of Long Beach or the Port of Los Angeles?
4 How many trips do you usually make in a day?
5 What cities do you usually deliver to?
6 Do you ever deliver to any rail or shipping yards in the Los Angeles area? If yes, which ones?
7 Do you ever use the 110, 710, 5, or 405 freeways? If yes, on which ones do you spend most of your time?
8 On average, how much of your time is spent per day travelling at speeds less than 25 mph?
9 What factor do you consider most when deciding which route to take? (travel distance, travel cost, travel time, unexpected delays, safety, etc.)
10 What factor contributes the most to your total travel costs? (insurance, fuel, tires, maintenance, repairs, tolls, etc.)
11 What factor contributes the most to your total travel time? (traffic, traffic lights, fueling stops, weighing stations, loading/unloading of your vehicle, rest stops, etc.)

Various truck drivers operating out of the city of Long Beach and Los Angeles were called over the telephone and asked a series of questions, whose answers is helpful in designing both the analytic hierarchy process survey and the stated preference survey. Twenty responses to eleven questions were recorded, although three of the truck drivers did not respond to all eleven questions. The purpose of these first three questions was to differentiate between the truck drivers that are part of the target population of the study and those who are not. The population that we targeted are owner-operator truck drivers that are coming out of the Port of Long Beach and/or the Port of Los Angeles, and we need to collect data separately for different classifications of trucks based on their number of axles from the FHWA and compare them with each other. The first question asked “do you own and operate your own vehicle?”; 13 responded yes to the question and 7 responded that the vehicle they drive is a company vehicle. The second question asked “how many axles does your vehicle have?”; 6 of them had a vehicle with 2 axles, 9 had 3 axles, and 5 had 4 axles. This suggests that a majority of the respondents’ vehicles fall into relatively small classifications of trucks. The third question asked “do you ever go to the Port of Long Beach or the Port of Los Angeles?”; 14 responded no to the question, and 6 responded yes (with 4 going to only the Port of Long Beach, 1 going to only the Port of Los Angeles, and 1 going to both).

The purpose of the next five questions (Q4-Q8) was to give us an idea of what to expect when randomly questioning truck drivers about how many deliver to rail yards, what freeways they use, what is their typical end destination, how many trips they make in a day, and how much time they spend in traffic every day. The fourth question asked “how many deliveries do you usually make in a day?”; the answers ranged anywhere from 1 to 12, where respondents who stay in the Long Beach and Los Angeles areas ranged from 1 to 12, and respondents who travel to other surrounding counties ranged from 1 to 6. The fifth question asked “what two cities do you deliver to the most?”; 7 respondents said that they most often deliver to various locations within Long Beach, and the rest of the responses were varied with answers such as Los Angeles, Riverside, San Diego, Irvine, etc. The sixth question asked “do you ever deliver to any rail yards in the Los Angeles area?”; 13 responded no to the question, and 7 said they deliver to the Union Pacific Railroad Company. The seventh question asked “do you ever use the 10, 110, 710, 5, or 405 freeways, and which one do you use the most?”; 3 said they don’t use any of those freeways, 2 said they use the 10 the most, 1 said they use the 110 the most, 4 said they use the 710 the most, 5 said they use the 5 the most, and 4 said they use the 405 the most. The eighth question asked “on average, how much of your day is spent travelling at speeds less than 25 mph?”; the answers to this question varied more than any other question with answers such as not much time at all, a lot of the day, a quarter of the day to half of the day, but the most common answer was about one to two hours.

The purpose of the last three questions was to identify the factor that truck drivers consider the most when deciding the best route to take, and to identify the factor that contributes the most to their travel time and travel cost. Responses to these questions were obtained for 17 of the 20 respondents. The first of these questions (Q9) asked “which of these factors do you consider the most when deciding what route to take: travel distance, travel cost, travel time, potential unexpected delays, or safety?”; 3 said they most consider travel time, 4 said they most consider potential unexpected delays, and 10 said that safety is what they consider most. Question 10 asked “which of these factors contributes the most to your total travel cost: insurance, fuel, tire replacement, maintenance, repairs, or tolls?”; all 17 respondents said that fuel costs contribute the most. The final question asked “which of these factors contributes the most to your total travel time: traffic, traffic lights, fueling stops, rest stops, weighing stations, or the loading/unloading of your vehicle?”; all 17 respondents said that traffic contributes the most.

The answers to all these questions gives us some very useful information regarding the sample population intended for the study and for the primary factors that will be focused on in the survey instrument, but there are a few problems with this questionnaire: the sample size is relatively small which was intentional so as to keep the cost of obtaining the information low, and it is biased towards English speaking truck drivers because the person who conducted the questionnaire only speaks English.

Therefore, the research team defined the objective of the stated preference survey as to evaluate route choice characteristics used by owner-operated trucks when choosing from two or three different types of roads. Shipper responses to travel cost, reliability on-time arrival, comfort, convenience, safety, and ownership are important to understand shipper behaviors and to aid in developing appropriate strategies and incentives for better managing shared systems. More specifically, the SP survey aims to evaluate the average value of travel time (VOT) and the average value of travel time reliability (VOR) of a representative sample of these truck drivers.

Figure 1 shows the overall schemata for the proposed research project. The research team selected the research boundary within Southern California’s network of toll-free and toll roads. Toll roads includes the I-10 and I-110 Express Lanes owned and operated by Metro, the 91 Express Lanes owned and operated by the Orange County Transportation Authority, the 241, 261, 133, and 73 Toll Roads operated by the Transportation Corridor Agencies, and the I-15 Express Lanes and SR-125 in San Diego County (Southern California Toll Roads 2014). According to CalTrans report, the 2010 data are based on a count of 1,368 trucks/day and 44,000 vehicles/day, or 3.1%. Over two-thirds of these trucks are small trucks, with two or three axles. Similar percentages can be calculated for locations farther south, such as the segments between SR 60 and I-10 (5.0%), north of I-5 (7.6%), north of I-405 (14.3%), and at the beginning of I-710 near the Port of Long Beach (26.4%). Truck count data, while useful, do not reveal anything about origins and destinations (where trucks are coming from and going to), which is ***the focal point of this research project since the project team will identify the origins and destinations of truck transportation***. Over 85% of truck trips in Los Angeles County stay completely within the six-county SCAG region (Ventura, Los Angeles, Orange, San Bernardino, Riverside, and Imperial Counties) and also do not involve goods from the San Pedro ports. For example, these truck trips are transporting goods from suppliers to manufacturers or from regional distribution centers to local stores. Only approximately 6% of truck trips in Los Angeles County are passing through on their way from an origin to a destination outside the region, such as agricultural products being transported from the Central Valley to the southwest. Less than 8% of truck trips in Los Angeles County start or end at the San Pedro ports, or are carrying goods directly transferred from the ports (SCAG

2012 RTP/SCS, Goods Movement, Table 4).

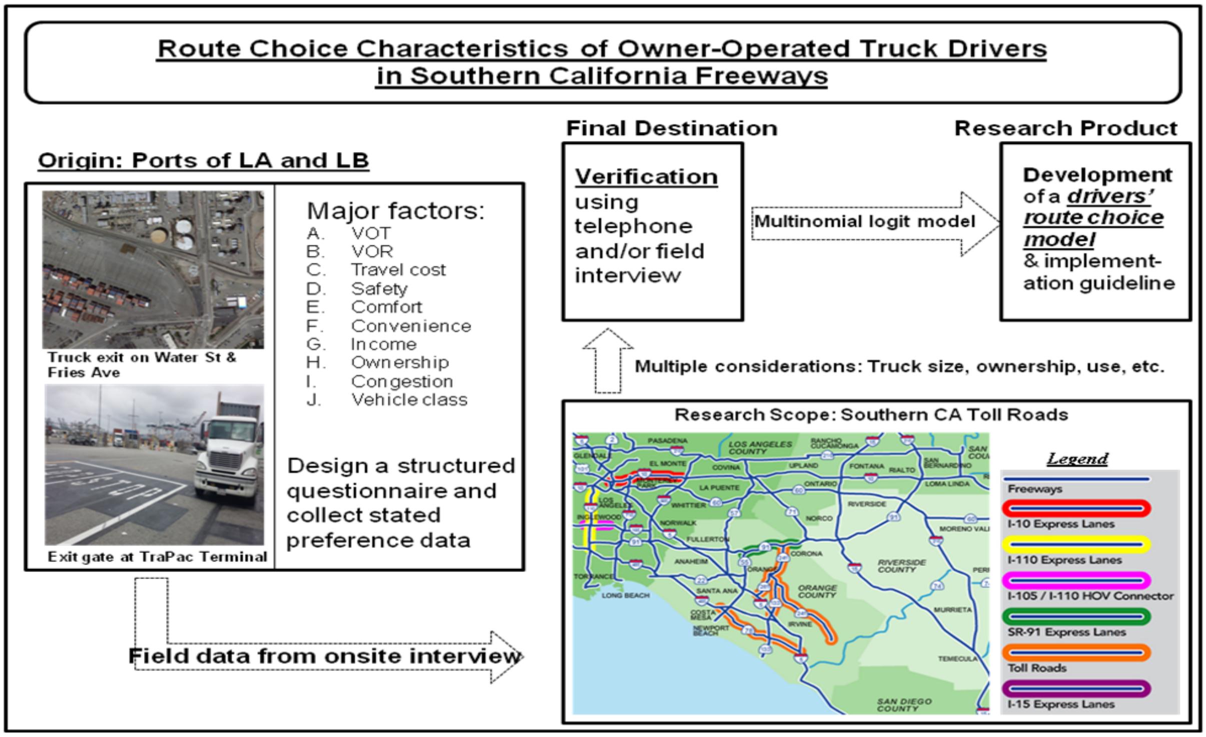

Figure 1: Overall schemata for the proposed research project

4.0 Development of a Survey Instrument and Identification of Sample Populations

The main objectives of this survey are to evaluate key factors that affect route choice characteristics of owner-operated trucks in Southern California freeways and provide an evaluation method for multi-criteria decision making in order to help researchers and managers to determine the drawbacks and opportunities. The fuzzy AHP technique is designed and applied to identify the key contemporary factors. This survey was motivated and carried out to overcome the severe level of congestion on freeways in Southern California, and particularly in the Los Angeles area, that have large levels of truck traffic, such as the 110 and 710 interstate freeways that lead to the ports of Los Angeles and Long Beach. In order to achieve the survey objectives, the authors undertake the following derived objectives:

1. To identify and evaluate key factors through information gathering from literature surveys;
2. To construct the evaluation criteria hierarchy and calculate the relative weights of criteria through applying fuzzy AHP model;
3. To achieve the final ranking results and summarize, compare, and compile the findings of truck routing choice characteristics and its improvement alternatives

Based on the factors obtained from Tasks 2 and 3, an analytic hierarchy process (AHP) survey was designed to obtain the significance level of each of these factors for the informed decision making process of which route to take. Figure 2 shows the AHP survey instrument. Figure 1 shows sample screenshot for the AHP questionnaire.

Factors Related to the Route:

Travel Time: Total time of the trip
Travel Time Reliability: The reliability of an always constant travel time
Travel Costs: All costs incurred during the trip
Congestion: The level of congestion on the route
Fuel Stations: The amount and availability of fuel stations throughout the trip
Truck/Toll Lanes: The amount and availability of distinct truck lanes or toll lanes
Safety: The overall safety and security of the truck driver and surrounding vehicles

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Please rank these factors in order of their importance using numbers 1 - 7 (where 7 is the most important and 1 is the least important)

Travel Time	
Travel Time Reliability	
Travel Costs	
Congestion	
Fuel Stations	
Truck/Toll Lanes	
Safety	

Click only once for each row to the appropriate number by comparing relative importance between the two factors.

	9	7	5	3	1	0	1	3	5	7	9	
Travel Time	○	○	○	○	○	○	○	○	○	○	○	Travel Time Reliability
Travel Time	○	○	○	○	○	○	○	○	○	○	○	Travel Costs
Travel Time	○	○	○	○	○	○	○	○	○	○	○	Congestion
Travel Time	○	○	○	○	○	○	○	○	○	○	○	Fuel Stations
Travel Time	○	○	○	○	○	○	○	○	○	○	○	Truck/Toll Lanes
Travel Time	○	○	○	○	○	○	○	○	○	○	○	Safety
Travel Time Reliability	○	○	○	○	○	○	○	○	○	○	○	Travel Costs
Travel Time Reliability	○	○	○	○	○	○	○	○	○	○	○	Congestion
Travel Time Reliability	○	○	○	○	○	○	○	○	○	○	○	Fuel Stations
Travel Time Reliability	○	○	○	○	○	○	○	○	○	○	○	Truck/Toll Lanes
Travel Time Reliability	○	○	○	○	○	○	○	○	○	○	○	Safety
Travel Costs	○	○	○	○	○	○	○	○	○	○	○	Congestion
Travel Costs	○	○	○	○	○	○	○	○	○	○	○	Fuel Stations
Travel Costs	○	○	○	○	○	○	○	○	○	○	○	Truck/Toll Lanes
Travel Costs	○	○	○	○	○	○	○	○	○	○	○	Safety
Congestion	○	○	○	○	○	○	○	○	○	○	○	Fuel Stations
Congestion	○	○	○	○	○	○	○	○	○	○	○	Truck/Toll Lanes
Congestion	○	○	○	○	○	○	○	○	○	○	○	Safety
Fuel Stations	○	○	○	○	○	○	○	○	○	○	○	Truck/Toll Lanes
Fuel Stations	○	○	○	○	○	○	○	○	○	○	○	Safety
Truck/Toll Lanes	○	○	○	○	○	○	○	○	○	○	○	Safety

Figure 2: Sample screenshot for AHP questionnaire
(Visit the link for full questionnaire on Qualtrics at
https://qtrial2015q4az1.az1.qualtrics.com/SE/?SID=SV_1HcFvlhZ3p2c6CV)

4.1 Fuzzy AHP Method

A decision making process is a complex process that takes into consideration multiple factors. These types of processes are commonly referred to as multi-criteria decision making (MCDM) processes. One of the most commonly used and widely accepted methods of analyzing MCDM processes is through the use of an Analytic Hierarchy Process (AHP), which juxtaposes the different criteria as well as the alternative factors within each criterion with all of the other criteria and alternatives on a one-by-one basis. That is, each criterion and alternative is compared to only one other at a time. By comparing them piece-by-piece, we can determine which of the criteria and alternatives have the greater relative importance to the MCDM process using the responses obtained by surveying the decision makers. However, as is explained in the work by Srichetta and Thurachon [(24)], the inherent weakness of the conventional AHP is its imprecision, which is a result of the vagueness of the human thought process, as well as the complex and uncertain nature of the decision making process. For this reason, the fuzzy AHP method was used in this paper for data analysis because the fuzzy AHP accounts for the fuzziness or uncertainty of the process. Instead of assigning the degree of each decision with a single set of precise numbers, as with conventional AHP, fuzzy AHP assigns the degree of each decision with a set of a range of values that have a lower, middle, and upper limit. The following steps describes the detail explanation of the fuzzy AHP to provide an evaluation method for multi-criteria decision making process.

Step 1: Triangular Fuzzy Number (TFNs)

The first step in the fuzzy AHP analysis is to construct the fuzzy pair-wise comparison matrices for the results of each respondent. The fuzzy pair-wise comparison matrices are constructed using Triangular Fuzzy Numbers (TFNs). The values of the TFNs are based on the degree of importance that a particular factor has over another. The degree of importance of one factor over another is represented by a numerical scale (1,3,5,7,9), and TFNs used are shown in Table 2. The TFNs for each degree of importance have three values: lower, middle, and upper (l,m,u). There is an upper and lower limit because of the uncertainty (hence the term fuzzy).

Table 2: Triangular Fuzzy Conversion Scale

Linguistic Scale	Numerical Scale	TFNs	Inverse TFNs
Equally important	1	(1, 1, 1)	(1, 1, 1)
Moderately more important	3	(2/3, 1, 3/2)	(2/3, 1, 3/2)
Strongly more important	5	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)
Very strongly more important	7	(5/2, 3, 7/2)	(2/7, 1/3, 2/5)
Extremely more important	9	(7/2, 4, 9/2)	(2/9, 1/4, 2/7)

Step 2: Construct the Fuzzy Pair-Wise Comparison Matrix

To construct the fuzzy comparison matrix $A=\{a_{ij}\}$ of n factors (criteria or alternatives), the TFNs are used as follows.

$$A = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ a_{21} & 1 & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & 1 \end{bmatrix}$$

When comparing factor *i* to factor *j*: if factor *i* is more important than factor *j*, then a_{ij}=TFN and a_{ji}=Inverse TFN; if factor *j* is more important than factor *i*, then a_{ji}=TFN and a_{ij}=Inverse TFN. For example; if a respondent marks the 5 that is closer to factor 1 in the row that compares factor 1 and factor 2, that means they feel as though factor 1 is strongly more important than factor 2, and the term a_{12} in the fuzzy pair-wise comparison matrix will be equal to the TFNs that correspond to a value of 5 and the term a_{21} will be equal to the inverse TFNs that correspond to a value of 5. A sample fuzzy pair-wise comparison matrix can be seen in Table 3, in which three numbers are assigned to each row and column: (*l*, *m*, *u*). The *l* is the lower limit TFN, *m* is the middle TFN, and *u* is the upper limit TFN.

Table 3: Sample Fuzzy Pair-Wise Comparison Matrix

	C1	C2	C3	C4	C5
C1	(1, 1, 1)	(5/2, 3, 7/2)	(2/3, 1, 3/2)	(5/2, 3, 7/2)	(5/2, 3, 7/2)
C2	(2/7, 1/3, 2/5)	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)
C3	(2/3, 1, 3/2)	(3/2, 2, 5/2)	(1, 1, 1)	(5/2, 3, 7/2)	(5/2, 3, 7/2)
C4	(2/7, 1/3, 2/5)	(3/2, 2, 5/2)	(2/7, 1/3, 2/5)	(1, 1, 1)	(2/3, 1, 3/2)
C5	(2/7, 1/3, 2/5)	(3/2, 2, 5/2)	(2/7, 1/3, 2/5)	(2/3, 1, 3/2)	(1, 1, 1)

Step 3: Aggregate the Group Decisions

The next step is to create an aggregated fuzzy pair-wise matrix by taking the geometric mean of all a_{ij} terms of the fuzzy pair-wise comparison matrices for all of the results. The aggregated TFN (U=u_{ij}) of *n* decision makers' responses is:

$$U = \left(\prod_{i=1}^{n} a_{ijk} \right)^{1/n}$$

where a_{ijk} is the relative importance in form of TFN of the k_{th} decision maker's response, and *n* is the total number of decision makers. A sample aggregated fuzzy pair-wise matrix is shown in Table 4.

Table 4: Sample Aggregated Fuzzy Pair-Wise Matrix

	C1	C2	C3	C4	C5
C1	(1, 1, 1)	(1.46, 1.79, 2.17)	(1.46, 1.69, 1.95)	(1.33, 1.53, 1.75)	(1.38, 1.69, 2.03)
C2	(0.46, 0.56, 0.69)	(1, 1, 1)	(0.95, 1.10, 1.26)	(1.21, 1.43, 1.68)	(0.99, 1.18, 1.39)
C3	(0.51, 0.59, 0.69)	(0.79, 0.91, 1.06)	(1, 1, 1)	(0.96, 1.15, 1.37)	(0.93, 1.07, 1.22)
C4	(0.57, 0.65, 0.75)	(0.60, 0.70, 0.83)	(0.73, 0.87, 1.04)	(1, 1, 1)	(0.98, 1.18, 1.42)
C5	(0.49, 0.59, 0.72)	(0.72, 0.85, 1.01)	(0.82, 0.93, 1.07)	(0.70, 0.85, 1.02)	(1, 1, 1)

Step 4: Compute the Value of Fuzzy Synthetic Extent

The fuzzy synthetic extent values (Si) are based on the sample aggregated fuzzy pair-wise matrix ($U=u_{ij}$) and are equal to the product of each individual row sum and the inverse of the sum of all row or column sums, where the $(l, m, u)^{-1}$ is equal to $(1/u, 1/m, 1/l)$. Table 5 lists the row and column sums for the aggregated fuzzy pair-wise matrix based on the aggregated fuzzy pair-wise matrix shown in Table 4 and the fuzzy synthetic extent values based on the equation below:

$$S_1 = (6.6226, 7.7090, 8.8987) * (23.0417, 26.3210, 30.1211)^{-1} = (0.2106, 0.2986, 0.4163)$$

Table 5: Horizontal and Vertical Sums and Fuzzy Synthetic Extent Values

Criteria	Row Sums	Column Sums	Fuzzy Synthetic Extent Value (S_i)
C1	(6.62, 7.71, 8.90)	(3.04, 3.39, 3.85)	(0.2106, 0.2986, 0.4163)
C2	(4.61, 5.27, 6.02)	(4.56, 5.24, 6.06)	(0.1466, 0.2043, 0.2818)
C3	(4.20, 4.72, 5.34)	(4.95, 5.60, 6.33)	(0.1335, 0.1827, 0.2497)
C4	(3.88, 4.40, 5.04)	(5.20, 5.96, 6.81)	(0.1234, 0.1705, 0.2358)
C5	(3.73, 4.22, 4.82)	(5.29, 6.13, 7.07)	(0.1186, 0.1633, 0.2256)
Sum of row or column sums		(23.04, 26.32, 30.12)	

Step 5: Approximate the Fuzzy Priorities

The next step is to approximate the fuzzy priorities and thereby determine the normalized and relative weights of each criterion. Based on the fuzzy synthetic extent values (S), the non-fuzzy values that represent the relative preference, or weight, of one criterion over the other criteria. The degree of possibility that $S_b \geq S_a$ is shown below:

$$V(S_b \geq S_a) = \begin{cases} 1 & , \ if\ m_b \geq m_a \\ 0 & , \ if\ l_a \geq u_b \\ \dfrac{l_a - u_b}{(m_b - u_b) - (m_a - l_a)} & , \ otherwise \end{cases}$$

where d is the ordinate of the highest intersection between μ_{Sa} and μ_{Sb} as shown in Figure 3. That is, it can be expressed that:

$$V(S_b \geq S_a) = height(S_a \cap S_b) = \mu_{S_a}(d).$$

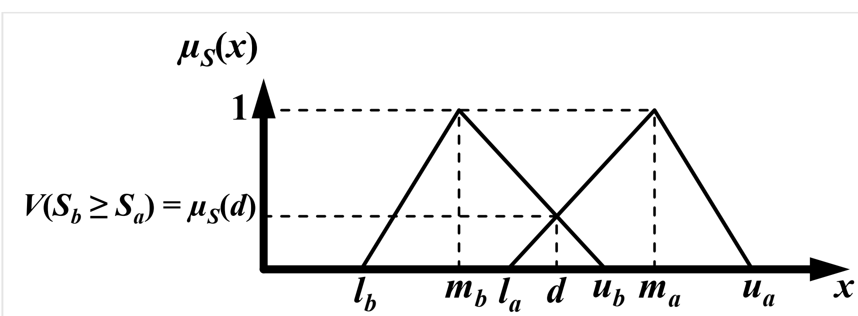


Figure 3: Intersection between S_a and S_b and their degree of possibility

The degree of possibility for a TFN (S_i) to be greater than the number of n TFNs (S_k) is found by taking the minimum of the values:

$$V(S_i \geq S_1, S_2, \ldots, S_k) = \min V(S_i \geq S_k) = w'(S_i)$$

where $k = 1, 2, \ldots, n$ and n is the number of criteria.

Each $w'(S)$ value represents the relative preference, or weight, of each criterion. However, the weights need to be normalized so that the sum of all $w'(S)$ values is equal to one, so that all weights can be represented as a percentage and graphed. The normalized weights, $w(S_i)$, are calculated by dividing each $w'(S)$ value by the sum of all $w'(S)$ values:

$$w(S_i) = \frac{w'(S_i)}{\sum_{i=1}^{n} w'(S_i)}$$

Listed below is the calculation for each degree of possibility for criterion C5:

$$V(S_{C5} \geq S_{C1}) = \frac{(0.2106 - 0.2256)}{(0.1633 - 0.2256) - (0.2986 - 0.2106)} = 0.0996$$

$$V(S_{C5} \geq S_{C2}) = \frac{(0.1466 - 0.2256)}{(0.1633 - 0.2256) - (0.2043 - 0.1466)} = 0.6583$$

$$V(S_{C5} \geq S_{C3}) = \frac{(0.1335 - 0.2256)}{(0.1633 - 0.2256) - (0.1827 - 0.1335)} = 0.8256$$

$$V(S_{C5} \geq S_{C4}) = \frac{(0.1234 - 0.2256)}{(0.1633 - 0.2256) - (0.1705 - 0.1234)} = 0.9336$$

Hence, the relative weight of criterion C5 is:

$$V(S_{C5} \geq S_{C1}, \ldots, S_{C4}) = \min(0.0996, 0.6583, 0.8256, 0.9336) = 0.0996 = w'(S_{C5})$$

The relative weights, and normalized weights, of all other criteria ($w'(S_{C1})$ through $w'(S_{C4})$) are listed in Table 6. Criterion C1 has the largest weight and criterion C5 has the smallest weight. This means that criterion C1 is the most important criteria in the decision making process, and criterion C5 is the least important.

Table 6: Relative and Normalized Weights

Criteria	Relative Weights ($w'(S_i)$)	Normalized Weights ($w(S_i)$)
C1	1	0.5137
C2	0.4301	0.2210
C3	0.2523	0.1296
C4	0.1646	0.0845
C5	0.0996	0.0512
Sum of $w'(S_i)$	1.9467	

Step 6: Consistency Test of the Comparison Matrix

The next step is to test the value of the consistency of each comparison matrix. The consistency rate (*CR*) is the ratio between the consistency of a consistency index (*CI*) and the consistency of a random consistency index (*RI*). Table 7 shows values of *RI* for different values of *n*. Its value should not exceed 0.1 for a matrix larger than 4x4.

$$CR = \frac{CI}{RI}$$
$$CI = \frac{\lambda_{max} - n}{n - 1}$$

where the eigenvalue λ_{max} is computed by averaging all the eigenvalues of the pair-wise comparison matrix and *n* is the number of factors.

Table 7: *RI* Values for Different *n* Values

n	*RI*	*n*	*RI*
3	0.58	8	1.41
4	0.9	9	1.45
5	1.12	10	1.49
6	1.24	11	1.51
7	1.32	12	1.48

4.2 Data Collection and Fuzzy Pair-Wise Comparison Matrix

This section presents the data collection process, the hierarchical structure to be analyzed using the factors studied from the literature review, and the fuzzy pair-wise comparison matrix.

4.2.1 Data Collection Process

The authors collected field data at the Harbor Truck Stop on 2130 W Pacific Coast Hwy in Long Beach, California. The data was first collected by conducting the full survey with the drivers face-to-face. This method proved to be problematic because most drivers were unwilling to complete the entire survey due to their busy schedule. That is why we decided data collection method to make pre-paid envelopes with the survey inside and instructions on how to send back the surveys through the mail, as well as slips of paper that directed the drivers that had access to the internet to the computerized survey. This proved to be more effective as the drivers could fill out the survey when they had some free time. Fifteen complete sets of responses were collected from owner-operator truck drivers at the field from March to June 2016. However, only 10 of them were used for the analysis because the CR value was too high for the five responses.

4.2.2 Hierarchical Structure of Selecting Key Factors

Figure 4 shows each criterion and the alternatives within each criterion that were used in the fuzzy AHP survey. A total of five criteria were used for the analysis, including route, trip, cargo, truck, and driver. The characteristics of the route have travel time, travel time reliability, travel costs, congestion, fuel stations, truck or toll lanes, and safety. Travel time is the total time it takes to complete the route, while travel time reliability is the reliability of an always constant travel time. Travel costs include all costs incurred throughout the route. Congestion means the level of traffic on the route, and fuel stations means the frequency and availability of fueling stations throughout the route. Truck or toll lanes indicate the availability of distinct truck lanes or toll lanes, and safety is defined as the overall safety and security of the truck driver and surrounding vehicles. The characteristics of the trip include trip length, time of day, setbacks at origin, unexpected delays, scheduled delivery, flexibility of schedule, and delivery location. Trip length is the total length in miles of the trip. Time of Day means the time at which the trip is taken while setbacks at origin indicate any setbacks that occur at the start of the trip. Unexpected delays include any unexpected delays that may occur throughout the trip. Scheduled delivery is a scheduled delivery time that must be met. Flexibility of schedule is the ability of the scheduled delivery time to be changed, and delivery location means the destination of the trip.

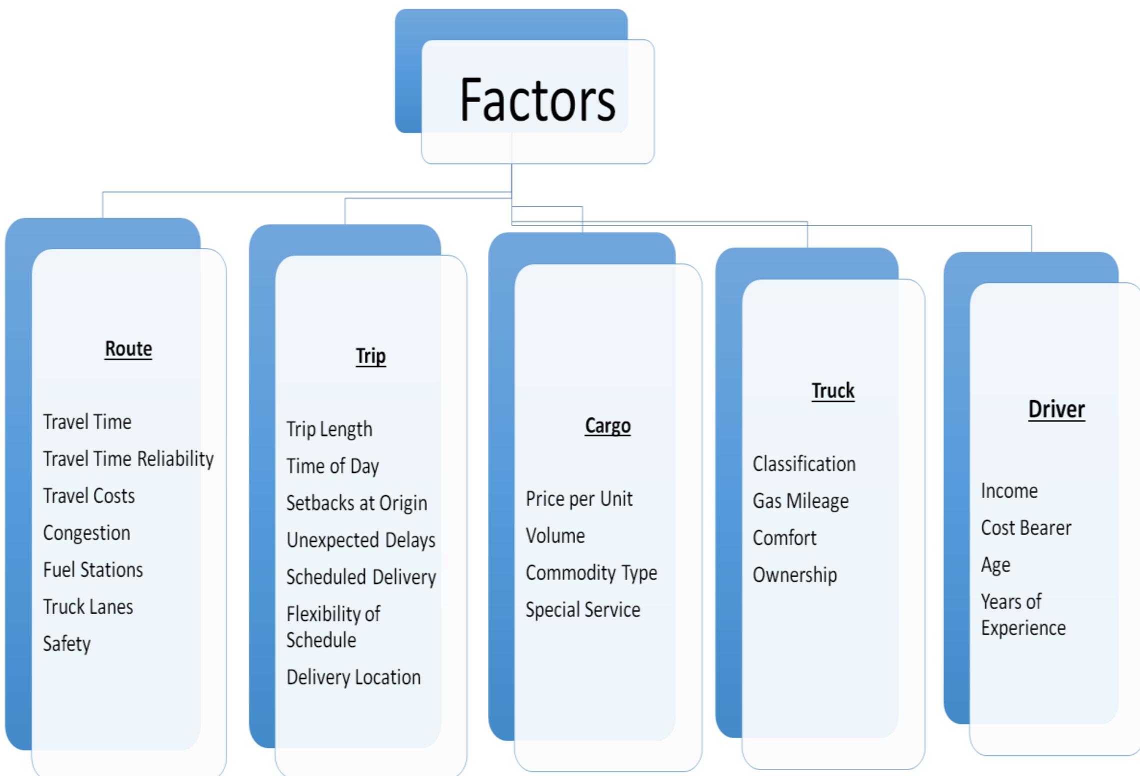


Figure 4: Criteria and alternatives used for Fuzzy AHP survey

The characteristics of the cargo include price per unit, volume, commodity type, and special service. Price per unit is the retail price of the cargo per unit of cargo while volume is the total amount of cargo in the truck. Commodity type indicates the type of commodity being transported while special service is the case if it is special cargo (i.e. temperature controlled, hazmat, wide, etc.). The characteristics of the truck include classification based on the FHWA classification of the truck by the number of axles. Gas mileage is calculated as the amount of gas used per mile while comfort means the overall level of comfort of the truck. Ownership decides whether or not the driver owns the truck. The characteristics of the driver include income that is the average level of income of the driver. Cost bearer means whether the driver or a company bears the costs (i.e. takes the risk). Age is simply the age of the driver while experience is the total number of years of experience of the truck driver.

4.2.3 Fuzzy Pair-Wise Comparison Matrix

Table 8 shows the fuzzy pair-wise comparison matrix for the first response of the criteria that was collected by those conducting the AHP survey.

Table 8: Fuzzy Pair-Wise Comparison Matrix for Criteria

	C1	C2	C3	C4	C5
C1	(1, 1, 1)	(1, 1, 1)	(2/3, 1, 3/2)	(3/2, 2, 5/2)	(3/2, 2, 5/2)
C2	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(3/2, 2, 5/2)	(3/2, 2, 5/2)
C3	(2/3, 1, 3/2)	(1, 1, 1)	(1, 1, 1)	(3/2, 2, 5/2)	(3/2, 2, 5/2)
C4	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(1, 1, 1)	(1, 1, 1)
C5	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(1, 1, 1)	(1, 1, 1)

4.3 Data Analysis and Findings

This section presents the findings obtained from the fuzzy AHP method, which includes the aggregated fuzzy pair-wise matrix, the computed fuzzy synthetic extent values, the approximated fuzzy priorities for criteria, and the approximated fuzzy priorities for alternatives.

4.3.1 Aggregated Fuzzy Pair-wise Matrix

Table 9 shows the aggregated fuzzy pair-wise matrix for all responses of the criteria that had acceptable CR values.

Table 9: Aggregated Fuzzy Pair-Wise Matrix for Criteria

	C1	C2	C3	C4	C5
C1	(1, 1, 1)	(1.18, 1.47, 1.82)	(1.08, 1.41,1.83)	(1.13, 1.47, 1.92)	(1.22, 1.58, 2.02)
C2	(0.55, 0.68, 0.84)	(1, 1, 1)	(0.78, 1.04, 1.39)	(0.70, 0.91, 1.19)	(0.68, 0.87, 1.13)
C3	(0.55, 0.71, 0.93)	(0.72, 0.96, 1.28)	(1, 1, 1)	(1.14, 1.43, 1.76)	(0.95, 1.16, 1.42)
C4	(0.52, 0.68, 0.89)	(0.84, 1.10, 1.43)	(0.57, 0.70, 0.88)	(1, 1, 1)	(0.88, 1.04, 1.24)
C5	(0.50, 0.63, 0.82)	(0.88, 1.15, 1.47)	(0.70, 0.86, 1.05)	(0.81, 0.96, 1.14)	(1, 1, 1)

4.3.2 Computed Fuzzy Synthetic Extent Values

Table 10 shows the Row and Column Sums of the aggregated fuzzy pair-wise matrix for the criteria, which were used to calculate the fuzzy synthetic extents. Table 12 shows the fuzzy synthetic extents for each criterion.

Table 10: Horizontal and Vertical Sums of Criteria

Criteria	Row Sums	Column Sums	Fuzzy Synthetic Extent Value (S_i)
C1	(5.61, 6.94, 8.58)	(3.11, 3.70, 4.48)	(0.1785, 0.2687, 0.4016)
C2	(3.71, 4.50, 5.56)	(4.63, 5.68, 7.00)	(0.1181, 0.1742, 0.2600)
C3	(4.36, 5.26, 6.38)	(4.14, 5.01, 6.15)	(0.1386, 0.2037, 0.2987)

C4	(3.80, 4.52, 5.43)	(4.77, 5.77, 7.01)	(0.1210, 0.1751, 0.2542)
C5	(3.89, 4.60, 5.49)	(4.73, 5.65, 6.81)	(0.1236, 0.1783, 0.2567)
Sum of row or column sums		(21.37, 25.82, 31.45)	

4.3.3 Approximated Fuzzy Priorities for Criteria

Table 11 shows the relative and normalized weights for the criteria.

Table 11: Weights of Each Criterion

Criteria	Relative Weights ($w'(S_i)$)	Normalized Weights ($w(S_i)$)
C1	1	0.3308
C2	0.4630	0.1531
C3	0.6492	0.2147
C4	0.4475	0.1480
C5	0.4637	0.1534

4.3.4 Approximated Fuzzy Priorities for Alternatives

Using the same analysis process that is used to find the weights of the criteria, we found the weights of each alternative. Table 12 tabulates the relative weights of the alternatives within each criterion. Table 12 also show the normalized weights of all the alternatives for all the criteria, which were calculated by multiplying the normalized weight of each alternative by the normalized weight of its corresponding criteria.

Table 12: Relative and Normalized Weights of All Alternatives

Alternatives	Relative Weights ($w'(S_i)$)	Normalized Weights ($w(S_i)$)	Alternatives	Relative Weights ($w'(S_i)$)	Normalized Weights ($w(S_i)$)
A1	1	0.1005	A14	0.6361	0.0212
A2	0.3806	0.0383	A15	1	0.1292
A3	0.2639	0.0265	A16	0.2805	0.0362
A4	0.2196	0.0221	A17	0.3589	0.0464
A5	0.2524	0.0254	A18	0.0222	0.0029
A6	0.5931	0.0596	A19	0.5348	0.0260
A7	0.5800	0.0583	A20	0.9855	0.0479
A8	0.9231	0.0307	A21	1	0.0486
A9	0.3066	0.0102	A22	0.5252	0.0255
A10	0.2558	0.0085	A23	0.2077	0.0203
A11	1	0.0333	A24	0.3634	0.0355
A12	0.9240	0.0307	A25	0	0
A13	0.5584	0.0186	A26	1	0.0976

4.4 Discussions and Summary

The process of deciding what route is the best option is a multi-criteria decision making process that all owner-operator truck drivers face. The process is a complex one that comprises many factors, which again consist of many alternatives within many criteria. Based on Fuzzy AHP analysis, it has been found that the criteria that plays the largest role in this decision making process is the route characteristics, and the alternative that plays the largest role amongst the other alternatives related to the route characteristics is travel time characteristic. This outcome was not surprising due to the fact that the variable of travel time was the variable that was most often considered in the related studies, as can be seen in Table 1. It was also not surprising that travel time reliability was the second most important amongst the alternatives relating to the route characteristics, as this was the variable that occurred the most right behind travel time. What was surprising was that the alternatives of the price per unit of the cargo and the level of experience of the driver were the characteristics that revealed so high in relation to all other alternatives, as both of these variables were not ones that were considered in the related studies. One explanation for this finding is that none of the related studies were conducted in Southern California highway systems specifically. Another explanation is that the truck drivers believe that these variables are important. Their opinions might suggest further data collection to be a better accurate representation of the population. This paper presented findings that for the most part were to be expected based on previous studies that were conducted in this same field and on consultation with real life truck drivers. The findings presented in this document can be used as a stepping stone to help project owners and/or managers make decisions concerning the practicality and economic feasibility of their projects. The VOT and VOR that will be obtained using these findings will be crucial in weighing the costs and benefits of these decisions.

5.0 Proposed Methodology for Generating a Representative Sample of Respondents

Route choice attributes are considered using cost measure, reliability measure, travel time measure, safety measure, weather measure, time of day measure, scheduled delivery time measure, truck cargo price measure, truck gas mileage measure, and truck comfort measure. The project team designed and provided a number of scenarios with each respondent for their route choices. Multiple responses from each respondent can be accommodated using discrete-choice model such as panel logit or mixed logit with appropriately correlated errors. The survey design aims to generate sufficient variation in attributes to obtain statistically significant parameter estimates. The ultimate goal of this survey is to evaluate the value of time and the value of reliability using field study techniques and survey data collected from truck operators. The study area for the survey is selected from Southern California freeway. The starting point of truck operators is from the ports of LA and LB and the end point is the designated distribution centers which are located within the closest distance. The scenarios for the full design include the followings:

- Los Angeles Port to Pasadena on I 110
- Long Beach Port to Compton on I 710
- Long Beach Port to Van Nuys on I 1405
- Long Beach Port to Van Nuys on I 1405 with different reliability and toll
- Los Angeles Port to San Diego on I 5
- Los Angeles Port to San Diego on I 5 with different reliability and toll
- Los Angeles Port to Pasadena on I 110 with safety measure
- Long Beach Port to Compton on I 710 with safety and weather measure
- Long Beach Port to Van Nuys on I 405 with safety and time measure
- Long Beach Port to Alhambra on I 710 with delivery time measure
- Los Angeles Port to Gardena on I 110 with truck cargo price measure
- Los Angeles Port to Dana Point on I 5 with truck cargo price measure
- Long Beach Port to Carson on I 710 with truck gas mileage measure

- Long Beach Port to Lake Forest on I 405 with truck gas mileage measure
- Los Angeles Port to Carson on I 110 with truck comfort level measure
- Santa Clarita to San Clemente on I 5 with truck comfort level measure

Once the field survey is completed and data are collected, the value of time and the value of reliability can be obtained using the logit models. Compared with other factors such as price, travel time, and reliability, the project team can examine whether the most significant factor for truck operators choosing a route is reliability of on-time arrival and whether the value of time is a higher priority in choosing a toll road over a freeway. As a result of this project, the project team expects to identify bottleneck locations on transport facilities by virtue of high travel times and/or delay, to measure arterial level of service using the average travel speeds and times, and to provide travel time data for economic evaluation of transportation improvements.

6.0 Pilot Test of the Survey Instrument

The pilot test is the only task that needs to be completed before the survey instrument can be administered and used in full scale in the future. The purpose of the pilot test is to obtain feedback from truck drivers and for those conducting the survey to have an understanding of how the process works and to identify anything that should be taken into consideration for anyone else who may be conducting the survey in the future. The feedback received from the truck drivers will be used to make any changes to the survey instrument that feel necessary to the designers of the survey.

7.0 Concluding Remarks

Based on survey results, it has been found that the criteria that plays the largest role in this decision making process is the route characteristics, and the alternative that plays the largest role amongst the other alternatives related to the route characteristics is travel time characteristic. This outcome was not surprising due to the fact that the variable of travel time was the variable that was most often considered in the related studies. It was also not surprising that travel time reliability was the second most important amongst the alternatives relating to the route characteristics, as this was the variable that occurred the most right behind travel time. What was surprising was that the alternatives of the price per unit of the cargo and the level of experience of the driver were the characteristics that revealed so high in relation to all other alternatives, as both of these variables were not ones that were considered in the related studies. These findings will be a foundation for conducting a large-scale research project by providing insight into truck travel patterns. Also, the findings will be of great interest to state transportation agencies because they will be very applicable to estimating the utility of a new road for trucks.

Not on toll lanes, heavy traffic

Origin	Port of LA on I 110
Destination	Pasadena
Trip Distance	30 miles
Toll Charges	None
Travel Time	60 mins
Average Speed	30 mph

On toll lanes, little/no traffic

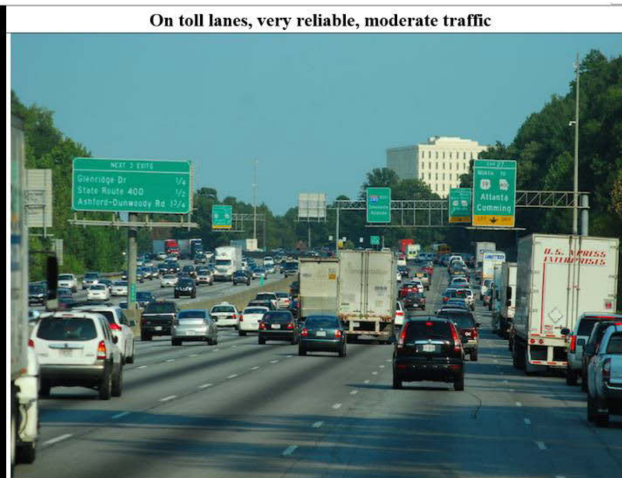
Origin	Port of LA on I 110					
Destination	Pasadena					
Trip Distance	30 miles					
Toll Charges	$15					
Travel Time	30 mins					
Average Speed	60 mph					
Do you prefer this toll charge?	Yes			No		
How much would you be willing to pay on a weekday (Monday-Thursday)?	$5	$10	$15	$20	$25	$30
How much would you be willing to pay on a weekend (Friday-Sunday)?	$5	$10	$15	$20	$25	$30

Figure 5: Los Angeles Port to Pasadena on I 110

Not on toll lanes, low reliability, either little/no traffic or heavy traffic

Origin	Port of Long Beach on I 710
Destination	Compton
Trip Distance	15 miles
Toll Charges	None
Average Speed	15 mph – 60 mph
Reliability	50% chance of a 15 min total travel time 50% chance of a 60 min total travel time

On toll lanes, very reliable, moderate traffic



Origin	Port of Long Beach on I 710					
Destination	Compton					
Trip Distance	15 miles					
Toll Charges	$10					
Average Speed	30 mph					
Reliability	100% chance of 30 min total travel time					
Do you prefer this toll charge?	Yes			No		
How much would you be willing to pay on a weekday (Monday-Thursday)?	$2	$5	$8	$10	$15	$20
How much would you be willing to pay on a weekend (Friday-Sunday)?	$2	$5	$8	$10	$15	$20

Figure 6: Long Beach Port to Compton on I 710

Not on toll lanes, heavy traffic

Origin	Long Beach on I 405
Destination	Van Nuys
Trip Distance	45 miles
Toll Charges	None
Travel Time	180 mins
Average Speed	15 mph

On toll lanes, little/no traffic

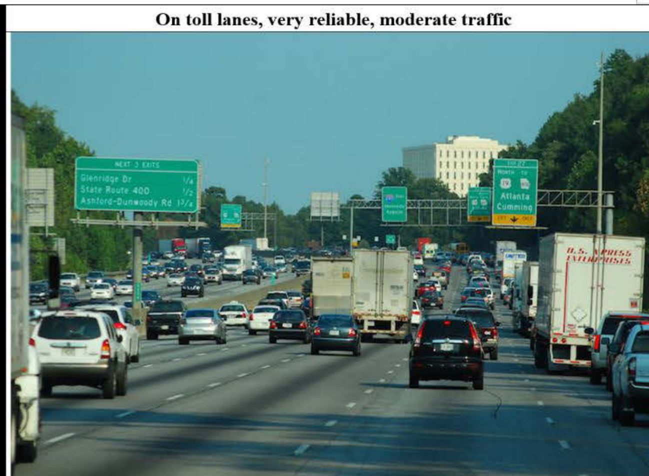
Origin	Long Beach on I 405					
Destination	Van Nuys					
Trip Distance	45 miles					
Toll Charges	$30					
Travel Time	45 mins					
Average Speed	60 mph					
Do you prefer this toll charge?	Yes			No		
How much would you be willing to pay on a weekday (Monday-Thursday)?	$10	$20	$30	$40	$50	$60
How much would you be willing to pay on a weekend (Friday-Sunday)?	$10	$20	$30	$40	$50	$60

Figure 7: Long Beach Port to Van Nuys on I 1405

Not on toll lanes, low reliability, either little/no traffic or heavy traffic

Origin	Long Beach on I 405
Destination	Van Nuys
Trip Distance	45 miles
Toll Charges	None
Average Speed	15 mph – 60 mph
Reliability	50% chance of a 45 min total travel time
	50% chance of a 180 min total travel time

On toll lanes, very reliable, moderate traffic



Origin	Long Beach on I 405					
Destination	Van Nuys					
Trip Distance	45 miles					
Toll Charges	$15					
Average Speed	30 mph					
Reliability	100% chance of 90 min total travel time					
Do you prefer this toll charge?	Yes			No		
How much would you be willing to pay on a weekday (Monday-Thursday)?	$5	$10	$15	$20	$30	$40
How much would you be willing to pay on a weekend (Friday-Sunday)?	$5	$10	$15	$20	$30	$40

Figure 8: Long Beach Port to Van Nuys on I 1405 with different reliability and toll

Not on toll lanes, heavy traffic

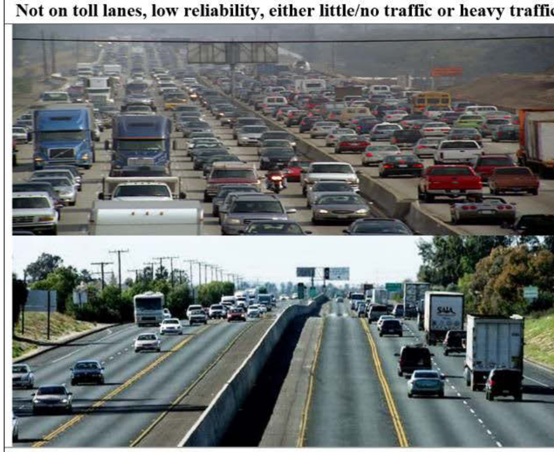
Origin	Los Angeles on I 5
Destination	San Diego
Trip Distance	120 miles
Toll Charges	None
Travel Time	360 mins
Average Speed	20 mph

On toll lanes, little/no traffic

Origin	Los Angeles on I 5					
Destination	San Diego					
Trip Distance	120 miles					
Toll Charges	$60					
Travel Time	120 mins					
Average Speed	60 mph					
Do you prefer this toll charge?	Yes			No		
How much would you be willing to pay on a weekday (Monday-Thursday)?	$15	$30	$45	$60	$90	$120
How much would you be willing to pay on a weekend (Friday-Sunday)?	$15	$30	$45	$60	$90	$120

Figure 9: Los Angeles Port to San Diego on I 5

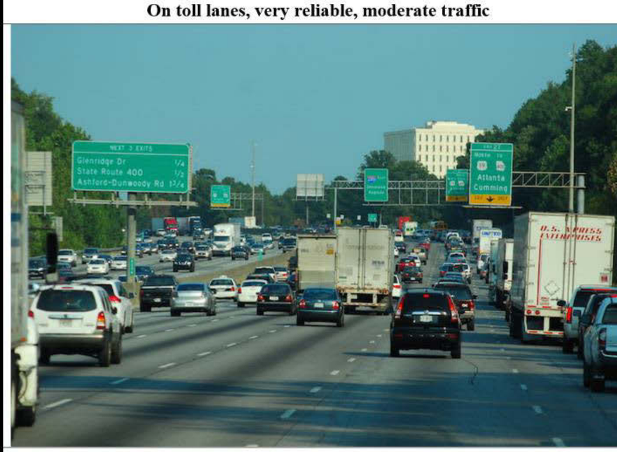
Not on toll lanes, low reliability, either little/no traffic or heavy traffic



Not on toll lanes, low reliability, either little/no traffic or heavy traffic

Origin	Los Angeles on I 5
Destination	San Diego
Trip Distance	120 miles
Toll Charges	None
Average Speed	20 mph – 60 mph
Reliability	50% chance of a 120 min total travel time
	50% chance of a 360 min total travel time

On toll lanes, very reliable, moderate traffic



On toll lanes, very reliable, moderate traffic

Origin	Los Angeles on I 5					
Destination	San Diego					
Trip Distance	120 miles					
Toll Charges	$30					
Average Speed	30 mph					
Reliability	100% chance of 240 min total travel time					
Do you prefer this toll charge?	Yes			No		
How much would you be willing to pay on a weekday (Monday-Thursday)?	$10	$20	$30	$40	$50	$60
How much would you be willing to pay on a weekend (Friday-Sunday)?	$10	$20	$30	$40	$50	$60

Figure 10: Los Angeles Port to San Diego on I 5 with different reliability and toll

Key Factor to be Considered: Safety

Not on toll lanes, little/no traffic, many passenger cars

Origin	Port of LA on I 110
Destination	Pasadena
Safety	Relatively Low
Trip Distance	30 miles
Toll Charges	None
Travel Time	30 mins
Average Speed	60 mph

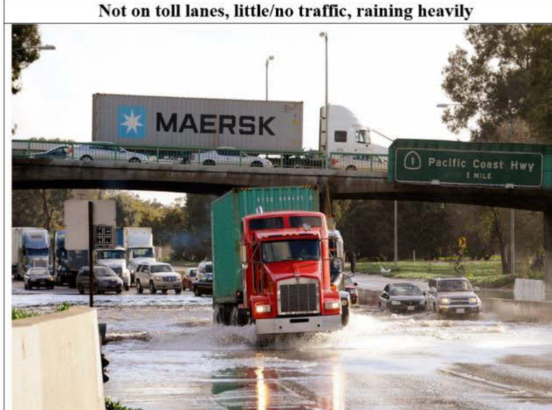
On toll lanes with toll, little/no traffic, no passenger cars

Origin	Port of LA on I 110					
Destination	Pasadena					
Safety	Relatively High					
Trip Distance	30 miles					
Toll Charges	$5					
Travel Time	30 mins					
Average Speed	60 mph					
Do you prefer this toll charge?	Yes			No		
How much would you be willing to pay on a weekday (Monday-Thursday)?	$0	$2	$4	$6	$8	$10
How much would you be willing to pay on a weekend (Friday-Sunday)?	$0	$2	$4	$6	$8	$10

Figure 11: Los Angeles Port to Pasadena on I 110 with safety measure

Key Factors to be Considered: Safety and Weather

Not on toll lanes, little/no traffic, raining heavily



Origin	Port of Long Beach on I 710
Destination	Compton
Weather	Heavy Rain
Safety	Relatively Low
Trip Distance	15 miles
Toll Charges	None
Travel Time	20 mins
Average Speed	45 mph

On toll lanes with toll, little/no traffic, not raining

Origin	Port of Long Beach on I 710					
Destination	Compton					
Weather	No Rain					
Safety	Relatively High					
Trip Distance	15 miles					
Toll Charges	$5					
Travel Time	20 mins					
Average Speed	45 mph					
Do you prefer this toll charge?	Yes			No		
How much would you be willing to pay on a weekday (Monday-Thursday)?	$0	$2	$4	$6	$8	$10
How much would you be willing to pay on a weekend (Friday-Sunday)?	$0	$2	$4	$6	$8	$10

Figure 12: Long Beach Port to Compton on I 710 with safety and weather measure

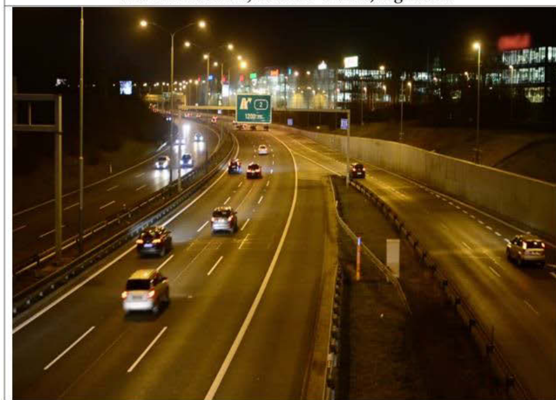
Key Factors to be Considered: Safety and Time of Day								
Not on toll lanes, little/no traffic, nighttime		On toll lanes with toll, little/no traffic, daytime						
								
Origin	Long Beach on I 405	Origin	Long Beach on I 405					
Destination	Van Nuys	Destination	Van Nuys					
Time of Day	Night	Time of Day	Day					
Safety	Relatively Low	Safety	Relatively High					
Trip Distance	45 miles	Trip Distance	45 miles					
Toll Charges	None	Toll Charges	$5					
Travel Time	60 mins	Travel Time	60 mins					
Average Speed	45 mph	Average Speed	45 mph					
		Do you prefer this toll charge?	Yes			No		
		How much would you be willing to pay on a weekday (Monday-Thursday)?	$0	$2	$4	$6	$8	$10
		How much would you be willing to pay on a weekend (Friday-Sunday)?	$0	$2	$4	$6	$8	$10

Figure 13: Long Beach Port to Van Nuys on I 405 with safety and time measure

Key Factor to be Considered: A Scheduled Delivery Time								
Not on toll lanes, heavy traffic, there is a scheduled delivery that must be met		On toll lanes, little/no traffic, there is a scheduled delivery that must be met						
Origin	Port of Long Beach on I 710	Origin	Port of Long Beach on I 710					
Destination	Alhambra	Destination	Alhambra					
Trip Distance	30 miles	Trip Distance	30 miles					
Toll Charges	None	Toll Charges	$30					
Travel Time	120 mins	Travel Time	30 mins					
Average Speed	15 mph	Average Speed	60 mph					
Scheduled Delivery	60 mins after departure	Scheduled Delivery	60 mins after departure					
		Do you prefer this toll charge?	Yes			No		
		How much would you be willing to pay on a weekday (Monday-Thursday)?	$10	$20	$30	$40	$50	$60
		How much would you be willing to pay on a weekend (Friday-Sunday)?	$10	$20	$30	$40	$50	$60

Key Factor to be Considered: A Scheduled Delivery Time								
Not on toll lanes, low reliability, either little/no traffic or heavy traffic, there is a scheduled delivery that must be met		On toll lanes, very reliable, moderate traffic, there is a scheduled delivery that must be met						
Origin	Port of Long Beach on I 710	Origin	Port of Long Beach on I 710					
Destination	Alhambra	Destination	Alhambra					
Trip Distance	30 miles	Trip Distance	30 miles					
Toll Charges	None	Toll Charges	$25					
Average Speed	15 mph – 60 mph	Average Speed	30 mph					
Reliability	50% chance of a 30 min total travel time	Reliability	100% chance of 60 min total travel time					
	50% chance of a 120 min total travel time							
Scheduled Delivery	60 mins after departure	Scheduled Delivery	60 mins after departure					
		Do you prefer this toll charge?	Yes			No		
		How much would you be willing to pay on a weekday (Monday-Thursday)?	$10	$20	$30	$40	$50	$60
		How much would you be willing to pay on a weekend (Friday-Sunday)?	$10	$20	$30	$40	$50	$60

Figure 14: Long Beach Port to Alhambra on I 710 with delivery time measure

Key Factor to be Considered: The Price of the Cargo in the Truck								
Not on toll lanes, heavy traffic, cargo being transported has a relatively low price		**On toll lanes, little/no traffic, cargo being transported has a relatively low price**						
Origin	Port of LA on I 110	Origin	Port of LA on I 110					
Destination	Gardena	Destination	Gardena					
Trip Distance	15 miles	Trip Distance	15 miles					
Toll Charges	None	Toll Charges	$15					
Travel Time	60 mins	Travel Time	15 mins					
Average Speed	15 mph	Average Speed	60 mph					
Cargo in Truck	Low Price	Cargo in Truck	Low Price					
		Do you prefer this toll charge?	Yes			No		
		How much would you be willing to pay on a weekday (Monday-Thursday)?	$2	$5	$8	$10	$15	$20
		How much would you be willing to pay on a weekend (Friday-Sunday)?	$2	$5	$8	$10	$15	$20

Key Factor to be Considered: The Price of the Cargo in the Truck								
Not on toll lanes, low reliability, either little/no traffic or heavy traffic, cargo being transported has a relatively low price		**On toll lanes, very reliable, moderate traffic, cargo being transported has a relatively low price**						
Origin	Port of LA on I 110	Origin	Port of LA on I 110					
Destination	Gardena	Destination	Gardena					
Trip Distance	15 miles	Trip Distance	15 miles					
Toll Charges	None	Toll Charges	$10					
Average Speed	15 mph – 60 mph	Average Speed	30 mph					
Reliability	50% chance of a 15 min total travel time 50% chance of a 60 min total travel time	Reliability	100% chance of 30 min total travel time					
Cargo in Truck	Low Price	Cargo in Truck	Low Price					
		Do you prefer this toll charge?	Yes			No		
		How much would you be willing to pay on a weekday (Monday-Thursday)?	$2	$5	$8	$10	$15	$20
		How much would you be willing to pay on a weekend (Friday-Sunday)?	$2	$5	$8	$10	$15	$20

Figure 15: Los Angeles Port to Gardena on I 110 with truck cargo price measure

Key Factor to be Considered: The Price of the Cargo in the Truck								
Not on toll lanes, heavy traffic, cargo being transported has a relatively high price		**On toll lanes, little/no traffic, cargo being transported has a relatively high price**						
Origin	Los Angeles on I5	Origin	Los Angeles on I5					
Destination	Dana Point	Destination	Dana Point					
Trip Distance	60 miles	Trip Distance	60 miles					
Toll Charges	None	Toll Charges	$60					
Travel Time	180 mins	Travel Time	60 mins					
Average Speed	20 mph	Average Speed	60 mph					
Cargo in Truck	High Price	Cargo in Truck	High Price					
		Do you prefer this toll charge?	Yes			No		
		How much would you be willing to pay on a weekday (Monday-Thursday)?	$15	$30	$45	$60	$90	$120
		How much would you be willing to pay on a weekend (Friday-Sunday)?	$15	$30	$45	$60	$90	$120

Key Factor to be Considered: The Price of the Cargo in the Truck								
Not on toll lanes, low reliability, either little/no traffic or heavy traffic, cargo being transported has a relatively high price		**On toll lanes, very reliable, moderate traffic, cargo being transported has a relatively high price**						
Origin	Los Angeles on I5	Origin	Los Angeles on I5					
Destination	Dana Point	Destination	Dana Point					
Trip Distance	60 miles	Trip Distance	60 miles					
Toll Charges	None	Toll Charges	$40					
Average Speed	20 mph – 60 mph	Average Speed	30 mph					
Reliability	50% chance of a 60 min total travel time 50% chance of a 180 min total travel time	Reliability	100% chance of 120 min total travel time					
Cargo in Truck	High Price	Cargo in Truck	High Price					
		Do you prefer this toll charge?	Yes			No		
		How much would you be willing to pay on a weekday (Monday-Thursday)?	$10	$20	$30	$40	$50	$60
		How much would you be willing to pay on a weekend (Friday-Sunday)?	$10	$20	$30	$40	$50	$60

Figure 16: Los Angeles Port to Dana Point on I 5 with truck cargo price measure

Key Factor to be Considered: The Gas Mileage of the Truck								
Not on toll lanes, heavy traffic, the truck has relatively good gas mileage		**On toll lanes, little/no traffic, the truck has relatively good gas mileage**						
Origin	Port of Long Beach on I 710	Origin	Port of Long Beach on I 710					
Destination	Carson	Destination	Carson					
Trip Distance	10 miles	Trip Distance	10 miles					
Toll Charges	None	Toll Charges	$10					
Travel Time	30 mins	Travel Time	10 mins					
Average Speed	20 mph	Average Speed	60 mph					
Truck's Gas Mileage	Good	Truck's Gas Mileage	Good					
		Do you prefer this toll charge?	Yes			No		
		How much would you be willing to pay on a weekday (Monday-Thursday)?	$2	$5	$8	$10	$15	$20
		How much would you be willing to pay on a weekend (Friday-Sunday)?	$2	$5	$8	$10	$15	$20

Key Factor to be Considered: The Gas Mileage of the Truck								
Not on toll lanes, low reliability, either little/no traffic or heavy traffic, the truck has relatively good gas mileage		**On toll lanes, very reliable, moderate traffic, the truck has relatively good gas mileage**						
Origin	Port of Long Beach on I 710	Origin	Port of Long Beach on I 710					
Destination	Carson	Destination	Carson					
Trip Distance	10 miles	Trip Distance	10 miles					
Toll Charges	None	Toll Charges	$5					
Average Speed	20 mph – 60 mph	Average Speed	30 mph					
Reliability	50% chance of a 10 min total travel time 50% chance of a 30 min total travel time	Reliability	100% chance of 20 min total travel time					
Truck's Gas Mileage	Good	Truck's Gas Mileage	Good					
		Do you prefer this toll charge?	Yes			No		
		How much would you be willing to pay on a weekday (Monday-Thursday)?	$2	$5	$8	$10	$15	$20
		How much would you be willing to pay on a weekend (Friday-Sunday)?	$2	$5	$8	$10	$15	$20

Figure 17: Long Beach Port to Carson on I 710 with truck gas mileage measure

Key Factor to be Considered: The Gas Mileage of the Truck								
No toll lanes, heavy traffic, the truck has relatively bad gas mileage		**On toll lanes, little/no traffic, the truck has relatively bad gas mileage**						
Origin	Long Beach on I 405	Origin	Long Beach on I 405					
Destination	Lake Forest	Destination	Lake Forest					
Trip Distance	30 miles	Trip Distance	30 miles					
Toll Charges	None	Toll Charges	$40					
Travel Time	120 mins	Travel Time	30 mins					
Average Speed	15 mph	Average Speed	60 mph					
Truck's Gas Mileage	Bad	Truck's Gas Mileage	Bad					
		Do you prefer this toll charge?	Yes			No		
		How much would you be willing to pay on a weekday (Monday-Thursday)?	$10	$20	$30	$40	$50	$60
		How much would you be willing to pay on a weekend (Friday-Sunday)?	$10	$20	$30	$40	$50	$60

Key Factor to be Considered: The Gas Mileage of the Truck								
Not on toll lanes, low reliability, either little/no traffic or heavy traffic, the truck has relatively bad gas mileage		**On toll lanes, very reliable, moderate traffic, the truck has relatively bad gas mileage**						
Origin	Long Beach on I 405	Origin	Long Beach on I 405					
Destination	Lake Forest	Destination	Lake Forest					
Trip Distance	30 miles	Trip Distance	30 miles					
Toll Charges	None	Toll Charges	$30					
Average Speed	15 mph – 60 mph	Average Speed	30 mph					
Reliability	50% chance of a 30 min total travel time 50% chance of a 120 min total travel time	Reliability	100% chance of 60 min total travel time					
Truck's Gas Mileage	Bad	Truck's Gas Mileage	Bad					
		Do you prefer this toll charge?	Yes			No		
		How much would you be willing to pay on a weekday (Monday-Thursday)?	$10	$20	$30	$40	$50	$60
		How much would you be willing to pay on a weekend (Friday-Sunday)?	$10	$20	$30	$40	$50	$60

Figure 18: Long Beach Port to Lake Forest on I 405 with truck gas mileage measure

Key Factor to be Considered: The Comfort Level of the Truck								
Not on toll lanes, heavy traffic, the truck is very comfortable		**On toll lanes, little/no traffic, the truck is very comfortable**						
Origin	Port of LA on I 110	Origin	Port of LA on I 110					
Destination	Carson	Destination	Carson					
Trip Distance	10 miles	Trip Distance	10 miles					
Toll Charges	None	Toll Charges	$20					
Travel Time	60 mins	Travel Time	10 mins					
Average Speed	10 mph	Average Speed	60 mph					
Truck's Comfort Level	Good	Truck's Comfort Level	Good					
		Do you prefer this toll charge?	Yes			No		
		How much would you be willing to pay on a weekday (Monday-Thursday)?	$5	$10	$15	$20	$30	$40
		How much would you be willing to pay on a weekend (Friday-Sunday)?	$5	$10	$15	$20	$30	$40

Key Factor to be Considered: The Comfort Level of the Truck								
Not on toll lanes, low reliability, either little/no traffic or heavy traffic, the truck is very comfortable		**On toll lanes, very reliable, moderate traffic, the truck is very comfortable**						
Origin	Port of LA on I 110	Origin	Port of LA on I 110					
Destination	Carson	Destination	Carson					
Trip Distance	10 miles	Trip Distance	10 miles					
Toll Charges	None	Toll Charges	$15					
Average Speed	10 mph – 60 mph	Average Speed	30 mph					
Reliability	50% chance of a 10 min total travel time	Reliability	100% chance of 20 min total travel time					
	50% chance of a 60 min total travel time							
Truck's Comfort Level	Good	Truck's Comfort Level	Good					
		Do you prefer this toll charge?	Yes			No		
		How much would you be willing to pay on a weekday (Monday-Thursday)?	$5	$10	$15	$20	$30	$40
		How much would you be willing to pay on a weekend (Friday-Sunday)?	$5	$10	$15	$20	$30	$40

Figure 19: Los Angeles Port to Carson on I 110 with truck comfort level measure

Key Factor to be Considered: The Comfort Level of the Truck								
No toll lanes, heavy traffic, the truck is not comfortable		**On toll lanes, little/no traffic, the truck is not comfortable**						
Origin	Santa Clarita on I 5	Origin	Santa Clarita on I 5					
Destination	San Clemente	Destination	San Clemente					
Trip Distance	90 miles	Trip Distance	90 miles					
Toll Charges	None	Toll Charges	$60					
Travel Time	270 mins	Travel Time	90 mins					
Average Speed	20 mph	Average Speed	60 mph					
Truck's Comfort Level	Bad	Truck's Comfort Level	Bad					
		Do you prefer this toll charge?	Yes			No		
		How much would you be willing to pay on a weekday (Monday-Thursday)?	$15	$30	$45	$60	$90	$120
		How much would you be willing to pay on a weekend (Friday-Sunday)?	$15	$30	$45	$60	$90	$120

Key Factor to be Considered: The Comfort Level of the Truck								
Not on toll lanes, low reliability, either little/no traffic or heavy traffic, the truck is not comfortable		**On toll lanes, very reliable, moderate traffic, the truck is not comfortable**						
Origin	Santa Clarita on I 5	Origin	Santa Clarita on I 5					
Destination	San Clemente	Destination	San Clemente					
Trip Distance	90 miles	Trip Distance	90 miles					
Toll Charges	None	Toll Charges	$45					
Average Speed	20 mph – 60 mph	Average Speed	30 mph					
Reliability	50% chance of a 90 min total travel time	Reliability	100% chance of 180 min total travel time					
	50% chance of a 270 min total travel time							
Truck's Comfort Level	Bad	Truck's Comfort Level	Bad					
		Do you prefer this toll charge?	Yes			No		
		How much would you be willing to pay on a weekday (Monday-Thursday)?	$15	$30	$45	$60	$90	$120
		How much would you be willing to pay on a weekend (Friday-Sunday)?	$15	$30	$45	$60	$90	$120

Figure 20: Santa Clarita to San Clemente on I 5 with truck comfort level measure

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Appendix I inside CSULB published on June 20, 2016

6/20/2016 Inside CSULB » Blog Archive » Understanding Route Choices That Truckers Make

CALIFORNIA STATE UNIVERSITY
LONG BEACH

inside CSULB

Understanding Route Choices That Truckers Make

Published: June 20, 2016

PHOTO COURTESY OF JOSEPH KIM
Much of the field research for Joseph Kim's study was conducted at gas and weigh stations, such as the one shown above.

By Richard Manly

CSULB civil engineering and construction management faculty member Joseph Kim is using a one-year $35,000 grant from USC-CALTRANS to better understand how area truck drivers choose their routes.

The primary goal of the research proposal, titled "Route Choice Characteristics of Owner-Operated Trucks in Southern California Freeways," will be to enhance private decision-making regarding the route choices of owner-operated truck drivers, explained Kim, a member of the university since 2009. "The focus is on how private truck drivers decide what route they will take through the local highway system.

"The secondary goal of this research project is to provide agencies and truck operators with useful information for benefit-cost analysis of public investment or tolling projects so that current road options can be considered such as high-occupancy toll roads," he added. "Therefore, the objective of this research initiation grant project is to develop a full research design."

The focus was on private truck owner/drivers.

"What factors did they consider most in choosing their routes?" asked Kim. "Was it saving time or liability? Was their main concern safety or arriving on time? Is their concern for the road system itself? What factor is the most important to a truck driver when they consider their routes?"

There are many influences on truck drivers besides speed. Most drivers are interested in saving

http://web.csulb.edu/misc/inside/2016/06/20/understanding-route-choices-that-truckers-make/

6/20/2016 Inside CSULB » Blog Archive » Understanding Route Choices That Truckers Make

money.

"If our research explains how they can save money, if there is a way they can deliver their goods on time and safely, that is the best idea," he said. "This is the stage where we hear their voices. Would they be willing to pay more money for that, even if it meant a toll fee? Would the drivers be willing to take a toll road?"

Based on the factors Kim analyzed from survey responses from area truck drivers, he designed a scenario that suggested how drivers choose their routes to the 710 freeway. "How much money would they be willing to pay for the development of a trucks-only road system or even a trucks-only lane?" Kim asked. "Eventually, I hope this report will help transportation planners or CALTRANS policy makers when they think about new road systems or even the allocation of a single lane for trucks. We are looking for a win-win situation where policy makers can develop new road systems so they can solve the traffic jam issue while, at the same time, make it possible for truckers to deliver their goods faster than before."

Kim feels his USC-CALTRANS research initiation grant will support a project he believes will fill a gap in the literature. "There has been little value of time-oriented research around the choice problem of truck routing," he said. "The findings of this study will form a foundation for conducting a large-scale research project by providing insight into truck travel patterns. The ultimate goal is to contribute the body of knowledge necessary for good benefit-cost analyses concerning toll roads."

Compared with other factors such as price, travel time and reliability, the project team will examine whether the most significant factor for truck operators choosing a route is reliability of on-time arrival and whether the value of time is a higher priority in choosing a toll road over a freeway. As a result of this project, the team will expect to identify bottleneck locations by virtue of high travel times and delay, to measure arterial level of service using the average travel speeds and times and to provide travel time data for economic evaluation of transportation improvements.

Students play a big role in Kim's research. "One of my students is a graduate who is writing his M.S. thesis based on our research," he said. "Another student assistant is an undergraduate who is studying civil engineering. Students like these are the backbone of this project. Without them, I could not move on."

Kim feels one of the strengths of his report is its emphasis on field research which was conducted at gas stations and weigh stations. "We would catch the truck driver while they took a break," Kim recalled. "We would interview some while others filled out survey forms. One of the difficulties was the lack of time. Now we contact the truck drivers over the phone."

He believes many will benefit from this research.

"For instance, look at the drivers," he said. "Perhaps what we do will help a CALTRANS planner design a better road system connecting the ports of Long Beach and Los Angeles to the I5. Maybe this report will help to resolve the traffic jam issue. Truck drivers will be able to deliver their goods faster than before."

It's an advantage to be in Long Beach to research trucking, Kim said. "Because our research time is based at CSULB, the area gas stations that serve both the L.A. and Long Beach port truckers are more readily available," he explained. "It's an advantage to work in the field. Most of the planning for tomorrow's roads happens from behind desks. We wanted to go out and meet the drivers. We wanted to listen to their voices. That is how we learned what they need right now."

G+1

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Appendix II AHP survey forms – English version

(1) Section I

Examine in contrast the main factors

(I) Route
(II) Trip
(III) Cargo
(IV) Truck
(V) Driver

Table 1

Assign a grade from 1 to 5 in 'Your score' column , where 5 is the most important and 1 is the least important

Factors	Major Supporting Considerations	Your Score (1-5)
Route	Characteristics of the route	
Trip	Characteristics of the trip	
Cargo	Type of cargo being transported	
Truck	Characteristics of the truck	
Driver	Characteristics of the truck driver	

Table 2

Circle/mark "X" only once for each row to the appropriate number by comparing Relative Importance between the two factors

Options	Extremely		Very Strongly		Strongly		Moderately		Equally		Moderately		Strongly		Very Strongly		Extremely	Options
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Route																		Trip
Route																		Cargo
Route																		Truck
Route																		Driver
Trip																		Cargo
Trip																		Truck
Trip																		Driver
Cargo																		Truck
Cargo																		Driver
Truck																		Driver

(2) Section II

Examine in contrast the factors which are grouped under Route

(I) Travel Time
(II) Travel Time Reliability
(III) Travel Costs
(IV) Congestion
(V) Fuel Stations
(VI) Truck/Toll Lanes
(VII) Safety

Table 1

Assign a grade from 1 to 7 in 'Your score' column , where 7 is the most important and 1 is the least important

Factors	Major Supporting Considerations	Your Score (1-7)
Travel Time	Total time of the trip	
Travel Time Reliability	The reliability of an always constant travel time	
Travel Costs	All costs incurred during the trip	
Congestion	The level of congestion on the route	
Fuel Stations	The amount and availability of fuel stations throughout the trip	
Truck/Toll Lanes	The amount and availability of distinct truck lanes or toll lanes	
Safety	The overall safety and security of the truck driver and surrounding vehicles	

Table 2

Circle/mark "X" only once for each to the appropriate number by comparing Relative Importance between the two factors

Options	Extremely		Very Strongly		Strongly		Moderately		Equally		Moderately		Strongly		Very Strongly		Extremely	Options
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Travel Time																		Travel Time Reliability
Travel Time																		Travel Costs
Travel Time																		Congestion
Travel Time																		Fuel Stations
Travel Time																		Truck/Toll Lanes
Travel Time																		Safety
Travel Time Reliability																		Travel Costs
Travel Time Reliability																		Congestion
Travel Time Reliability																		Fuel Stations
Travel Time Reliability																		Truck/Toll Lanes
Travel Time Reliability																		Safety
Travel Costs																		Congestion
Travel Costs																		Fuel Stations
Travel Costs																		Truck/Toll Lanes
Travel Costs																		Safety
Congestion																		Fuel Stations
Congestion																		Truck/Toll Lanes
Congestion																		Safety
Fuel Stations																		Truck/Toll Lanes
Fuel Stations																		Safety
Truck/Toll Lanes																		Safety

(3) Section III

Examine in contrast the factors which are grouped under Trip
(I) Trip Length
(II) Time of Day
(III) Setbacks at Origin
(IV) Unexpected Delays
(V) Scheduled Delivery
(VI) Flexibility of Schedule
(VII) Delivery Location

Table 1
Assign a grade from 1 to 7 in 'Your score' column , where 7 is the most important and 1 is the least important

Factors	Major Supporting Considerations	Your Score (1-7)
Trip Length	The total length of the trip	
Time of Day	The time at which the trip is taken	
Setbacks at Origin	Any setbacks at the start of the trip	
Unexpected Delays	Any unexpected delays that may occur	
Scheduled Delivery	A scheduled delivery time that must be met	
Flexibility of Schedule	Flexibility of the scheduled delivery time	
Delivery Location	The destination of the trip	

Table 2
Circle/mark "X" only once for each row to the appropriate number by comparing Relative Importance between the two factors

Options	Extremely		Very Strongly		Strongly		Moderately		Equally		Moderately		Strongly		Very Strongly		Extremely	Options
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Trip Length																		Time of Day
Trip Length																		Setbacks at Origin
Trip Length																		Unexpected Delays
Trip Length																		Scheduled Delivery
Trip Length																		Flexibility of Schedule
Trip Length																		Delivery Location
Time of Day																		Setbacks at Origin
Time of Day																		Unexpected Delays
Time of Day																		Scheduled Delivery
Time of Day																		Flexibility of Schedule
Time of Day																		Delivery Location
Setbacks at Origin																		Unexpected Delays
Setbacks at Origin																		Scheduled Delivery
Setbacks at Origin																		Flexibility of Schedule
Setbacks at Origin																		Delivery Location
Unexpected Delays																		Scheduled Delivery
Unexpected Delays																		Flexibility of Schedule
Unexpected Delays																		Delivery Location
Scheduled Delivery																		Flexibility of Schedule
Scheduled Delivery																		Delivery Location
Flexibility of Schedule																		Delivery Location

(4) Section IV

Examine in contrast the factors which are grouped under Cargo
(I) Price Per Unit
(II) Volume
(III) Commodity Type
(IV) Special Service

Table 1
Assign a grade from 1 to 4 in 'Your score' column , where 4 is the most important and 1 is the least important

Factors	Major Supporting Considerations	Your Score (1-4)
Price Per Unit	The price of the cargo per unit	
Volume	The total amount of cargo	
Commodity Type	The type of commodity being transported	
Special Service	Special cargo (temperature controlled, hazmat, wide, etc.)	

Table 2
Circle/mark "X" only once for each row to the appropriate number by comparing Relative Importance between the two factors

Options	Extremly		Very Strongly		Strongly		Moderately		Equally		Moderately		Strongly		Very Strongly		Extremly	Options
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Price Per Unit																		Volume
Price Per Unit																		Commodity Type
Price Per Unit																		Special Service
Volume																		Commodity Type
Volume																		Special Service
Commodity Type																		Special Service

(4) Section V

Examine in contrast the factors which are grouped under Truck
(I) Classification
(II) Gas Mileage
(III) Comfort
(IV) Ownership

Table 1
Assign a grade from 1 to 4 in 'Your score' column , where 4 means very important and 1 means least important

Factors	Major Supporting Considerations	Your Score (1-4)
Classification	The FHWA classification of the truck based on number of axles	
Gas Mileage	The amount of gas used per unit length	
Comfort	The level of comfort of the truck	
Ownership	Whether or not the driver owns the truck	

Table 2
Circle/mark "X" only once for each row to the appropriate number by comparing Relative Importance between the two factors

Options	Extremely		Very Strongly		Strongly		Moderately		Equally		Moderately		Strongly		Very Strongly		Extremely	Options
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Classification																		Gas Mileage
Classification																		Comfort
Classification																		Ownership
Gas Mileage																		Comfort
Gas Mileage																		Ownership
Comfort																		Ownership

(6) Section VI

Examine in contrast the factors which are grouped under Driver

(I) Income
(II) Cost Bearer
(III) Age
(IV) Years of Experience

Table 1

Assign a grade from 1 to 4 in 'Your score' column , where 4 is the most important and 1 is the least important

Factors	Major Supporting Considerations	Your Score (1-4)
Income	The level of income of the driver	
Cost Bearer	The bearer of the costs; i.e. the risk taker (driver or company)	
Age	The age of the driver	
Years of Experience	The total years of experience of the driver	

Table 2

Circle/mark "X" only once for each row to the appropriate number by comparing Relative Importance between the two factors

Options	Extremely		Very Strongly		Strongly		Moderately		Equally		Moderately		Strongly		Very Strongly		Extremely	Options
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Income																		Cost Bearer
Income																		Age
Income																		Years of Experience
Cost Bearer																		Age
Cost Bearer																		Years of Experience
Age																		Years of Experience

Appendix III AHP survey forms – Spanish version

(1) Section I

Examine a diferencia de los principales factores

(I) Ruta
(II) Viaje
(III) Carga
(IV) Camión
(V) Conductor

Tabla 1

Asignar calificación de 1 a 5 en la columna 'Tu puntuación ' , donde 5 es el más importante y 1 es el menos importante

Factores	Consideraciones importantes de Soporte	Tu puntuación (1-5)
Ruta	Características de la Ruta	
Viaje	Características del Viaje	
Carga	Tipo de Carga transportada	
Camión	Características del Camión	
Conductor	Características del Camión Conductor	

Tabla 2

Círculo / marca "X " sólo una vez en cada fila para el número apropiado mediante la comparación de importancia relativa entre dos de los factores

Opciones	Extremadamente		Muy fuerte		Fuertemente		Moderadamente		Igualmente		Moderadamente		Fuertemente		Muy fuerte		Extremadamente	Opciones
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Ruta																		Viaje
Ruta																		Carga
Ruta																		Camión
Ruta																		Conductor
Viaje																		Carga
Viaje																		Camión
Viaje																		Conductor
Carga																		Camión
Carga																		Conductor
Camión																		Conductor

(2) Section II

Examine en contraste los factores que se agrupan bajo la Ruta

(I) Tiempo de viaje
(II) Fiabilidad Duración del viaje
(III) El costo del viajes
(IV) Congestión
(V) Estaciones de combustible
(VI) Camión/Toll Lanes
(VII) La seguridad

Tabla 1

Asignar calificación de 1 a 7 en la columna " Su puntuación ' , donde 7 es el más importante y 1 es el menos importante

Factores	Consideraciones importantes de Soporte	Tu puntuación (1-7)
Tiempo de viaje	El tiempo total del viaje Viaje	
iabilidad Duración del via	La fiabilidad de un siempre constante Tiempo de Viaje	
El costo del viajes	Todos los gastos incurridos durante el viaje Viaje	
Congestión	El nivel de congestión en la Ruta	
Estaciones de combustibl	La cantidad y disponibilidad de Estaciones de combustible a lo largo del Viaje	
Camión/Toll Lanes	La cantidad y disponibilidad de los carriles camión distintas o carriles de peaje	
La seguridad	La seguridad global y la seguridad del conductor y de vehículos Camión circundantes	

Tabla 2

Círculo / marca "X " sólo una vez en cada uno para el número apropiado mediante la comparación de importancia relativa entre dos de los Factores

Opciones	Extremadamente		Muy fuerte		Fuertemente		Moderadamente		Igualmente		Moderadamente		Fuertemente		Muy fuerte		Extremadamente	Opciones
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Tiempo de viaje																		Fiabilidad Duración del viaje
Tiempo de viaje																		El costo del viajes
Tiempo de viaje																		Congestión
Tiempo de viaje																		Estaciones de combustible
Tiempo de viaje																		Camión/Toll Lanes
Tiempo de viaje																		La seguridad
Fiabilidad Duración del viaje																		El costo del viajes
Fiabilidad Duración del viaje																		Congestión
Fiabilidad Duración del viaje																		Estaciones de combustible
Fiabilidad Duración del viaje																		Camión/Toll Lanes
Fiabilidad Duración del viaje																		La seguridad
El costo del viajes																		Congestión
El costo del viajes																		Estaciones de combustible
El costo del viajes																		Camión/Toll Lanes
El costo del viajes																		La seguridad
Congestión																		Estaciones de combustible
Congestión																		Camión/Toll Lanes
Congestión																		La seguridad
Estaciones de combustible																		Camión/Toll Lanes
Estaciones de combustible																		La seguridad
Camión/Toll Lanes																		La seguridad

(3) Section III

Examine en contraste los factores que se agrupan bajo Viaje

(I) Viaje Length
(II) Hora del día
(III) Los reveses en origen
(IV) Los retrasos inesperados
(V) Entrega programada
(VI) La flexibilidad de la Lista
(VII) Lugar de entreg

Tabla 1

Asignar calificación de 1 a 7 en la columna " Su puntuación ' , donde 7 es el más importante y 1 es el menos importante

Factores	Consideraciones importantes de Soporte	Tu puntuación (1-7)
Viaje Length	La longitud total del Viaje	
Hora del día	El momento en que se toma el Viaje	
Los reveses en origen	Cualquier retraso en el inicio del Viaje	
Los retrasos inesperados	Cualquiera Los retrasos inesperados que pueden ocurrir	
Entrega programada	Una vez Programada Entrega que se deben cumplir	
La flexibilidad de la Lista	La flexibilidad del tiempo de Entrega Programada	
Lugar de entreg	El destino del viaje Viaje	

Tabla 2

Círculo / marca "X " sólo una vez en cada fila para el número apropiado mediante la comparación de importancia relativa entre dos de los factores

Opciones	Extremadamente		Muy fuerte		Fuertemente		Moderadamente		Igualmente		Moderadamente		Fuertemente		Muy fuerte		Extremadamente	Opciones
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Viaje Length																		Hora del día
Viaje Length																		Los reveses en origen
Viaje Length																		Los retrasos inesperados
Viaje Length																		Entrega programada
Viaje Length																		La flexibilidad de la Lista
Viaje Length																		Lugar de entreg
Hora del día																		Los reveses en origen
Hora del día																		Los retrasos inesperados
Hora del día																		Entrega programada
Hora del día																		La flexibilidad de la Lista
Hora del día																		Lugar de entreg
Los reveses en origen																		Los retrasos inesperados
Los reveses en origen																		Entrega programada
Los reveses en origen																		La flexibilidad de la Lista
Los reveses en origen																		Lugar de entreg
Los retrasos inesperados																		Entrega programada
Los retrasos inesperados																		La flexibilidad de la Lista
Los retrasos inesperados																		Lugar de entreg
Entrega programada																		La flexibilidad de la Lista
Entrega programada																		Lugar de entreg
La flexibilidad de la Lista																		Lugar de entreg

(4) Section IV

Examine en contraste los factors que se agrupan bajo Carga

(I) Precio por unidad
(II) Volumen
(III) Tipo de la materia
(IV) Servicio especial

Tabla 1

Asignar calificación de 1 a 4 en la columna 'Tu puntuación ' , donde 4 es el más importante y 1 es el menos importante

Factores	Consideraciones importantes de Soporte	Tu puntuación (1-4)
Precio por unidad	El precio de la Carga por unidad	
Volumen	La cantidad total de Carga	
Tipo de la materia	El tipo de mercancía transportada	
Servicio especial	Carga Especial (temperatura controlada, de materiales peligrosos, ancho, etc.)	

Tabla 2

Círculo / marca "X " sólo una vez en cada fila para el número apropiado mediante la comparación de importancia relativa entre dos de los factores

Opciones	Extremadamente		Muy fuerte		Fuertemente		Moderadamente		Igualmente		Moderadamente		Fuertemente		Muy fuerte		Extremadamente	Opciones
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Precio por unidad																		Volumen
Precio por unidad																		Tipo de la materia
Precio por unidad																		Servicio especial
Volumen																		Tipo de la materia
Volumen																		Servicio especial
Tipo de la materia																		Servicio especial

(5) Section V

Examine en contraste los factors que se agrupan bajo Camión

(I) Clasificación
(II) Kilometraje
(III) Comodidad
(IV) Propiedad

Tabla 1

Asignar calificación de 1 a 4 en la columna 'Tu puntuación ' , donde 4 significa muy importante y 1 significa menos importante

Factores	Consideraciones importantes de Soporte	Tu puntuación (1-4)
Clasificación	La FHWA Clasificación del Camión basada en el número de ejes	
Kilometraje	La cantidad de gas usado por unidad de longitud	
Comodidad	El nivel de la comodidad del Camión	
Propiedad	Independientemente de que el conductor posee el Camión	

Tabla 2

Círculo / marca "X " sólo una vez en cada fila para el número apropiado mediante la comparación de importancia relativa entre dos de los factores

Opciones	Extremadamente		Muy fuerte		Fuertemente		Moderadamente		Igualmente		Moderadamente		Fuertemente		Muy fuerte		Extremadamente	Opciones
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Clasificación																		Kilometraje
Clasificación																		Comodidad
Clasificación																		Propiedad
Kilometraje																		Comodidad
Kilometraje																		Propiedad
Comodidad																		Propiedad

(6) Section VI

Examine en contraste los factors que se agrupan bajo la dirección de

(I) Ingresos
(II) costo del portador
(III) Edad
(IV) Años de experiencia

Tabla 1

Asignar calificación de 1 a 4 en la columna 'Tu puntuación ' , donde 4 es el más importante y 1 es el menos importante

Factores	Consideraciones importantes de Soporte	Tu puntuación (1-4)
Ingresos	El nivel de Ingresos del Conductor	
Costo del portador	El portador de los costos; es decir, el tomador de riesgo (conductor o empresa)	
Edad	El Años del Conductor	
Años de experiencia	El total Años de Experiencia del Conductor	

Tabla 2

Círculo / marca "X " sólo una vez en cada fila para el número apropiado mediante la comparación de importancia relativa entre dos de los factores

Opciones	Extremadamente		Muy fuerte		Fuertemente		Moderadamente		Igualmente		Moderadamente		Fuertemente		Muy fuerte		Extremadamente	Opciones
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Ingresos																		costo del portador
Ingresos																		Años
Ingresos																		años de experiencia
costo del portador																		Años
costo del portador																		años de experiencia
Edad																		años de experiencia

Appendix IV Truck Classifications

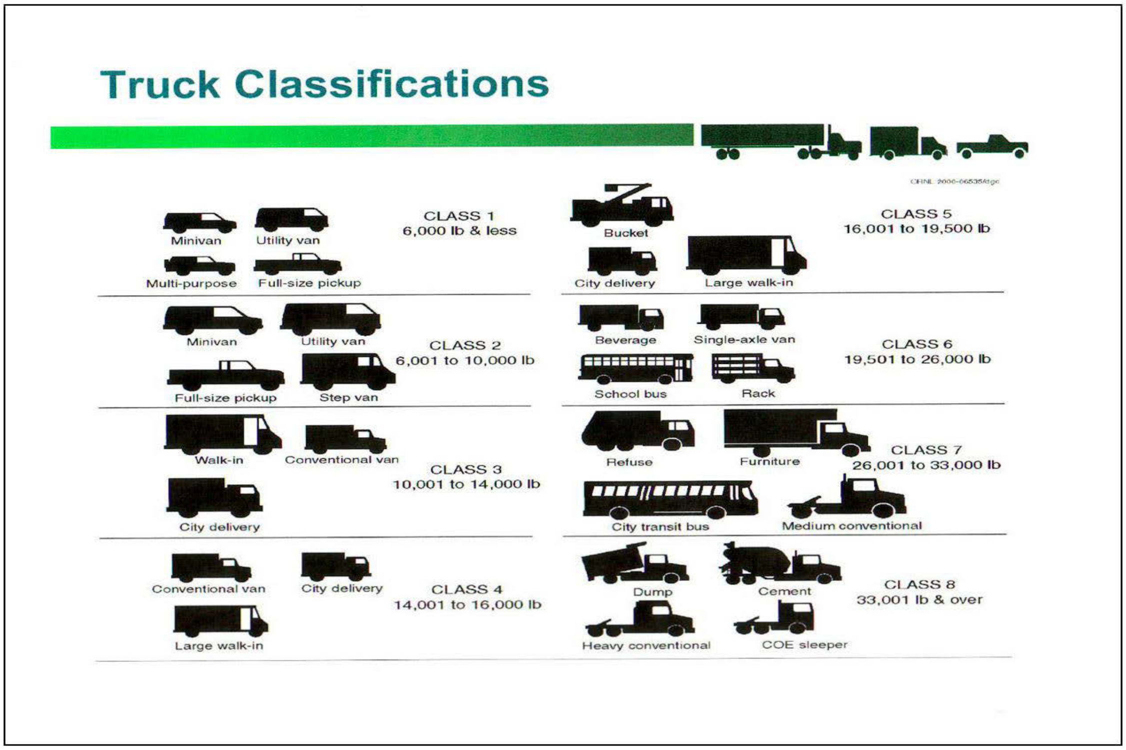

Figure A4-1. Truck Classifications based on Gross Vehicle Weight

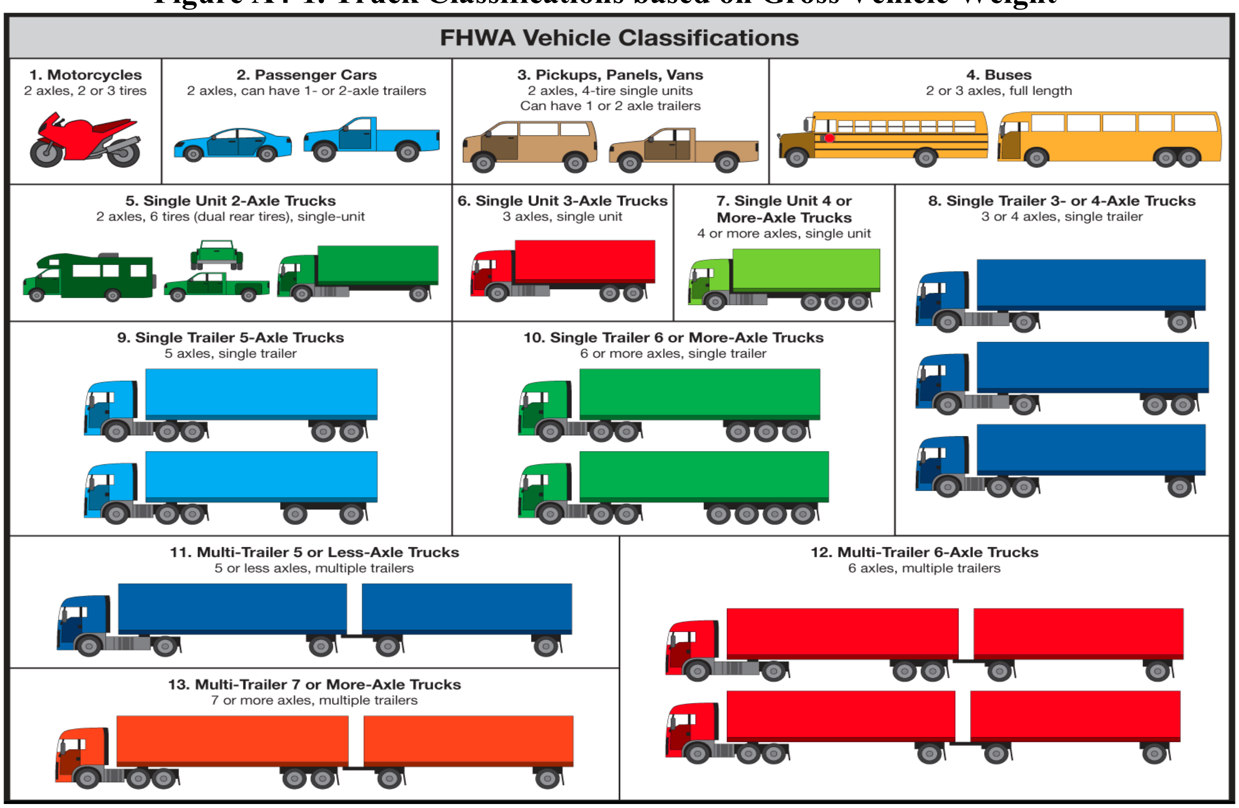

Figure A4-2. FHWA Truck Classifications based on Axle and Vehicle

Appendix V Southern California Truck Routes

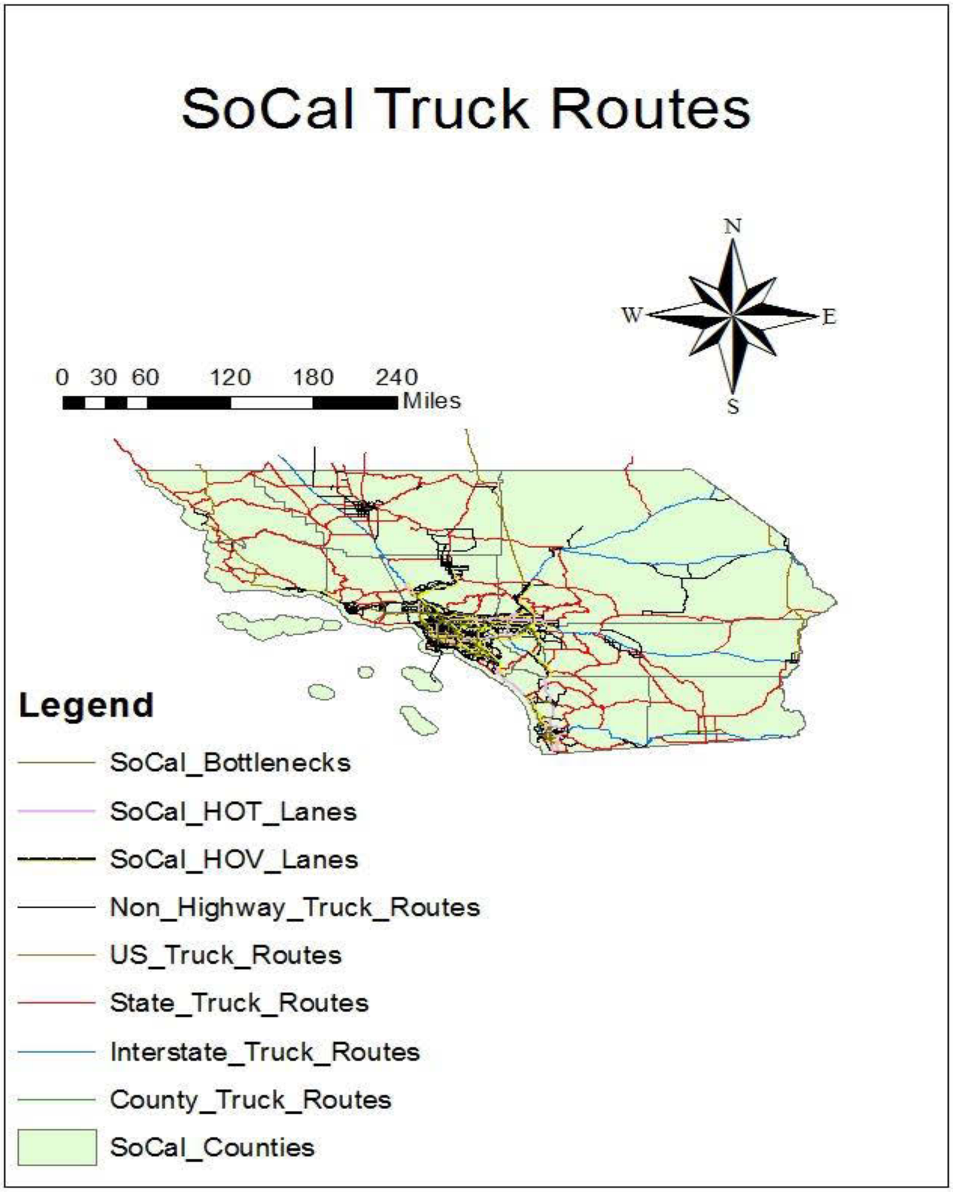

Figure A5-1. GIS Map of Southern California Truck Routes

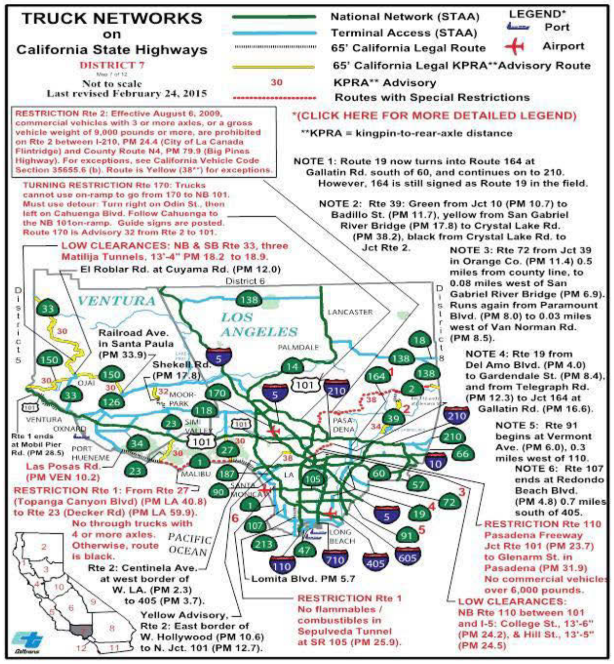

Figure A5-2. Caltrans Map of Truck Networks in District 7

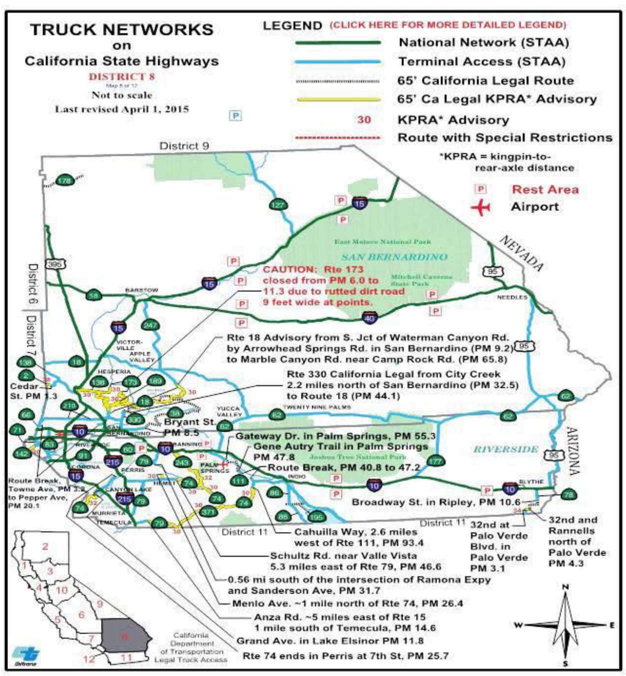

Figure A5-3. Caltrans Map of Truck Networks in District 8

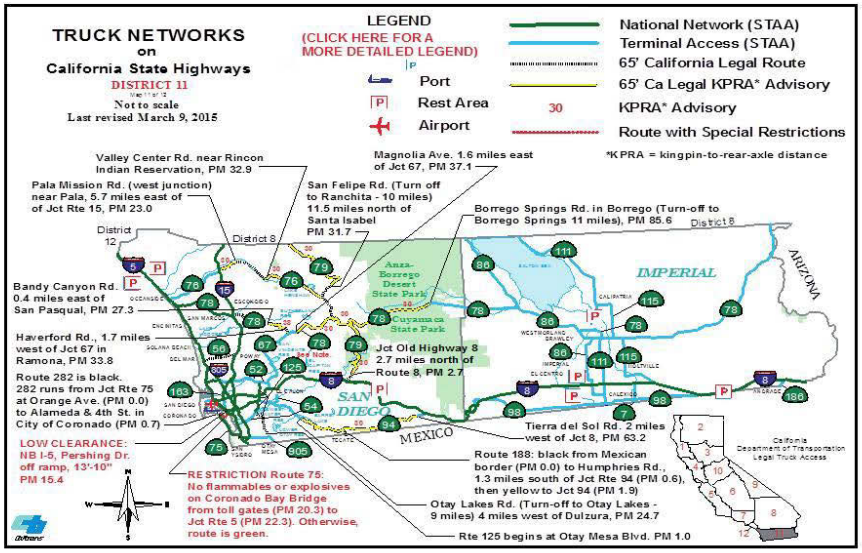

Figure A5-4. Caltrans Map of Truck Networks in District 11

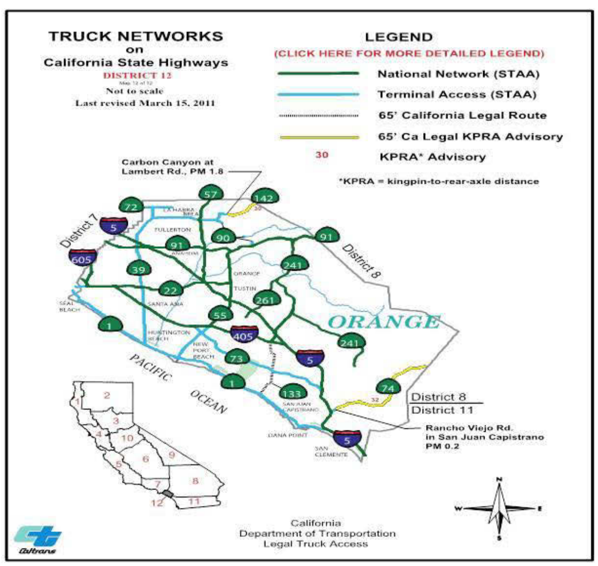

Figure A5-5. Caltrans Map of Truck Networks in District 12

Appendix VI Major Freeways in Los Angeles County

Table A6-1. Interstate Routes in Los Angeles County

Interstate Routes in LA County

Name		LA County			Notes
Interstate	Auxiliary	Northern or Eastern Terminus	Southern or Western Terminus	Length (miles)	
I-5	I-405	I-5 in San Fernandino	I-5 in Irvine	72	•Busiest and most congested freeway in US •San Diego Freeway •Bypass of I-5
	I-605	Irwindale	Seal Beach	27	•San Gabriel Freeway
	I-105	Norwalk	El Segundo	18	•Spur of I-5
I-10	I-710	Valley Blvd	SR 47	23	•Spur of I-10 •Long Beach Freeway •SR-710 •Proposed 4.5 mile Tunnel Project connecting 710 to 210
	1-110	Pasadena	SR 47	31	•Harbor Freeway
	I-210	I-10	I-5	86	

Appendix VII Significance of Freight Trucks

Table A7-1. Weight of Shipments by Transportation Mode

Table 2-1. Weight of Shipments by Transportation Mode: 2007, 2012, and 2040[1]
(millions of tons)

	2007				2012				2040			
	Total	Domestic	Exports[2]	Imports[2]	Total	Domestic	Exports[2]	Imports[2]	Total	Domestic	Exports[2]	Imports[2]
Total	**18,879**	**16,851**	**655**	**1,372**	**19,662**	**17,523**	**901**	**1,238**	**28,520**	**23,095**	**2,632**	**2,794**
Truck	12,778	12,587	95	97	13,182	12,973	118	92	18,786	18,083	368	335
Rail	1,900	1,745	61	93	2,018	1,855	82	82	2,770	2,182	388	201
Water	950	504	65	381	975	542	95	338	1,070	559	164	347
Air, air & truck	13	3	4	6	15	3	5	7	53	6	20	27
Multiple modes & mail[1]	1,429	433	389	606	1,588	453	540	595	3,575	645	1,546	1,383
Pipeline[1]	1,493	1,314	4	175	1,546	1,421	13	112	1,740	1,257	17	467
Other & unknown	316	266	36	14	338	277	47	14	526	362	130	34

[1] 2007 total and domestic numbers for the multiple modes & mail and the pipeline categories were revised as a result of Freight Analysis Framework database improvements.

[2] Data do not include imports and exports that pass through the United States from a foreign origin to a foreign destination by any mode.

Notes: Numbers may not add to totals due to rounding. The 2012 data are provisional estimates that are based on selected modal and economic trend data. All truck, rail, water, and pipeline movements that involve more than one mode, including exports and imports that change mode at international gateways, are included in multiple modes & mail to avoid double counting. As a consequence, rail and water totals in this table are less than other published sources.

Table A7-2. Value of Shipments by Transportation Mode

Table 2-2. Value of Shipments by Transportation Mode: 2007, 2012, and 2040[1]
(billions of 2007 dollars)

	2007				2012				2040			
	Total	Domestic	Exports[2]	Imports[2]	Total	Domestic	Exports[2]	Imports[2]	Total	Domestic	Exports[2]	Imports[2]
Total	**16,651**	**13,457**	**1,196**	**1,997**	**17,352**	**13,927**	**1,392**	**2,033**	**39,265**	**27,131**	**5,303**	**6,831**
Truck	10,780	10,225	267	287	11,130	10,531	309	289	21,465	19,315	985	1,166
Rail	512	374	45	93	551	400	55	96	898	555	148	195
Water	340	158	15	167	339	170	21	148	337	138	46	153
Air, air & truck	1,077	151	422	505	1,182	163	470	549	5,043	834	1,997	2,212
Multiple modes & mail[1]	2,884	1,646	394	844	3,023	1,697	478	848	9,925	5,203	1,911	2,811
Pipeline[1]	716	651	4	61	768	699	9	61	776	605	17	154
Other & unknown	341	252	48	41	359	267	51	41	821	482	199	139

[1] 2007 total and domestic numbers for the multiple modes & mail and the pipeline categories were revised as a result of Freight Analysis Framework database improvements.

[2] Data do not include imports and exports that pass through the United States from a foreign origin to a foreign destination by any mode.

Notes: Numbers may not add to totals due to rounding. The 2012 data are provisional estimates that are based on selected modal and economic trend data. All truck, rail, water, and pipeline movements that involve more than one mode, including exports and imports that change mode at international gateways, are included in multiple modes & mail to avoid double counting. As a consequence, rail and water totals in this table are less than other published sources.

Appendix VIII Reviews of the literature

Yichen Sun (2011) In her research studied the decision-making process and the elements that influence choosing of routes by truck drivers. The data from truck drivers has been collected by impede interviews from three truck stops and rest areas along major highways in the United States. Two programmed surveys were conducted for the purpose. The first survey solicited background information such as the elements that contribute to truck drivers routing decisions, recognizing the decision makers, and sources consulted in making routing decisions. In the second survey, the author has prepared a stated preference survey questionnaire in which 252 respondents had to choose between two theoretical alternative routes. The two hypothetical scenarios adopted are a turnpike and a bypass scenario.

Cargo segments considered are trucks LTL (Less than truckload), TL (Truck Load), and Parcel (or courier) service. In LTL segments, trailers are not fully filled and all the cargo might not be for a single shipper. LTL trucks generally load cargo onto other trucks, so they have multiple stops and much less options for choosing routes. In TL segments, trailers are fully filled and there will generally be a single shipper, so they usually have long hauls and thus have many options for choosing routes. The third cargo segment is Parcel/courier Service, who do door to door delivery service. Special cargo segments are temperature control, overweight, Hazmat, etc. Eight percent of the 3.2 million truck drivers are owner operated in the US (256,000). A small percentage of these owner-operated truck drivers are from Southern California, and will be the population of interest for our study. Owner operated truck drivers lease to carriers either as Gross Lease or Net Lease. Toll prices are charged based on the number of axles a vehicle has. The author citied works of many other journals that used various methods such as a logit model and regression analysis to calculate the Value of Time. Large variations in VOT's obtained many factors like cargo value, time of day, characteristics of the truck driver (owner-operated, private fleet). In most cases, it was found that owner-operated drivers have a higher VOT.

Gerard de Jong and et al. (2004) Research has been carried out for the Transport Research Center of the Dutch Ministry of Transport in order to set up a monetary value for the Value of Time (VOT) and the Value of Reliability (VOR) for 5 different modes: truck, rail, inland water ways, sea transport, and air transport. A list of factors influencing costs were identified and were categorized into five categories: fixed costs, variable costs, labor costs, specific costs, and company costs. A successful survey was conducted on carriers and shippers across these different modes. It was based on time and reliability versus cost trade-off ratios. A revealed preference survey interview and two stated preference survey interviews were organized for the study purpose. One stated preference survey was conducted within mode as respondents had to choose alternatives within a mode, and the other stated preference survey had respondents choose between any two specific freight modes. Based on the data obtained from surveys, discreet choice models were developed to provide 2 trade-off ratios between travel time and travel cost and between travel reliability and travel cost. Using these trade off ratios, the Values of Time and Value of Reliability are estimated. The travel time and travel cost Trade off ratio signifies how willing respondents are to reducing their travel time by increasing travel cost; similarly, The travel reliability and travel cost trade off ratio signifies how willing respondents are to increasing travel reliability with an increment in travel cost. The mixed logit models developed did not give substantially better output than logit models. In order to overcome the problem of multiple observations on respondents, each response was taken to be independent of each other.

The Value of Time per hour was found out to be:

Mode		VOT in €/hour
Truck	Low value raw materials	38
	High value raw materials	49
	Finished products	38
	Containers	42
Rail		918
Inland Water Ways		74
Sea Transport		73
Air Transport		7935

The Value of Reliability for a single trip was found out to be:

		VOR in €/trip
Truck	Low value raw materials	1.01
	High value raw materials	1.31
	Finished products	2.67
	Containers	2.85
Rail		898.08
Inland waterways		62.53
Sea Transport		930.60
Air Transport		15429

John Holland Knorring. (2003) In his study focuses on empirical analysis of decisions made by truck drivers for choosing routes. For this study, a revealed preference data set was used. Since truck drivers are authorized to drive only specific amounts of time per day, the stop they make after driving the authorized hours for that day are considered to be the end of the trip. Study zone areas have been selected in such a way that the route network is around a major city, so there will be multiple alternatives for truck drivers, like routes through downtown and bypass routes. Since these areas would have a larger scope for decision making, the study considers trade-offs between trip distance and travel time factors, such as: trip distance of alternate routes, traffic volume, risk aversion, truck driver income, the level of education of the driver, and the duration of the trip. The author highlights the fact that the Value of Time for bypass routes > the Value of Time for downtown routes, and the Variance of Travel Time for bypass routes < Variance of Travel Time for downtown routes.

$$L = \sum_{i=1}^{n} \left[D_i * \log\left(\frac{\exp(\Delta Utility)}{1 + \exp(\Delta Utility)} \right) + (1 - D_i) * \log\left(1 - \frac{\exp(\Delta Utility)}{1 + \exp(\Delta Utility)} \right) \right]$$

The equation of the logit model developed for the study

Drivers are assumed to be time and cost minimizers more so than distance minimizers. Subjects who make decisions regarding routes consider maximum utility. From his results, the author interpreted that travel time is a more crucial factor than travel distance.

Gerard de Jong. (2008) In his research, The Value of Travel-Time Savings (VTTS) attributes to benefits from alleviated Value of Time (VOT). The calculation of the Value of Travel-Time Savings (VTTS) has two aspirations. In the scope of freight transport, it is used for forecasting models, as well as in cost-benefit analyses of transportation networks. The author states that there are two methods to calculate freight VTTS: Factor-Cost method and Modelling studies. Modelling studies are further classified into revealed preference data and stated preference data. Aggregate data (zonal level) and disaggregate data (household level) are the levels at which revealed preference experiments could be conducted. Similarly, stated preference experiments were conducted between modes, and also within a mode. The author highlights the fact that disaggregate models are branched into inventory and behavioral models. The Value of Time (VOT) is calculated as a ratio of time to cost coefficient.

The unit for passenger VTTS is cost/minute, whereas freight VTTS has cost/hour as its unit because of low average speeds and larger travel distances for freight transport when compared to passenger transport. Interview results have shown that shippers play a major role in mode choice and in route choice for truck freight; also, truck drivers choose the route they drive. The factors required to calculate VTTS for cost-benefit analyses differ from the factors required to calculate VTTS for freight transport. WinMint was used to program the SP/PR questionnaire. The VOT in the Netherlands for containers and total road transport was found out to be □42 and □32 respectively.

Hirotaka Sekiya and et al. Their article focuses on how the characteristics of container cargo contribute in route selection. The four cargo container characteristics considered are trip distance, scheduled delivery, cargo quantity, and facility type. The author emphasizes the fact that unlike passenger cars, where route choice depends mainly on transport facility characteristics, the route choice for freight trucks also depends on the cargo characteristics. The relationship between freight trucks route choice and container cargo characteristics is indicated using a ratio of express way use. A scheduled delivery factor is specified via am/pm detail, hour detail, due date detail, and no detail. Similarly, facility type characteristics are sorted as refrigerated warehouse and open warehouse. Three Relationships between the ratio of expressway use and freight characteristics are given. A survey question was directly asked to respondents about the usage of expressway, from which three relations were developed. All of the 85 varieties of cargo surveyed were categorized into 9 types. They are agriculture and fishery, light industry, mechanical industry, special product, chemical, other industry, forestry, waste, and mining. The list shows the descending order of the 9 freight types and their ratios of expressway use. First relation: Ratio of Expressway Use vs Refrigerated Warehouses.

The ratio of expressway use is larger for cargo coming from refrigerated warehouses than from open warehouses. The author attributes the reason for a larger ratio of expressway use for agriculture and fishery is because it is cargo from refrigerated warehouses, which are perishable and need to be delivered within a certain time. Null hypothesis testing was done to prove the same for a significance level of $\alpha = 0.1$. Second relation: Ratio of Expressway Use vs Scheduled Delivery. 19.2 % of agriculture and fishery cargo had scheduled deliveries in the year 2005. Freight trucks encountering scheduled deliveries preferred more reliability. Similarly, null hypothesis testing was done to prove the same for a significance level of $\alpha = 0.1$. Third relation: Ratio of Expressway Use vs Cargo Quantity. The frequency of cargo delivery increases as the

weight of the freight being shipped in a single freight truck decreases. The trucks are classified into 4 categories: (1) the shippers own trucks, (2) forwarder trucks carrying cargo for multiple shippers, (3) forwarder trucks carrying cargo for single shipper, and (4) other. The ratio of expressway use is highest for forwarder trucks carrying cargo for multiple shippers.
A logit model was developed to predict the ratio of expressway use:

$$Logit(f) = log\left(\frac{f}{1-f}\right) = \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \alpha_4 x_4$$

The logit model has four variables that were considered by the author, which are:
X_1 = Trip distance in kilometers
X_2 = Facility type (refrigerated facility gets a value of 1; if not, it gets a value of 0)
X_3 = Scheduled delivery gets a value of 1 if specified; if not, it gets a value of 0
X_4 = Cargo quantity in tons
α_0 = Intercept
α_1 = Coefficient of X_1
α_2 = Coefficient of X_2
α_3 = Coefficient of X_3
α_4 = Coefficient of X_4

The value of this ratio lies from 0% to 100%. This logit model shows that as X_1, X_3, and X_4 increases, then ratio of expressway use also increases. The ratio of expressway uses for the facility type of refrigerated warehouses and for freight with scheduled delivery is greater than that of other freight. The following four factors have a statistically significant influence on freight truck route selection in terms of the ratio of expressway use: (1) trip distance, (2) scheduled delivery, (3) cargo quantity, and (4) facility type. The accuracy ratio of the model was 0.72, which is not very high, indicating that there is a need to improve the model further.

Qinfen Mei and et al. has reported a Truck Cost Model: This study is the first to give values of time for trucks of varying cargo type and truck class. Studies have shown that the Value of Time (VOT) varies significantly by the parameters of travel distance, truck characteristics, and the type of cargo being transported. Two different hypotheses are used to test the Value of Time: time and distance based costs and distance based costs. The results of a comparative study on the simulation convey that values of time scrupulously follow the first hypothesis (time and distance based costs). The comparative study conducted also revealed that in response to tolls, truck drivers change their routes when the imperviousness of the primary route exceeds the imperviousness of alternative routes. With a lower value of time, truck drivers tend to choose alternative routes, but when the value of time is higher, truck drivers tend to choose the path which is shortest in order to save time. Considering the substantial influences of cargo and characteristics of trucks on the value of time, and also considering the susceptibility of drivers to tolls, there is a necessity to individually examine all truck classes when executing traffic assignments. The author points to the fact that many studies on freight truck route selection were based on Travel Time; however, he also emphasizes the importance of Travel Cost along with Travel Time. The Value of Time is also an important variable that truck drivers consider when having to choose toll roads. It was found that the Value of Time varies for journey characteristics, truck class, and cargo type. The author enlightens the possibility of two hypotheses: time and distance based costs and distance based costs. The truck costs are required in order to find this Value of Time. A truck cost model was adopted to determine the truck cost. In this truck cost model, the total shipping cost is the sum of all independent expenses, such as fuel, labor, depreciation, maintenance, loading and unloading, insurance, overhead, and extra expenses. Truck cost model consists of parameters and constants. Known (or default) values are plugged in for the parameters in the model, and then linearized using regression analysis to get the coefficients. The slope of the regression line will give the Value of Time and per-mile cost. Truck traffic assignment is done using the Mississippi Valley Freight Coalition (MVFC) Microsimulation Model, which considers only truck class 2 and truck class 5.

Conclusion: the values of time have been tested using two different hypotheses, time and distance based costs and distance based costs. Observations of the simulation results with definite traffic data show that the values of time more thoroughly pursue the time and distance based cost hypothesis. Trucker drivers tend to choose alternative routes when value of time is lower, whereas they tend to choose the shortest route in order to save time when Value of time is higher. The heavily weighted variables influencing Value of Time are commodity and truck type, and considering the sensitivity of truck drivers regarding tolls, there is a necessity to independently acknowledge truck characteristics when carrying out traffic assignments.

John M Rose (2009). The author states that orthogonal survey designs are common in practice; however, he describes that stated preference efficient survey designs generate equally good—or better—survey data. Stated preference survey respondents were required to select one or more alternatives amongst a finite set. The dependent variable is categorical in discrete choice models. The planner initially has to decide on having a labeled or non-labeled experiment. Non-labeled experiments require only non-specific parameters to be estimated; for labeled experiments, either non-specific or alternative specific parameters are to be estimated. A labeled experiment is one where the names of alternatives give meaningful knowledge to respondents, like Truck, Rail, Public Transit, etc. In non-labeled experiments, the alternatives will signify only the respective order of appearance, like Route A, Route B, etc. The number of parameters should always be less than the number of rows. If there are n number of attributes with a specific attribute level for each attribute, then the lowest common multiple of all the attribute levels will have the least number of choice tasks. Discrete choice models are not linear, so asymptotic variance covariance (AVC) for discrete choice models are obtained by the negative inverse of the expected second derivatives of the log-likelihood function of the model. Six methods that generate stated preference survey experiments were compared. Namely, Balanced Incomplete Block design, L^{JK} fractional factorial design, Fold-over, Optimal Orthogonal choice deigns, Efficiency choice designs, and Optimal Choice Probability design. The first method used Balanced Incomplete BIBD master design rows for alternatives. A specific column represents each alternative, whereas choice tasks are represented as a specific row. The second method adopts L^{JK} designs. The last methods don't need to be orthogonal, but at the expense of requiring early information, which will be obtained from the pilot study.

The author states that the use of orthogonal designs in stated preference survey methods will only add to the needless bigger sample sizes to significant values, in contrast to the non-orthogonal designs. The author gives the reason that orthogonal designs are not for discrete choice models, but used for the econometric part of regression. If the estimates of parameters are close to zero, then orthogonal designs give better results than other models; however, it is not the case with the estimates of parameters moving away from zero. Optimal orthogonal design is the most effective deign among the six methods compared to generate a stated preference survey experiment. The limitation of this paper is that the authors have examined only 6 methods that generate the stated preference survey methods.

David A. Hensher (2009) This paper recognizes and measures willingness to pay (WTP) generated from methods that evaluate Hypothetical bias. The experiments, which diverge from real market settings, are known as Hypothetical Bias. It is an expanse at which respondents behave inconsistently, as they don't need to follow the alternatives they choose. The author classified SC choice into Contingent Valuation (CV) and Choice Experiments (CE). He points that results as shown that respondents tend to overstate TWTP and MWTP. Mean MWTP for time saving's is lower for trading time and cost in utility expressions associated with SC alternatives, compared to RP alternatives.

The value of Time and Reliability: Measurement from a Value Pricing Experiment
The models show that most of the results are reasonably robust for how the simultaneous decisions about mode and transponder choice are handled. Accounting for mode choice raises VOT by about 28%, with little effect on VOR. Accounting explicitly for transponder choice reveals that the transponder installation decision has its own determinants, and distracts from those of the daffy decision for whether or not to use the transponder, but accounting for this does not affect VOT and VOR very much. The authors regard Model, which accounts explicitly for both transponder and mode choice, as the most trustworthy of those presented This model produces a VOT of $22.87 per hour and VOR of $15.12 per hour for a demand of $31.91 per hour, all from a sample with weighted average wage rate equal to $31.69 per hour

AI1 the models show interesting and mostly plausible variations in the propensities for various choices with respect to personal characteristics; in particular, several factors are brought to light by our unusual opportunity to observe route choice when one route is subject to time-of-day pricing. Income, gender, and language especially seem to affect the willingness to undertake the fixed cost of installing a transponder, whereas work-hour flexibility and total trip distance seem to influence the daily decision of which route to take. It will be interesting to see if further research can identify more explicitly the reasons why so many people who have transponders make different decisions from day to day as to whether to use them.

Type of Choice	Value of Time $/h	Value of Reliability $/h	
		Male	Female
Route	11.90	11.90	28.72
Route & time of day	5.72	5.72	7.42
Route & Mode	12.85	12.85	33.92
Transponder & route	14.23	14.23	26.74
Transponder, mode & route	15.12	15.12	31.91

Heterogeneity in Motorists' Preferences for Travel Time and Time Reliability: Empirical Finding from Multiple Survey Data Sets and Its Policy Implications

This dissertation has applied recent econometric advances to analyze the behavior of commuters in Southern California and found substantial heterogeneity in commuters' preferences for both travel time and travel time reliability. As expected, commuters with higher household income have higher values of time and reliability. Additionally, commuters with long trip distances have lower values of time, which is consistent with residential selectivity. However, most of the heterogeneity in commuters' preferences cannot be explained by observed characteristics. One possible explanation is that in very expensive and congested metropolitan areas such as Southern California, consumers face significant constraints in trading off housing expense for commuting time.

Based on a simulation model and the uncovered heterogeneity, this dissertation found pricing policies with a greater chance of public acceptance by catering to varying preferences. Recent "value pricing" experiments have made a start to account for varying preferences by letting motorists make a choice between priced and un-priced roads. However, as shown in the simulation results of this dissertation, leaving part of the roadway un-priced severely reduces the efficiency. Differentiated pricing, taking preference heterogeneity into account, can realize substantial efficiency gains on the one hand, and ameliorate distributional concerns on the other hand. Differentiated pricing is also politically feasible by reducing the direct loss in consumer surplus. This policy may thus be the key to break the impasse in efforts to relieve highway congestion.

This dissertation also investigated how to employ the new advances in the Bayesian approach for estimating the multinomial probit model in travel demand analysis, combining different sources of data. The multinomial probit model has advantages to model the correlation across choice alternatives and across observations of different data from the same individual, and the Bayesian approach, also with theoretical advantages in interpreting results, makes the multinomial probit model more feasible to handle in practice. The Bayesian approach provides us with a new tool to measure commuters' behavior based on more flexible model specifications.

Hypothetical bias, choice experiments and willingness to pay

This paper has brought together elements of the literature on revealed and stated choice studies (CV and CE) to identify the nature and extent of hypothetical bias, and what might be sensible specifications of data and models to reduce the gap between MWTP estimates, likely to exist in actual markets, when observed 'at a distance', and estimates from choice experiments. The mean MWTP for time saving's is lower when trading time and cost in utility expressions associated with SC alternatives, when compared to RP alternatives. A way forward within the context of choice experiments, when the interest is on estimating MWTP under conditions of habit, which is common in many transport applications, is to recognize the real market information present in a reference alternative. What was found, empirically, is that when a pivoted design is used for constructing choice experiments, and the model is specified to have estimated parameters of time and cost that are different for the reference alternative than the hypothetical alternatives, the estimated value of travel time savings is higher for the reference alternative than for the hypothetical alternatives. This model specification is not the specification that researchers have generally used with data from pivoted experimental designs. Usually, time and cost are specified to have the same parameters for the reference and hypothetical alternatives. The proposal herein for reducing hypothetical bias is to use a pivoted design and allow different parameters for the reference and hypothetical alternatives.

Despite the importance of good experimental design, the disproportionate amount of focus in recent years on the actual design of the choice experiment, in terms of its statistical properties, may be at the expense of placing substantially less focus on real behavioral influences on outcomes that require a more considered assessment of process, especially for referencing that is grounded in reality. There are many suggestions from the literature, derived from mixtures of empirical evidence, that are carefully argued theoretical and behavioral positions, and have a speculative explanation. The main points that emerge, that appear to offer sensible directions for specifications of future choice studies, were: we also support future empirical studies that can confirm or deny the growing body of evidence on hypothetical bias in choice experiments. Using a toll road context as an example, an empirical study might be undertaken of the following form: packages around their chosen alternative, and enables construction of a choice model that looks like the traditional RP model form. This can then be calibrated with choice-based weights.

- The context is the choice amongst competing existing tolled and non-tolled routes including the option to consider none of these.
- The attributes of interest should be, as a minimum, door-to-door travel time and cost, where the latter is running cost and toll cost for the tolled route, and running cost for the non-tolled route.
- The sampled individuals are people who currently use one of the two routes. This defines a reference alternative.
- Group A, which participates in a stated choice experiment with no endowment and no randomly selected alternative for implementation, as is often practice in CV studies.

The authors have selected the two groups as a way to test some of the imposed conditions common in many of the studies outside of transportation, as reported in this paper.

The impact of traffic images on travel time valuation in stated-preference choice experiments

It is well understood by those who develop stated preference choice experiments for travel-time valuation that the Value of Time is an ambiguous metric without fully considering the type of travel time it is conditioned on. Moreover, value of time estimates may be dubious if SP survey instruments are unable to tie their hypothetical travel scenarios to real-world travel experiences. These concerns have motivated modern practices, such as distinguishing between free-flow and congested travel-times and developing pivot designs. They have also forced practitioners to pay careful attention to the number of attributes that characterize their hypothetical travel scenarios, understanding that more attributes may enhance realism, but at the expense of increased complexity and possible attention biases. It is somewhat surprising that little research has been devoted to complementing trip attribute descriptions with traffic images, given that they might improve the correspondence between hypothetical and real world travel conditions, and could help to conserve the number of attributes specified. Yet, it is understandable, given that their sources that would be required to incorporate real-time image generation into a modern SP choice experiment.

The findings of preliminary evidence that incur such expenses might indeed be worthwhile. Based on an SP choice experiment that exploits modern SP design and estimation methods demonstrated that even rudimentary traffic mages in SP surveys could dramatically influence the value of time estimates. Moreover, the author shows that the congestion premium implied by the difference between congested and free-flow VTTS can depend critically on whether or not these images are included.

Commercial Vehicle Value of Time and Perceived Benefit of Congestion Pricing

Using the SR91 congestion pricing project in Orange and Riverside County as a case study, the benefits for commercial vehicles were calculated based on perceived value of time. The analyses showed that commercial vehicles on SR91 have received over $2 million of perceived annual benefit since the opening of the toll lanes in 1995 due to the added capacity. If the toll lanes were opened to heavy vehicles, the annual benefit would reach over $3 million. Further analyses revealed that trucks with high values of time would receive a disproportional amount of benefit, especially if the toll is expensive. The comparison between for-hire and private trucks indicated that the former, due to a considerably higher mean value of time, tend to receive much greater benefits individually and collect slightly more aggregate benefits than the latter, despite smaller numbers. However, the share of the benefits received by each sector is relatively unaffected by the level of the toll charged. Several assumptions had to be made because of the lack of data to estimate the truck volume on SR91. To our knowledge, detailed truck traffic data that extend beyond daily volumes, axle counts, and peaking characteristics have never been collected on a continuous basis on a major road in this country. Travel characteristics such as business type, shipment size, and trip length are usually collected from company surveys, and it is difficult to transfer those data to the composition of the traffic on a particular facility. Fortunately, the computer data on truck operations that contains these characteristics is usually maintained by the Department of Motor Vehicles or similar organizations. Also, on a visible part of each truck, a number is painted that links it to the computer data. Therefore, the detailed truck traffic data that is required to conduct policy studies such as this project can be obtained from a traffic survey, even though it may be an expensive effort. The case study can be extended to include situations in which congestion pricing is implemented on an existing facility. While the SR91 project offered a Pareto improvement, in which no one is made worse-off, extending congestion pricing to an existing road or bridge will reduce benefits for some travelers. Since all of the existing congestion pricing projects in this country provide Pareto improvements, a simulated case must be created. The comparison of the results against those for SR91 will provide an insight into the effects of the types of congestion pricing facilities and the distribution of the value of time. Although the small volume of trucks and relatively flat grade of SR91 justified the assumption that the travel times on both free and toll lanes were not affected by the mode share, this can be relaxed in future studies. If the trucks were allowed to use the toll lanes on SR91, there would be increases in benefits for passenger cars on the free lanes and decreases in benefits for passenger cars on the tolled lanes. Further analysis could be performed to determine the net effects of these changes on the distribution and level of benefits to passenger car travelers.

Finally, the framework presented in this study can be transferred to passenger travel by relaxing some of the simplifying assumptions. First of all, the changes in travel times on tolled and free lanes, with respect to different toll levels and values of time distributions, must be calculated. This will require an equilibrium traffic assignment. A technique similar to the traffic assignment module used in the UTPS type of models that is modified to incorporate the random coefficient logit model may be developed to perform the task. Also, the measurement of benefits is much more complicated for passenger travel since it involves changes in utility, which are not measurable. However, alternating measurements such as compensating variations and consumer surplus, which can be directly obtained from the random parameter logit model, may be used to measure the change in utility.

International comparison of background concept and methodology of transportation project appraisal

An initial comparison of the different components of the Project Evaluation System of different developed countries have presented the degree of project impact consciousness, the level of efficiency, and the various stages of developments of the world's leading project appraisal procedures. Although there are significant differences as to the institutional setup of transport sectors among the studied countries, there is much in common in the basic characteristics of the transportation system, as well as the guiding principles behind the methodology of transport project evaluation: economic efficiency and equity in a broad sense, and environmental and social impacts, just to name a few. The cost-benefit analysis as a tool is basically the most commonly used technique to measure the direct impacts in monetary values and to evaluate the economic efficiency of a project. The treatment on equity, environment, and regional factors, however, are less agreed upon. For example, Germany formulates these impacts as an integrated component in the cost-benefit analysis while other countries have informal procedures in treating equity, environmental, and social impacts. The majority, though, adopt an informal comprehensive evaluation with or without criteria analysis in order to incorporate the result of a cost-benefit analysis. The technical aspect of a cost-benefit analysis is also fairly common. Comparing each country's method in transportation demand forecasting, value of time, traffic safety, environmental impact, regional impact, and efficiency criteria, there seem to be no significant differences, except for the specific set of values being used. Problems encountered in the use of some methods are also common. For example, every country uses the conventional stepwise method for transportation demand forecasting, which has some inconsistencies among the steps. That is probably the case because other forecasting methods are too complex to be applied in practice. This hints a need of further researching for the possible application of existing theories in a new approach. As it was pointed out, levels or degrees of development among various criteria vary from one country to another. One country, for instance, may have well-established guidelines in considering one parameter, yet just starting to include another parameter in the evaluation procedure, which might in turn be already well established in another country's model. By conducting a careful study on the components of the different models, it would be possible to come up with a superior model by integrating all the good components of the existing models. This is a simple case of learning from each country's experiences.

Likewise, the valuation of non-market goods is another area where different countries can actively work with. The value of time is one of the key components for users' benefit estimation.

Although its methodology is common, its system of classifying input parameters is quite different (e.g. the distinction of working and non-working time, classification of vehicle type, journey purpose, by mode, by distance, and so on). There has been research done on the value of time, but values of time for commodity transport has not yet been thoroughly studied. There should also be a common methodology to monetarily evaluate the aspect of safety. On the other hand, the value of human life and the cost of injury are quite different among countries. Decision criteria are also slightly different in terms of net present value, benefit-cost ratio, and internal rate of return. Among the biggest difference is on the social discount rate, which ranges from 3% to 8%. The authors believe that it is necessary for the SDR to be determined through a political and economic consensus. A number of related research studies can serve as a take-off point towards the development of a practical method in determining SDR based on observable economic data. The environmental impact assessment, which requires global or regional considerations, infrastructure planning, and other environmental impact-reduction efforts can be well coordinated in the international scene if there is a common set of environmental valuation systems. Considerations like regional economic and network wide analysis, particularly in the case of geographically adjacent countries, such as those in Europe, may also require a more standardized system. At present, there might be significant differences in the institutional setup of the transportation sector of each country. Also, each country's development priorities and stages of technology, research, and development might be different. However, despite these differences, the factors that motivate each country to come up with an improved project evaluation procedure are very much in common: efficiency, economy, environment, and controlled development, just to name a few. These common goals could bind everyone together to open up joint research and development opportunities in formulating a better project evaluation technique. This issue containing a collection of papers is just the beginning.

Economic Assessment of Road Schemes: The COBA Manual

This document is a user manual for the cost-benefit analysis computer program COBA11. It includes details of basic economic concepts used in the appraisal of highway schemes and details of the Overseeing Organization's requirements on the reporting of appraisals. COBA (Cost Benefit Analysis) is used in the appraisal of Trunk Road schemes in England, Wales and Northern Ireland. In addition, COBA is used by many Local Authorities to appraise a wide range of highway schemes. Five objectives are considered when appraising transport projects: Environment, Safety, Economy, Accessibility and Integration. The COBA program compares the costs of providing road schemes with the benefits derived by road users--in terms of time, vehicle operating costs and accidents--and expresses the results in terms of a monetary valuation. The output contributes to the appraisal process in the following ways:

- 'Economy' Objective: Time and Vehicle Operating Cost (VOC) changes
- 'Safety' Objective: Changes in Accident Costs and Casualties
- 'Environment' Objective: Changes in the amount of fuel used to assist in determining environmental changes

COBA calculates the user costs on the network in terms of the three user cost streams: changes in time, changes in operating costs, and changes in accident costs. The total costs of the scheme are considered in terms of: capital costs (including preparation and supervision costs) and changes in the capital cost of maintenance of the network.

The Value of Travel-Time: Estimates of the Hourly Value of Time for Vehicles in Oregon
The purpose of this journal is to provide estimated values of travel-time for vehicles driving on Oregon roads. The author explains that user costs associated with travel are typically grouped into three primary types: travel- time costs, vehicle operating costs, and safety costs. Only one of the three primary transportation user cost categories is presented here: costs associated with travel-time. This paper considers costs associated with time as separate from vehicle operating costs. They found that the variables that contribute to the value of travel-time depends on six elements: type of vehicle, vehicle occupancy, purpose of the trip, costs included or excluded when building the estimates, underlying assumptions regarding input data, and the availability of detailed data. The value of one hour of vehicle travel-time was estimated for three vehicle categories using Oregon wage data: automobiles, light trucks, and heavy trucks. Within these categories, the values of travel-time were found for on-the-job and off-the-job travel, and a total weighted average was obtained by summing the two. The total weighted averages were found to be: $16.31 for automobiles, $20.35 for light trucks, and $29.50 for heavy trucks.

Value of Freight Travel-Time Savings (from Handbook of Transportation Modelling)
The author explains that the value of travel-time savings (VTTS) is used primarily for two different purposes: as an input into the cost-benefit analysis of infrastructure projects, and in traffic forecasting models, in which one of the explanatory variables is a linear combination of travel time and cost (called "generalized cost"). The methods that are used for the evaluation of freight VTTS are factor-cost methods and modeling studies. The factor-cost method tries to find the cost of all input factors that will be saved in case of travel time savings, or the cost of additional inputs if travel time is increased. Studies that have applied this method usually include labor cost and fuel cost among the time-dependent costs. Modeling studies are classified into revealed preference (RP) studies and stated preference (SP) studies. Both RP and SP models are used in calculating the freight VTTS. Various choices made by truck drivers can be modeled, and the model estimates can be used to find the freight VTTS values implied by the actual decision-making outcomes. The choices include: mode choice between a fast and expensive mode and a slower and cheaper mode, choice of carrier (or between own account transport and contracting out), choice between a fast toll route and a congested toll-free route, and choice of supplier.

A Joint SP/RP Model of Freight Shipment from the Region Nord-Pas de Calais
A joint SP/RP survey was conducted in the Nord-Pas de Calais region in France in 1999 and 2000. The RP survey had a database of 650 shipments (of 200 shippers), and the SP survey had a database of 150 shipments (from 100 shippers). The SP survey contained both within-mode experiments (two alternatives are presented, both referring to the same mode) and between-mode experiments (choice between two different modes). The attributes considered in these experiments include travel time, travel cost, reliability, probability of delay, availability of adapted logistic services, flexibility, and frequency. A joint nested logit model was estimated on the mixed RP and SP information. For this study, the method developed in Bradley and Daly (1991) to combine SP and RP data in a single estimation framework was used. This method takes account of differences in the amount of unobserved variation in data coming from

different sources. The values of time for the road hire and reward, the only mode that had sufficient data, were generally lower than in the within-mode SP model. In the model on the between-mode SP data, the values of time for this mode were between those from SP within-mode and RP alone. This was probably caused by the limited possibilities for trading off in mode choice, when compared to choices within a mode.

Fehmarn Belt Traffic Demand Study

This publication describes the assumptions necessary to carry out the forecasts with a FemEx model, and the subsequent results are presented and compared with similar results from a FTC main model. The FemEx model is an executive version of the Fehmarn Belt Traffic Model (FTM). It was developed as a computer tool, and provides a mean for the Ministries to carry out calculations on their own, varying different input variables and getting new traffic and transport figures as a consequence. The FemEx model consists of two different models, one for passenger traffic and one for freight traffic, which are developed in the same structure. The two models apply different data and are therefore completely distinguished in the computer application. For both models, the overall model structure consisted basically of three different modules: a growth module, a mode choice module, and a route choice module. The study forecasts the number of passengers and the percent of the distribution between a variety of different modes: car passengers by fixed link, all car passengers, rail passengers, bus passengers, walk-on passengers, air passengers, and the total of all of them. It was found that the FTC model forecasted a declining rail and bus market in 2010, whereas the FemEx model forecasted an increase in the relative market shares of rail and buses. Both models anticipated a sharp decline in the relative share of walk-on passengers.

Highway Economic Requirements System-State Version

The HERS-ST model is a highway investment/performance model that considers engineering and economic concepts and principles in reviewing the impact of alternative highway investment levels and program structures on highway condition, performance, and user impacts. Specifically, the HERS-ST model simulates highway condition and performance levels and identifies deficiencies through the use of engineering principles. When it simulates the selection of improvements for implementation, it relies on economic criteria. In general, HERS-ST is designed to select only those projects where benefits will exceed initial costs. Its benefits consist of reductions in user costs, agency maintenance costs, and externalities over the life of the improvement. HERS-ST attempts to optimize the relationship between public highway investment and user costs. It is an enhanced version of the HERS model which has been used by the Federal Highway Administration (FHWA) since 1995 to provide estimates of the investment required to either maintain or improve the Nation's highway system. The HERS model is a synthesis of engineering knowledge and applied microeconomics. The relationships among traffic volumes, capacity, pavement deterioration, speeds, crashes, travel time, curves and grades, and other highway attributes are based on engineering relationships. Although demand forecasts are supplied externally, HERS adjusts these forecasts to take account of improvements that make travel easier, and therefore attract more users, or conversely, deter travel by increasing congestion and worsening pavement condition. Thus, there are many points in the model at which economic and engineering principles interact and find a resolution. The HERS model estimates the total highway investment required to implement all improvements whose benefits exceed their costs. It does this by taking a representative sample of highway sections, designing alternative improvements for each section, selecting the best improvement (if any), and extrapolating the results to the national highway network. Benefits are the reductions in user costs, agency maintenance costs, and externalities, over the life of the improvement. Costs are the initial capital costs of the improvement.

Values of Time for Road Commercial Vehicles

An AHCG SP survey was conducted to evaluate the Value of Time (VOT) for freight vehicles. AHCG devoted just 4 pages of their final report to the analysis of values of time in their road freight survey. There were two different experiments, one of which was analyzed with and without the exclusion of some respondents. Log-normal models were applied to one of the experiments, but the report does not say which. Except for the log-normal model, results are available for four segments, being the combinations of LGV vs HGV and Hire & Reward vs Own Account. The first experiment considered the choice between two untolled roads, having different times and costs, as well as differences in other attributes. Estimated values of time were 45 pence/min for Hire & Reward, and 35 pence/min for Own Account. The second experiment charged a toll to use the quicker (current) route against a slower (but free) alternative route. It was found that the typical VOT is about 20 pence/min. The HGV Own Account value is 33 pence/min, with a 95% Confidence Interval of 20 pence/min to 46 pence/min. The overall average over the 4 categories used is 22.4 pence/min. This is consistent with the reported value of 21.1 pence/min for a similar 1993 Accent/Hague study.

Valuation of Travel-Time Savings and Predictability in Congested Conditions for Highway User-Cost Estimation

This journal contains the findings of a study to develop methodologies for measuring the effects of congestion on the values highway users place on travel-time savings and predictability. The methodologies were used to generate values for factors for different degrees of congestion. The study also defines an approach for incorporating these factors in highway user-cost estimates.
The study addresses two questions about the value of travel time. First, do travelers and freight carriers place a premium on travel-time savings (or reduced delays) during periods of heavy congestion? Second, is there a separate value placed on the predictability of travel times? In answering these questions, the study develops methodologies for measuring the effect of congestion on the values that highway users place on travel-time savings and predictability. The methodologies are used to generate values for travel-time savings and predictability.

Value of Time for Commercial Vehicle Operators in Minnesota

The Value of Time (VOT) was estimated for commercial vehicle operators in Minnesota to quantify the effects of spring load restrictions. A sample was constructed from several trucking industry sources to conduct a survey. Interviews were conducted using an adapted stated preference (ASP) survey to derive an estimate to the nearest dollar. A tobit model was fit to the data from the interviews to derive the estimate for the VOT, $49.42 per hour. Variation in the distribution of values is explained in part by fleet operation: whether the firm operates as a for-hire carrier or a private carrier.

End of Report