Research Report

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Examining the Value of Travel Time Reliability for Freight Transportation to Support Freight Planning and Decision-Making

Final Report

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METRIC CONVERSION CHART

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	mega grams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE and PRESSURE or STRESS				
lbf	pound force	4.45	newton	N
lbf/in^2	pound force per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	mega grams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newton	0.225	pound force	lbf
kPa	kilopascals	0.145	pound force per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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16. Abstract

This report presents the findings of a valuation study recently conducted in Florida to quantify the freight users' willingness to pay (WTP) for the improvement of transportation-related attributes, particularly reliability. A stated preference (SP) survey was developed and administered between January and May 2016. The survey collected responses from 150 shippers, carriers, and forwarders. After rigorous data checking and validation, econometric models, including mixed and multinomial logit models, were developed to estimate the users' WTP for the improvement of transportation time and reliability. Preference heterogeneity in WTP was also explored by commodity group, product type, and various other shipment characteristics, including shipping distance and weight.

Model results indicated that the value of reliability (VOR) values ranged from $17.00 to $177.00 per shipment-hour and $1.38 to $10.20 per ton-hour, while the value of time (VOT) values ranged from $12.00 to $277.00 per shipment-hour and $0.50 to $23.00 per ton-hour among the user groups. Carriers were found with the lowest WTP compared to other freight users. The results showed large variations in WTP values when user heterogeneity sources were considered. This study contributes to the literature by providing empirical evidence in quantifying VOR for freight transportation and the impacts of user heterogeneity on the valuation of reliability. The study results will help advance the understanding of the impacts of the performance of transportation systems on the freight industry. The report also provided a brief discussion on the approaches to incorporating VOR in the benefit-cost analysis (BCA) for project evaluation and accommodating the effect of unreliability into demand models.

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EXECUTIVE SUMMARY

Today's logistics practices are moving from inventory-based push supply chains to replenishment-based pull supply chains, leading to lower and less centralized inventory, smaller shipment sizes, and more just-in-time deliveries. As a result, industries are now demanding greater reliability in freight transportation than ever. Delays and uncertainty in freight transportation translate directly into additional inventory, higher costs of manufacturing, less economic competitiveness for businesses, and higher costs of goods that are being passed on to the consumers. Given the growing demand in freight transportation, the emerging needs to better understand freight behavior for better policy and investment decisions, and the increasing role of reliability in freight transportation, this project aims at providing (a) better understanding of how the freight system users value travel time reliability in their transportation decisions and (b) advanced methods and tools in evaluating the effectiveness of alternative freight management and operational strategies.

To understand how the freight industry values travel time reliability in their transportation decisions, and particularly the presence of user heterogeneity, this study conducted a stated preference (SP) survey. A comprehensive SP survey design framework was proposed. Considering the differences in how the users perceive cost and transportation reliability, this framework covers all user groups (i.e., shippers with and without transportation, carriers, and forwarders) in four transportation modes, along with various other market segments. Four choice experiments were developed, each focused on different attributes and trade-offs among the attributes. The respondents are assigned to different experiments according to their indications on the willingness to shift mode (between road and rail) and time of day (peak and off-peak hours).

The survey mainly consisted of three major sections: typical shipment information, stated choice preference questions, and background and attitude questions. The last part of the survey was made optional to reduce respondent burden. Reliability was measured as the standard deviation of travel time and presented as frequency of on -time and late delivery in the choice scenarios, based on the feedback received during the pilot stage.

The survey collected 1,226 responses from 159 firms in Florida between January and May 2016 via both online and paper methods. Although the proposed survey framework and design cover all freight modes, including road, rail, air and waterways, this study was only able to collect enough sample for truck mode. Therefore, the model analyses in this report were limited to roadway freight.

Various modeling approaches were explored to estimate the willingness to pay (WTP) measures among freight users, including multinomial logit (MNL) models, mixed logit models, and incorporating interaction effects. Since multiple responses were collected from individual respondents, the panel data approach was also adopted to address the limitation of violation of independence of irrelevant alternatives (IIA). Market segmentation and interaction modeling techniques were employed to investigate preference variations among users groups, commodity groups, product type, and various other shipment characteristics, including shipping distance and weight.

In general across all groups in the sample, a value of $37.00 per shipment-hour ($1.53 per ton-hour) for travel time savings and $55.00 per shipment-hour ($3.81 per ton-hour) for improvements of reliability were found in this study. Among the user groups, the value of time (VOT) values ranged from $12.00 to $277.00 per shipment-hour or $0.50 to $23.00 per ton-hour, while the VOR values ranged from $17.00 to $177.00 per shipment-hour and $1.38 to $10.20 per ton-hour. Carriers showed the lowest WTP, probably because they bear these additional costs directly. Shippers without transportation exhibited the highest VOT values, and shippers with transportation had the highest VOR values. As expected, shippers with transportation showed the greatest RR values followed by carriers, indicating that shippers without transportation value reliability relatively less than time savings compared to other groups.

As expected, perishable products showed higher VOT and VOR values than non-perishable products, as both time savings and reliability are important in shipping perishable items. Also, higher RR values for perishable products indicated that reliability was relatively more important than time savings compared with non-perishable products. Similarly, agriculture and food products reflected the highest VOT and VOR values, and RR values among the commodity groups. Furthermore, while investigating the effects of shipping characteristics on the user's preference in WTP, the results suggested that shipping distance and weight were the two most important variables.

The results from this study highlighted the importance of user heterogeneity in studying WTP for freight users. This study provided empirical evidence in quantifying VOR in freight transportation and the impacts of user heterogeneity. The study results help advance the understanding of the impacts of the performance of transportation systems on freight transportation, which will lead to policy and investment decisions that better serve the needs of the freight community. This study is subject to the sample limitation. Future work can expand the geographic scope of the study and explore other model techniques to further examine the taste variations in freight transportation decisions.

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1 INTRODUCTION

Freight transport is the backbone of the nation's economy. The efficient flow of freight is essential for the competitiveness of American industries in the global economy. The performance of the freight transportation system also has direct implications on the standard of living and the social and environmental goals of the communities. In 2012, the U.S. transport network carried more than 32.0 million tons of goods worth nearly $37.3 billion (Margreta et al., 2014) and the number of freight tons is expected to increase by 62 percent by 2040 (Strocko et al., 2014).

Increasing congestion is expected to accompany this growth, as there are obvious limitations in the capacity of the nation's freight transportation system to carry the movements of goods and services. Schrank et al. (2012) reported that congestion alone cost the nation $121 billion in 2011, an increase of 30% since 2000. Similarly, a study sponsored by the Federal Highway Administration confirmed that highway bottlenecks cost the trucking industry more than $7.8 billion annually (Cambridge Systematics, 2005)

Effective freight planning relies on the ability to identify the needs of the various sectors of the freight community and assess their responses to planning and management strategies. As freight users constantly adapt to changes in the transportation system, through mode shifts, temporal and route shifts, moving points of manufacturing, and shifting points of entry, etc., understanding the pattern and sensitivity of the demand is critical to freight investment and policy decisions.

Today's logistics practices are moving from inventory-based push supply chains to replenishment-based pull supply chains, leading to lower and less centralized inventory, smaller shipment sizes, and more just-in-time deliveries. As a result, industries are now demanding greater reliability in freight transportation than ever. Delays and uncertainty in freight transportation translate directly into additional inventory, higher costs of manufacturing, less economic competitiveness for businesses, and higher costs of goods that are being passed on to the consumers.

Given the growing demand in freight transportation, the emerging needs to better understand freight behavior for better policy and investment decisions, and the increasing role of reliability in freight transportation, this project aims at providing (a) better understanding of how the freight system users value travel time reliability in their transportation choices, and (b) advanced methods and tools in evaluating the effectiveness of alternative freight management and operational strategies. The study results will facilitate local, state, and national agencies in evaluating and prioritizing alternative investment and policy strategies that promote the best use of the freight transportation system and support the needs of the freight stakeholders.

Given the above motivation, the specific objectives of this study include:

1. Synthesize existing studies on the value of reliability, focusing on freight movement, and identify knowledge and data gap;
2. Conduct stated preference survey among freight system users to understand their transportation choice decision-making;
3. Develop econometric models to estimate value of reliability by stratification, such as, commodity type, trip length, and business type, etc.
4. Recommend a framework to incorporate the value of reliability in freight analysis and project evaluation processes.

This report starts with the literature review chapter, which summarized theories and existing studies relevant to the valuation of travel time reliability in freight transportation, followed by a description of the survey design. The next three chapters describe the proposed survey framework and design, the lessons learned from the pilot survey, and the final survey questionnaire. Chapter 6 and 7 summarizes the survey implementation and survey results. Chapter 8 presents the modeling efforts in estimating value of time (VOT) and value of reliability (VOR) values for various user groups and shipment characteristics. Chapter 9 discusses the recommended framework and approaches to incorporating the study results into freight planning and project evaluation, and the final chapter concludes this study.

2 LITERATURE REVIEW

Starts with an overview of the logistics industry, this chapter reviews the importance of travel time reliability to the industry, and summarizes major studies in travel time reliability research in terms of the definition of reliability, the methods to measure value of reliability, the empirical studies, the market segment, and the modeling techniques.

2.1 Overview of Logistics

In general there are three parties involved in the logistics decision-making process: the shipper, the receiver, and the carrier (Small, 1999). Typically, shippers, which include mainly the distribution mangers of a manufacturing firms, are those who send their goods to the receivers, whereas receivers are customers, retailers, or the purchasing, inventory managers of manufacturing firms; and carriers are the transportation firms that provide services to the shippers. Usually, receivers give orders to shippers with the amount of products required and the desired delivery schedule. By choosing shippers, receivers create demand for shippers' goods, and pay for the products. On the other hand, shippers (those who do not own any transport) select carriers for the transport of the goods, and carriers are responsible to transport the goods from shippers to receivers within scheduled time. Carriers take the decisions independently on the transport mode, route and travel time. However, these decisions often are influenced by different factors, such as logistics cost, commodity value, the level of inventory stock, reliability, loss and damage and so on.

Guo and Gong (2012) proposed a multi-layer theoretical framework to present the complex underlying interactions among different stakeholders in the freight industry. The study interviewed seven stakeholders from different industries and conducted an extensive literature review on firms' logistics systems. The framework put customer demand and services in the first layer at the core of the system, as shown in Figure 1. The activities and interactions among the components in the framework are influenced by the recent trend moving from "Push strategies (firms first asses the demand based on past data/experiences, then supply those products to the local distributors) to "Pull" strategies (customers' demands are assessed at the local level, then orders are placed in the factories accordingly).

The most challenging part of this paradigm shift is to assess the demand accurately and to select the percentage of the customer demand that should be satisfied with on-hand inventories, which dictates three important components of the process: the policy on inventory and ordering, the firm's structure and facility location, and the purchasing procedure, which are shown in the second layer in Figure 2-1. Although purchasing goods and selecting suppliers do not have any direct impact on freight transport, other activities such as inventory and ordering goods dictates the shipment size and schedule, whereas planning a firm's structure and facilities influences the long-term commodity flow of the firms.

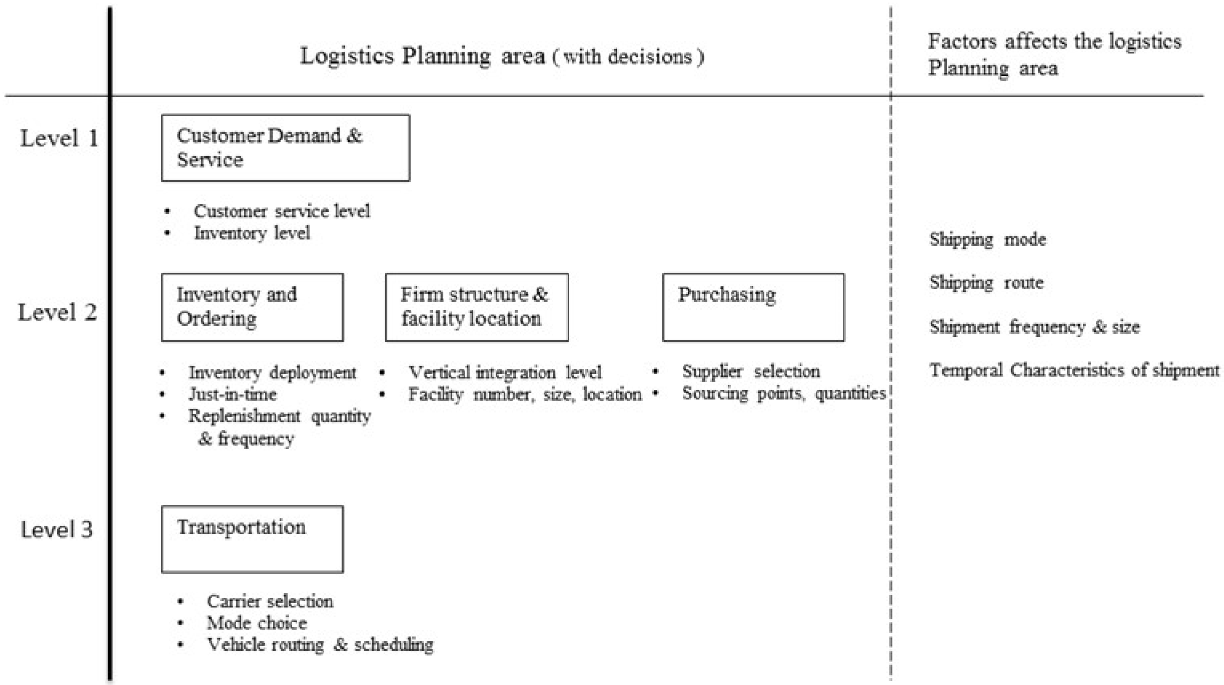


Figure 2-1: Overview of logistics management process (source: Guo and Gong, 2012)

The inventory and ordering process, from freight transport's point of view, involves the transportation and storage of commodities, and relates to all other components of the logistics management process. Inventory and ordering strategies can be discussed from two perspectives, one focus on the supply of finished products, and the other on the supply of raw materials for production use. For the supply of finished products, there are two types of inventory management, as indicated previously, "Push approach" and "Pull approach". In the "Push approach", local demand is assessed and inventory management at all levels is designed in such a way that the demand is met at a satisfactory level; here, raw materials are first passed on to the manufacturers, then manufacturers push the finished products to distribution centers, which again in turn serve the customers demand. On the contrary, the "Pull approach" involves all decisions from manufacturing to delivering products based on the customer's need or orders. Since this approach does not depend on on-hand inventory, it demands a highly reliable and timely delivery of products; otherwise, it runs the high risk of losses. For the supply of raw materials, firms use either the advanced buying or just-in-time (JIT) strategy. While advanced buying may not have an impact, the impact of the JIT strategy on freight transport planning is significant. For example, JIT is favorable as long as supplies come in at scheduled times because this prevents the need to manage inventory, which in turn reduces overhead product costs. However, the consequence of a missed shipment may be more severe. Basically, the activities at the second level set up the basic operations for firms, such as establishing the commodity flow, and production strategies, etc.

The final layer of the process is the transportation services that focus on how goods are actually moved from one location to another. Typically, this involves making decisions about transportation modes, routes, and service providers. However, the decision making process of this stage depends on the firm's policy on the transportation of goods. A firm's policy will determine whether to use the firm's vehicles, contract a carrier, or use of a third party (3PL) service provider. The amount of responsibility that a firm is willing to relegate influences the hire of a carrier firm or third part service provider (3PL). The simplest definition of a 3PL is a company that works with shippers to manage their logistics operations. Logistics can include elements of warehousing, transportation management software, freight rate negotiation, in-depth reporting, forecasting, freight bill auditing and much more. There are literally thousands of 3PLs in the market that have different models and perform different tasks. Some 3PLs will specialize in certain industries, frozen food for example. Others might specialize in one specific area of logistics such as auditing freight bills, warehousing or providing logistics related software. One advantage of using a third party service is that the service provider arranges everything for the shippers, from transport to the warehouse facility. This results in reduced cost, expedited delivery, and reliability.

2.2 Consequences of Unreliability in Freight Industry

Unreliability in travel time has been a major source of concern in freight industry for a long time. Previous studies (Al-Deek and Emam,2006;List et al.,2012) found that factors, such as traffic incidents, weather, work zones, fluctuations in demand, special events, traffic control devices, and inadequate base capacity are the main sources of travel time unreliability on road networks. Not only does congestion affect business logistics, it also shrinks business market areas and reduces the agglomeration economies of business operation (Weisbrod et al., 2001).

The cost incurred by freight delays could be categorized into four types which are excess holding cost, additional labor cost, losses due to stock-out, and the risk of losing customers/business (McKinnon, 1998). Situations may become complicated when multiple deliveries come late, and shipments are to wait for clearance in the unloading areas. Moreover in case of cross-docking operation, where products from a supplier or manufacturing plant are distributed directly to a customer or retail chain with marginal to no handling capabilities, the issues will escalate quickly. Typically firms keep a safety stock in order to avoid running out of stock which depends on factors such as lead time, uncertainty about the lead time, customer demands, and uncertainty about demand during the lead time. Again, this excess stock comes with higher inventory-carrying cost. While a single late delivery may not affect operations significantly, regular and frequent delays may drive away business or deter future customers.

From a manger's perspective, freight delays can be classified into five levels (McKinnon et al., 2008), including

- Level 1: delays are accommodated within normal operating procedure.
- Level 2: temporary redeployment of staff and equipment at minimal cost.
- Level 3: temporary deployment of additional resources such as overtime working.
- Level 4: delay to the next link in the supply chain – such as an outbound departure.
- Level 5: missed connection – more serious consequences involving the possibility of an out-of-stock situation, loss of sales and underutilization of outbound transport.

The lower levels of delay (level 1-3) can be accommodated by normal operating procedures, by doing nothing, or by assigning labor and equipment to the issue. However when delays are longer (level 4-5), there exists a great probabilities of delaying in outbound departures, an out-of-stock situation, loss of sales, and under-utilization of outbound transport.

Fowkes and Whiteing (2006) investigated delay in terms of disutility from a production point of view. In this paper, the author stated that disutility is minimized at the optimal departure time, but it increases slowly for a slack/buffer time period and continues to rise for some time due to redeployment of resources. Finally, it reaches a stage where disutility no longer matters as shipments are likely to be missed by then. Fowkes et al. (2004) also highlighted a few possible opportunity costs to freight shippers while analyzing it from the supply side. In the case of reliable transport, shippers can consolidate multiple deliveries and even plan for two-way operation, thus saving operating costs and reducing journey times.

Facing increasing traffic congestion, a report from the Netherlands (Kuipers and Rozemeijer, 2006) summarized the responses taken by freight shippers and carriers. Shippers mainly allow more time for transport, making use of information communication and technology (ICT) for short mitigation, and planning for more distribution centers in the future. On the other hand, carriers are focusing more on the early departure of trucks, operating at night more frequently, using more vehicles, and consolidating the transport networks in the long run. In either case, taking into account reliability plays an important role in their operation decisions.

2.3 Travel Time Reliability – Freight Perspective

Travel time unreliability can be defined as the unexpected deviation from the expected duration of travel. Travelers develop the mental basis for expected journey time through their travel experiences or from external sources (i.e. online sources), and make their travel plans accordingly. However, journey times are likely to vary in real life; congestion is the main source for the variation. This causes travelers to allocate additional time, or adjust the departure time for the next destination. In view of that, travel time reliability can be regarded as the degree to which randomness in journey time is realized. Although this randomness is hard to measure, travel time reliability can be quantified statistically based on the variance of travel times. Lower variation in travel times means higher reliability (Zamparini and Reggiani, 2007).

Although travel time reliability has been defined by agencies and researchers in a variety of ways, it can be broadly categorized into two categories. The first is based on the variation in travel time, and the other involves the probability of success or failure against a pre-established threshold travel time (List et al., 2012). The following are a few definitions that have been adopted by different agencies:

- National Cooperative Highway Research Program (NCHRP) defined travel time reliability as a measure of variability that can be measured using the standard deviation of travel time (Cambridge Systematics et al., 1998).
- Florida Department of Transportation (FDOT) defined reliability as the percentage of travel that takes no longer than the expected travel time, plus a certain acceptable additional time (FDOT, 2000).
- The Texas Transportation Institute Urban Mobility Report made a distinction between variability and reliability of travel time. The Report stated that

variability refers to the amount of inconsistency of operating conditions, while reliability refers to the level of consistency in transportation service (Schrank and Lomax, 2003).

- Federal Highway Administration (FHWA) defined travel time reliability as the consistency or dependability in travel times, as measured from day-to-day, and/or across different times of the day (TTI, 2006).

From the freight perspective, users are more concerned about the scheduled arrival of shipment. Hence, researchers in freight studies have employed slightly different definitions for reliability. Some definitions are given as follows:

- The absolute or relative variations in transit/travel times (Winston, 1981; Halse et al., 2010; Significance et al., 2012)
- Delay from the preferred/scheduled arrival time (Small, 1999; Fowkes et al.,2004; Halse et al.,2010; Significance et al.,2012)
- The percentage of deliveries/shipments that arrive within scheduled time (Bolis and Maggi, 2003; De Jong et al., 2004; Beuthe and Bouffioux,2008)

In supply chain and logistics terms, shippers make agreements with the customers to deliver the shipment within an agreed timeframe. The formality of the time of delivery agreement between the customers and shippers can vary, while sanctions for lateness are usually included. When a delivery fails, the shippers run the risk of incurring losses which can be financial or in terms of reputation. At the same time, customers have to rush for production, assign extra labor, and more importantly, face the possibility of missing an outbound delivery. If these events happen regularly, a business may not survive. Therefore, freight transport users are very likely to pay extra in return of more predictable transport.

2.4 Value of Reliability – Mathematical Formulation

Value of reliability (VOR) refers to the monetary value that users are willing to pay to reduce travel time variability when moving shipping goods from one place to another. In the past, two approaches have been most commonly used to estimate VOR in freight transportation: random utility maximization (RUM) and inventory based (Bone et al., 2013). The first one attempts to identify the key decision makers (i.e. shippers, carriers, customers) and to maximize their utility using discrete choice models. The second one attempts to quantify VOR from the integrated logistics approach using inventory-based models.

2.4.1 Utility-Based

Utility based behavioral model has been widely used to estimate the VOR for freight transportation. By definition, utility is a measure of the relative attractiveness which a decision maker tries to maximize through his or her choice(s). The critical assumption of this model is that decision makers (i.e. shippers, carriers, customers) perceive some monetary values to avoid uncertainty in shipment times; thus an equivalency between the reliability of travel time and cost can be derived that gives the estimate of VOR. In this attempt to maximize utility, the user is forced to trade-off reliability and shipment cost (Winston, 1981; Small, 1999; etc.). When this is considered, equilibrium between travel time reliability and cost can be derived in order to estimate of VOR. If n individuals face with J alternatives in T choice scenarios, the choice can be modeled as:

$$y_{int} = \begin{cases} 1, & if\ U_{int} > U_{int}\ for\ j = 1, .., J \\ 0, & otherwise \end{cases} \tag{1}$$

$$Utility, U_{int} = V_{int} + \epsilon_{int} \tag{2}$$

where V_{int} is the deterministic part of the utility, which can be expressed as:
$V_{int} = \sum_k \beta_k X_{intk}$ (for linear-in-attribute case), and ϵ_{int} is the error term (Ben-Akiva and Lerman, 1985).

Now, the VOR can be easily estimated by first taking the total derivative of utility (U_{int}) with respect to changes in the reliability attribute (X_r) and the cost attribute (X_c). When this is set to zero it yields:

$$VOR = \frac{dX_c}{dX_r} = -\frac{\beta_r}{\beta_c} \tag{3}$$

Based on how travel time reliability is defined, the studies which were reviewed were classified into three groups: mean-variance based approach, scheduling based approach, and on-time delivery based approach.

2.4.1.1 Mean-Variance Based Approach

The mean-variance based approach measures the variations in travel times. This method can be traced back to the work of Jackson and Jucker (1982), where a model was proposed to study the choice behavior of travelers who seek to trade between travel time and its variability explicitly. The most critical assumption of this model was that the users were aware of the uncertainty involved in their travel times and they try to reduce the uncertainty as well as the expected travel time.

Following this approach, Winston (1981) developed one of the first freight models which considered reliability. In this model, reliability was measured as the ratio of the standard deviation of travel time to travel time. The model also considered other variables describing modal attributes and firms' characteristics such as production plan, desired lot, daily quantity received, and attitude towards risk. However, recent have used solely the standard deviation of travel time as reliability measure studies (Halse et al., 2010; De Jong et al., 2014). Thus, the formulation of the utility function is as follows:

$$U = \beta_c C + \beta_T T + \beta_R \sigma + \varepsilon \qquad (4)$$

where

β_T = travel time coefficient to be estimated,
β_C = travel cost coefficient to be estimated,
β_R = reliability coefficients to be estimated,
σ = standard deviation of the travel time,
T = travel time,
C = travel cost,
ε = the random error term.

2.4.1.2 *Scheduling Based Approach*

Any shipment arriving before or after the preferred arrival time (PAT) would likely to cause disutility. The theoretical basis of this approach comes mainly from the seminal work of previous researchers (Gaver, 1968; Knight,1974), while Small (1982) was the first that incorporated schedule delay (both early and late) directly in the utility functions to investigate the travel behavior towards early or late arrival at the work place, as shown below :

$$U = \beta_c * C + \beta_T * T + \beta_{Early} * SDE + \beta_{Late} * SDL + \Theta * D_L \qquad (5)$$

where

β_{Early} = coefficient of early arrival,
β_{Late} = coefficient of late arrival,
SDE = schedule delay early (in number of minutes earlier than preferred),
SDL = schedule delay later (in number of minutes late than preferred).

The study estimated freight users' willingness to pay in order to avoid early or late arrival shipments from their choices. Their choices reflected their trade-offs among attributes such as delay, cost, and travel time.

Later Small (1999) extended the model for the uncertain condition, by incorporating the stochastic characteristics of travel time reliability in the utility functions. The main hypothesis is that, since users will not be able to anticipate their transit time beforehand, every departure time (t_d) corresponding to that transit time they choose will now be associated with the probability of occurrence. Hence, the utility function (which is expected now) can be written as a function of travel time distribution, and the utility is maximized when they choose the optimal departure time (t_d). The expected utility function is as follows:

$$\begin{aligned} E(U) &= \int_0^\infty U\,(t_d) f(T) dT \\ &= \beta_c C + \beta_T E(T) + \beta_{Early} E(SDE) + \beta_{Late} E\,(SDL) + \Theta E(D_L) \end{aligned} \quad (6)$$

where $E(X_1, \ldots, X_n)$ is the expected value of attributes $(X_1, \ldots \ldots, X_n)$.

Nevertheless, the literature indicated that few freight studies (Kurri et al., 2000; Gong et al., 2012) used SDE and SDL directly in their utility functions without taking into consideration the probability function. Others argue that values estimated from the latter approach may not truly represent unreliability because individuals in this case make decisions without uncertainty (Carrion and Levinson, 2012). For example, if carriers are aware of congestion, they may adjust their departure time, and can be certain that the shipment will arrive on time which essentially violates variability in travel time.

It should be noted that a theoretical equivalence between the scheduling-based approach and the mean-variance based approach can be drawn under certain assumptions (Fosgerau and Karlstrom, 2010). The main assumptions include that the travel time distribution is independent of departure time, there is no discrete lateness penalty, the departure time is continuous, and there is no congestion. Many studies in the freight context used the scheduling approach more often, but this equivalence shows the promise to bridge the gap between these two approaches.

2.4.1.3 On-Time Delivery Based Approach

The on-time delivery approach measures reliability according to the percentage of shipments arriving on time. As shown in table 1, this approach has been used extensively in past studies. It is possible that the frequency of its use is related to its explicit meaning and similarity to inventory management; this is impactful as it may make it easier for respondents to understand and make trade-offs between attributes. The utility function for this approach is as follows:

$$U = \beta_c C + \beta_{ont} X_{ont} + \varepsilon \quad (7)$$

where

β_{ont}= coefficient for on-time delivery based reliability,

X_{ont}= the percentage of delivery arrived on-time.

In summary, three main measurement approaches, including scheduling, mean-variance, and on-time delivery have been used in freight studies. The discussion revealed that each of these methods makes different assumptions and has slightly different formulations, which are to blame for variability in estimated values. The primary difference among these three approaches is that on-time delivery reflects the user's willingness to pay for an improved ratio of on-time deliveries, while scheduling relates more to the user's willingness to pay to avoid late arrivals; the mean-variance based approach focuses more on variations in travel time.

From the theoretical perspective, it may be preferable to use the scheduling-based approach as it directly measures deviations from the pre-determined schedule. However, the most suitable approach greatly depends on the intended use of the estimate. For instance, some studies preferred to use the mean-variance approach over other approaches because the VOR values derived from this model can be easily incorporated into the existing travel demand model framework and the project appraisal stages without any major modification (Halse et al., 2010; De Jong et al., 2014; De Jong and Bliemer, 2015).

2.4.2 Inventory-Based

Inventory-based model, on the other hand, considers transportation and inventory decisions jointly/together while estimating the VOR. The background for this method draws upon the traditional economics theorem where optimum order size, also known as economic quantity of order (EOQ), is determined by minimizing the cost function. Typically, the cost function considers all possible incurring costs, such as purchase, order, in transit and holding cost, which are again functions of the average annual demand quantity and reorder point (at this level new order is placed for stock replenishment, as shown in Figure 2-2).

When the demand and lead time are deterministic, the inventory manager can order at the reorder point level to avoid stock-out. This point can be directly determined from the annual average demand quantity and lead time (the time between the ordering and receiving the shipment). However, in reality, demand and lead time are hardly deterministic. There are considerable amount of uncertainty involved in estimating the lead time and demand, especially during the lead time. These variations, which are also unreliability, can be incorporated into the inventory model through the stochastic consideration of lead time, and demand during lead time (Paknejad et al., 1992; Nasri et al., 2008).

These concepts can be better explained, with the assumption that demands during lead time follows normal distribution (Fetter and Dalleck, 1961; Dullaert and Zamparini, 2013). Then, the variation of demand during lead time and safety stock can be expressed as follows (Eq: 8 & 9):

Standard deviation of demand during lead time,

$$\sigma_{DDLT} = \sqrt{(L\,\sigma_D^2 + D^2\,\sigma_L^2)} \qquad (8)$$

Safety stock,

$$SS = k\,\sigma_{DDLT} \qquad (9)$$

where

L = lead time,
D = annual average demand ,
σ_D^2 = variation in demand,
σ_L^2= variation in lead time,
k = safety factor multiplier.

When these expressions are put into the main cost function, the impact of the reduction in lead time, L and the variation in lead time σ_L^2 on total cost can be quantified, which are simply VOT and VOR. Thus, VOT and VOR can be derived as the amount of savings in total inventory costs due to reduction in lead time and the variation of lead time.

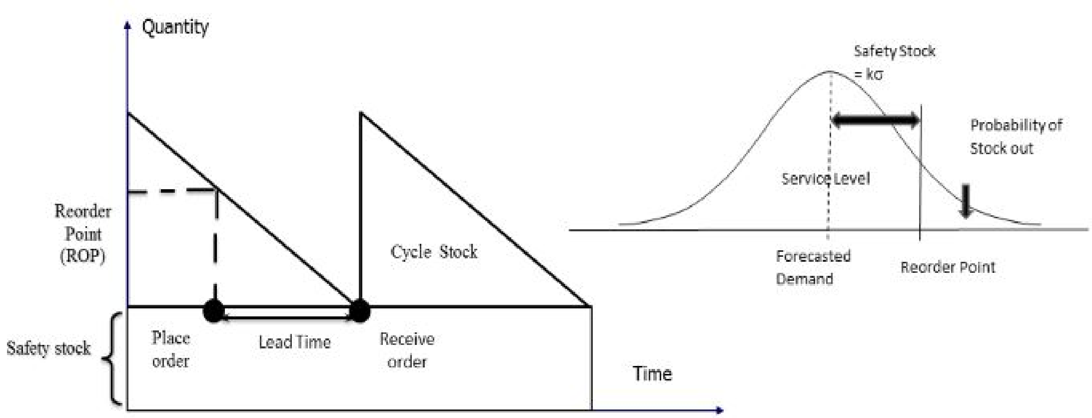


Figure 2-2: EOQ model and stochastic distribution of demand during lead time

Besides utility based and inventory based methods, a small group of studies employed the profit maximization or cost minimization approach (Bergkvist and Westin, 2001). It uses a cost function where all attributes including shipper's quantity, transport related modal attributes, firm characteristics, and shipment characteristics are converted into a generalized cost. From this it attempts to minimize the cost, or maximize the profit, for given constraints. The underlying assumption of this model is that a user is likely to choose the transport option with the lowest cost

2.5 VOR-Modeling Techniques

As indicated in the previous section, there are two approaches, the inventory based model and the utility based behavioral model, which have provided the foundation to quantify VOR in freight transportation. This section provides a detailed discussion on these two methods to estimate VOR. In the utility based behavioral model, the focus has been on the identification of economic agents (i.e. shippers, carriers, customers, or something else along the chain) and the maximization of its utility. The inventory based model, on the other hand, follows a more holistic approach that considers all kinds of possible costs incurred along the supply chain such as transport cost, labor cost, and varying inventory cost due to varying lead time and degree of service level.

2.5.1 Utility-Based Model

2.5.1.1 Model Structure

Various model structures have been used in freight studies in order to better fit the data (Ben-Akiva and Lerman, 1985; Garrow, 2010) and often to accommodate heterogeneity (user's preference towards taste) in the model estimation (Marcucci and Gatta, 2012). Logit models, including multinomial logit (MNL) and mixed logit (ML), were the most commonly used to analyze SP data. Earlier studies mainly used MNL models which require the user to assume that the error terms are Independent and Identically Distribution (IID) (Ben-Akiva and Lerman, 1985). With these assumptions, the probability of individual q choosing alternative i can be estimated with the following closed form:

$$P_{iq} = \frac{\exp(V_{iq})}{\sum_{j=1}^{J} \exp(V_{jq})} \tag{10}$$

The estimation is typically based on the statistical principle of "likelihood maximization" (Ben-Akiva and Lerman, 1985). However, both rating and ranking can be analyzed as choice data through appropriate transformations (Chapman and Staelin, 1982). Previous studies, (Fowkes and Tweedle, 1996; 2001; Bolis and Maggi, 2003) used the following transformation equations 11:

$$\begin{aligned}
&If\ Rating < 100,\\
&then\ \ P_A = 1 - \left(\frac{0.5 \cdot Rating}{100}\right);\\
&If\ Rating > \ 100,\\
&then\ \ P_A = \left(\frac{0.5 \cdot Rating}{100}\right).
\end{aligned} \tag{11}$$

The greatest limitation of using the Logit model for SP design is the violation of the Independent and Identically Distribution (IID) across individuals, alternatives, and choice situations as responses are collected multiple times from same individuals. Later studies adopted several techniques to overcome this limitation. One such technique is to re-sampling (i.e. jackknife) the dataset before model estimation (De Jong et al., 2014). This eliminates systematic bias by taking the average of the estimated model parameters for each sub-sample (De Jong et al., 2014). However, the MNL model can provide only the mean effect of model parameter on the utility because of its assumptions. As a result, most freight studies accommodated heterogeneity by developing separate models for different market segments or interacting variables with the main attributes in the model (see Table 2-1).

Mixed Logit (ML) has also been used to relax the restrictions imparted by the IID assumption and to capture individual preferences in the model parameters (Halse et al., 2010; De Jong et al., 2014; Masiero and Hensher, 2010). ML models use the same utility function as MNL, but assume continuous or discrete distribution for the coefficients (instead of fixed values such as in MNL). In that sense, ML is an extension of MNL, and becomes MNL when there is no statistically significant deviation. The mixed logit model can be expressed for individual q in choice situation t choosing alternative j as follows:

$$U_{jtq} = \beta_q' X_{jtq} + \varepsilon_{jtq} \tag{12}$$

where

ε_{jtq}= error component which is correlated across individual q,

β_q'= coefficient distributed randomly across individuals.

Since there is no closed form expression for this model, it can be solved using simulation techniques with the following log-likelihood equation 13:

$$Log(L) = \sum log \int \prod (P_{njt})^{yn}(1 - \ Pnjt\ )^{1-\,yn} d, G(\alpha \,\big|\, \delta) \tag{13}$$

where

$G(\alpha \mid \delta)$ = mixing function given the distribution function of α,

δ = parameters of the distribution,

α = random error component.

Because α is the random error component, its mean is assumed (and forced) to be 0 while δ is a measure of its dispersion, or standard error.

A few important remarks on the use of the mixed logit model:

- Since one (or more) of coefficient is no longer fixed, the researcher must assume an underlying distribution. This can be either a continuous distribution or a discrete distribution. In the case of a continuous distribution usually a specific statistical distribution is employed such as normal or lognormal. By simply examining whether the standard deviation is zero or not, the performance of mixed logit model over MNL can be tested (Hensher et al., 2005; Significance et al., 2012)
- The number of draws be used for simulation needs to be previously specified.
- Sometimes, complicacy arises while specifying the continuous mixed logit model, but can be overcome by latent class or non-parametric techniques (Fosgerau, 2007; Significance et al., 2012).

However, most of previous studies were unable to estimate statistically significant coefficients due to inadequate sample size (Halse et al., 2010; De Jong et al., 2014). One of the advantages of ML is that the limitation of IID violation can be addressed in model specifications.

In addition, the literature showed that other models such as latent class model (LCM) and heteroskedastic multinomial logit (H-MNL) have also been used; these models were mostly used to capture unobserved heterogeneity of freight users (Puckett and Rasciute, 2010; Masiero and Hensher, 2012). Theoretically, LCM is an alternative form of ML. LCM assumes a discrete class of distribution of coefficients rather than continuous, but offers more advantages. For example, it provides a closed-form solution, which reduces the computational burden, and the estimation of this model does not depend on the distribution assumption as it uses the probabilistic function which improves the estimation accuracy (Hensher et al., 2005).

While investigating mode choice among freight users in another study in the Friuili Venezia Giulia region of Italy, Zotti and Danielis (2004) found that there was considerable randomness in transport related attributes; the attributes included in the development of ML their models were travel time, reliability, damage, and losses.

Additionally, the study found two groups when LCM was developed for the same survey: one group was more interested in the travel time of shipments and the other cared more about safety. In Australia, Puckett et al. (2007) conducted a freight SP survey, with the purpose to capture the freight users' preference towards a (hypothetical) distance-based road pricing system. Using the data from this survey, Puckett and Rasciute (2010) was able to distinguish two sub-groups within the survey group for both shippers and carriers using LCM. Their findings showed that one group was more sensitive towards the cost related attributes, such as freight rate paid by the receivers of the goods and fuel cost (unlike other studies, this study used the breakdown of freight cost) and the other placed more emphasis on the on-time reliability and level of service.

Similarly, H-MNL relaxes the assumption of IID across alternatives which makes it possible to represent the scenarios with varying variance (i.e. the variance associated with travel time or reliability increases with shipment distances). For example, using H-MNL model enabled Masiero and Hensher (2012) to investigate the combined effect of shipment distance and weight on VOR values. The results indicated a positive effect for weight and negative effect for distance which implied that as distance increased the overall utility decreased, but it could be compensated by the increase of shipment weight.

Recent studies have benefited from the improvement of econometric models and the computational abilities of commercial software used in model estimation. However, it seems that there is still a need for the systematic approach of probing heterogeneity, as suggested in Marcucci and Gatta (2013). By systematically investigating heterogeneity through the model developments for the observed part (i.e. MNL models with and without interaction variables, ML, LC models), the unobserved part (i.e. error component model (EC), see Hensher et al., 2005 for more detail), or as a whole (using conjoint ML and EC model), the authors showed that only examining a single or two model structures might not be enough to reveal user's preference wholly.

2.5.1.2 *Model Specification*

According to the literature, the most recent studies have focused on formulating non-linear utility specifications and non-linear attribute functions. The main motivation for this was to explore non-additive linear specifications or attribute effects that could better explain the random errors in the model and to produce better estimations.

For example, in Netherlands, De Jong et al. (2014) found that the model shown below performed well when the error term was assumed to be multiplicative in the utility function.

$$U = \lambda * log(C + VOT * T + VOR * \sigma) + \epsilon \tag{14}$$

where λ is the scale parameter associated with error term, ϵ.

Halse et al. (2010) also had similar findings in Norway. The authors proposed a multiplicative form of error specification, with the inclusion of one additional variable which captured the systematic bias due to the order in which questions were presented; this form is shown below.

$$U = e^{\alpha L} + (C + VOT * T + VOR * \sigma)^{\mu} e^{\epsilon} \tag{15}$$

where L is the conditional variable which is equal to one if the alternative is shown on the left side in choice questions and zero otherwise. This treatment of "left side" is in line with the previous finding that the order in which information is encountered has a strong impact on choice making. As an example, information appearing early in a sequence may have a stronger influence on the choice making than does subsequent information (Kardes and Herr, 1990).

Similar to the specification, there were a few studies which considered the non-liner attribute effects in their model estimation. This has led to explain few complex user's underlying behaviors, such as risk prone or averse, which was ignored in previous studies. For example, Li and Hensher (2012) investigated the risk taking attitude among freight users (shippers and carriers) in Australia by adopting a power specification $\left(U = \frac{x^{1-\alpha}}{1-\alpha}\right)$ of travel time variable (x) for the utility function, as below:

$$U = \beta_{time} * \left[T^{1-\alpha} /_{1\ \alpha} \right] + \beta_{Cost} * C + \epsilon \tag{16}$$

where α is the coefficient of risk proneness.

Similarly, Masiero and Hensher (2012) formulated a utility function with the purpose of capturing the combined effect of variables on the overall utility. Assuming that shipment distance and weight play a significant role in freight transportation decisions, the study introduced a multiplier which is a function of all conditional variables, into the specification as shown in equation 17:

$$U = \left(1 + \beta_{ce} * CE + \sum \beta_{(ce/z)} * Z\right) * \sum_{k} \beta_k X_k + \epsilon \tag{17}$$

where

CE = conditional effect, its value will be 1 when true, otherwise 0,
β_{ce} = coefficient associated with the conditioning effect of variables, such as shipping distance and weight,
$\beta_{ce/Z}$ = coefficients associated with those variables (Z) that are assumed to be related to this effect,
X_k = all other variables.

De Jong et al. (2014) employed a relative model specification, in which the attributes were normalized by their base values, as shown in Equation 18:

$$U = \beta_c^{rel}\ {}^{C}/_{C_0} + \beta_T^{rel}\ {}^{T}/_{T_0} + \beta_R^{rel}\ {}^{\sigma}/_{\sigma_0} + \epsilon \tag{18}$$

where
C_0 = base values for transport cost,
T_0= base values for travel time,
σ_0 = base values for the standard deviation of travel time.

Since the typical shipment characteristics vary widely among the users, the use of this relative specification helps to cope with the heterogeneity by eliminating abnormal effects of any attribute on the utility in model estimation. In this regard, past studies (i.e. Gatta and Marcucci, 2016) showed that ignoring the non-linearity in attribute level tended to generate unreliable model estimates, which ultimately led to two different policy implications.

Table 2-1 provides a summary of the utility function and model structures used in past studies.

The table also shows that earlier studies (before 2000) mostly used simple MNL models, with no consideration for the violation of IIA. Recent studies (De Jong et al., 2014; Hales et al., 2010; Significance et al., 2012) took this into account, and estimated the models with different approaches. For example, De Jong et al. (2014) estimated MNL with a bootstrapping (i.e. Jackknife) technique, whereas Hales et al. (2010) estimated ML with a panel data approach; Significance et al. (2012) applied both of these techniques, but with different error specification for ML.

The literature showed that a wide number of freight transport quality attributes have been used by researchers in addition to travel time and reliability. These include travel cost, frequency (the number of shipments offered by a transport company, or any freight forwarding agent, in a determined period of time), flexibility (the number of unplanned shipments that are executed without excessive delay), and loss and/or damage (the percentage of the shipment that is damaged or lost during transportation).

Table 2-1: Utility-Based Modeling Techniques Used in Freight VOR Studies

Author	**Utility/cost function**	**Attributes**	**Model Structure**
Winston, 1981	Utility function	Transit time, reliability	
Bergkvist and Westin, 1998	Utility function	Time, cost, reliability, damage per mill	Logit models and solved with weighed Maxi LL method
Bolis and Maggi, 2003	Utility function	Cost, journey time, reliability, frequency, minimal notice time for transport orders in hours, whether road transport, whether use multimodal transport	Logistic regression model
Jovicic G., 1998	Utility function	Travel cost and time (door to door), risk of damage (per mile), delay, frequency, information system and flexibility	Hierarchical multinomial logit
Small,1999	Utility function	Travel cost, travel time, reliability	Conditional logit model
Wigan et al., 2000	Liner utility function	Travel time, reliability, damage	Logit Model
Kurri et al., 2000	Utility function	Travel time, cost, reliability	Logit Model
Bolis and Maggi, 2003	Cost function	Travel time, reliability, frequency, flexibility	Tobit model
Fowkes et al.,2004	Weighted utility function	Time, reliability	Weighted linear regression of logit transforms of the ratios of the ratings
De Jong et al., 2004	Linear utility function	Travel time, cost, reliability, damage and loss, frequency	Mixed logit; MNL with Jack knife bootstrapping
Danielis et al., 2005	Utility function	Cost, time, reliability, and damage	Probit ordered; logit model
Fowkes and Whiteing, 2006	Cost function	Cost, journey time duration, spread, early shift, late shift, lateness, lateness squared, earliness, earliness squared	Weighted linear regression of logit transforms of the ratios of the ratings
Beuthe and Bouffioux, 2008	Expected utility function	Travel time, frequency, reliability, carrier's flexibility and safety	Ordered logit model
Hales et al., 2010	Utility function	Transport cost, travel time, reliability	Mixed logit with multiplicative error; MNL with panel data approach
Significance et al., 2012	Utility function (utility space, preference)	Transport cost, travel time, reliability	Mixed logit with additive error; MNL with Jackknife bootstrapping

2.5.2 Inventory-Based Model

Typically, this type of method considers in-transit inventory cost, stationary inventory cost, freight charges, ordering cost, cost of holding stock safely, and cost of stock out. Gong et al., (2012) estimated the VOR for freight using data collected from Texas and Wisconsin regions. This study considered truck cost and in-transit cost in addition to the warehouse inventory cost, as shown below:

$$Cost_{\ overall} = C_{Truck} + C_{in-transit} + C_{Inventory\ holding} \tag{19}$$

where

$C_{Truck} = f(\text{order size, annual demand, weight of goods})$,

$C_{intransit} = (\text{mean transit time, annual demand, in transit inventory cost})$,

$C_{Inventory\ holding}$ = sum of holding cost, ordering cost, and stock-out cost, which is a function of order size, reorder point, demand during lead time, holding cost, purchasing cost, ordering cost, and lead time.

This cost function was minimized with respect to order quantity and mean transit time for two possible cases -- one with the possibility of stock out and another with no stock out -- along with other assumptions such as consideration of random lead time only, or random demand only, or both random demand and lead time. Finally, the value of reliability ($\frac{\partial C_{min}}{\partial mean\ transit\ time}$) were derived for different types of commodities (such as food, chemical, pharmaceuticals, auto, paper, electronics, clothing, other manufactures, merchandise), based on corresponding unit cost price, which were collected from the survey.

Similarly, Dullaert et al. (2013) also estimated the VOR for freight, using data from w et al. (2008). The study assumed that lead time and demand during the lead time are stochastic. Unlike the previous one, this study considered the unreliability in shipment time implicitly into the variation of lead time. The study simulated the safety stock levels for different levels of service (which is related to the company's policy to fulfill customers' demand). This estimation of safety stock for different uncertainty levels gave the opportunity to assess the amount of inventory that can be saved. Nevertheless, these amounts were quantified into monetary values by multiplying the corresponding value of goods, (600 euro per ton in the study) and the inventory holding costs, (20% per year), which reflected the monetary value that firms were willing to pay for different service levels. Interestingly, this paper also showed that empirical studies may get negative values of VOR, when the reduction in variability does not necessarily always lead to savings in inventory quantity for certain range of level of service (herein, 0.5 to 0.65).

Overall, the main drawback of the inventory based method is the firms' unwillingness to reveal this information as they fear that this may take out their competitive edge in the market. Thus, VOR estimates from most of the studies that employed inventory based models, show great variations in value.

2.6 Market Segmentation

The market segmentation for freight is particularly complex as there is no unanimous decision makers as in the case of passenger travel. As described in Section 2.1 (Overview of logistics), the responsibility of freight transport may be placed upon many different agents along the supply chain depending on the firm's structure, the firm's policy on inventory management, and policy on hiring transportation services, etc.

Literature indicates that most of the freight studies estimated VOR by transport mode or route. The decision of mode choice among the available alternatives (rail, roadway, sea, air, or a combination) is mainly based on the decision maker's past experiences, perceptions of modes, the commodity values, and time sensitivity of the goods. For instance, managers typically possess negative views towards the use of rail, whereas shipment via air is usually associated with great urgency and limited time window. Many studies (Hales et al., 2010; Beuthe and Bouffioux, 2008; Danielis et al., 2005; Kurri et al., 2000) have focused on rail and roadway, while others (Beuthe and Bouffioux, 2008; Significance et al., 2012) considered other modes such as air, inland waterways, and sea transportation. Kawamura (1999) estimated the VOT values for commercial trucks (by business type, shipment weight, pay scale) in California, with the focus on estimating the effect of congestion pricing (SR 91 corridor) asking respondents to choose between general purpose lanes and toll lanes.

Other segmentation strategies have also been implemented to take into account the heterogeneity that exists in freight transportation. Common categories are summarized below (see Table 2-2 for more detail).

- Commodity Type (time sensitivity, amount, values)
- Shipment characteristics (such as type, weight, distance)
- Firm's Characteristics (size, transport ownership, inventory management)
- Miscellaneous (time of day, congestion vs non-congestion, regional differences)

Table 2-2: Marketing Segments Used in Freight Studies

Characteristics	Segments	Studies
Modal Choice	Rail VS road and all other mode choices	Significance et al. (2012), Hales et al. (2010), Beuthe and Bouffioux (2008), Danielis (2005)
Shipment Type	Container VS Non-container	Significance et al. (2012)
Shipment Weight	Full truck load VS Partial truck load	Beuthe and Bouffioux (2008), Wigan et al. (2000)
Shipment Distance	Inter-capital/city, Metropolitan, (Single drop), Metropolitan (Multi drop)	Beuthe and Bouffioux (2008), Wigan et al. (2000), Bergkvist and Westin (2001), Jovicic (1998)
Ownership Of Transport	Shippers with or without transport Carriers	Hales et al. (2010), Fowkes (2004), Significance et al. (2012)
Commodity Type	Low value (food, drink, grocery); High value (chemicals, minerals, textiles); Perishable VS Non-perishable; Bulk VS Non-bulks; Time sensitivity (low, moderate, high)	Beuthe and Bouffioux (2008), Fowkes (2007, 2004), Erik (1998), Jovicic (1998), Small (1999)
Inventory Management	Jitney transport operation VS Non-jitney	Fowkes et al. (2004), Danielis (2005)
Inflow Or Outflow	Supply of raw materials VS Finished product	Danielis et al. (2005)
Transportation Network	Congestion VS Non-congestion	Small (1999)
Geographical limitations	Regional differences (i.e. south, north)	Fowkes et al. (2004), Bergkvist and Westin (2001), Jovicic (1998)
Miscellaneous	Firm size, time of day	Bolis and Maggi (1998), Danielis et al. (2005)

It is well established that the importance of on-time delivery is greatly influenced by the type of commodity being shipped. For example, perishable commodities like food, beverages, or fresh products are time sensitive and need to be delivered within a short time period, while non-perishable commodities such as coal, petroleum oil, and construction materials may be able to tolerant reasonable delays. Many studies categorized VOR estimates based upon commodity types.

Similarly, shipping characteristics such as distance, weight, or type (container or non-container) are critical in the estimation of VOR. Wigan et al. (2000) considered shipment weight, distance, and different types of commodities (such as finished versus unfinished, low versus high time sensitivity, low versus high value density, etc.) for segmentation. The study considered shipment traveling less than 100 km as metropolitan transport and any other distances as inter-capital shipment, but cautioned that these values were only applicable for Australia. One of the interesting findings was that shippers value reliability for urban (metropolitan) areas almost twice as much as the reliability for inter-region (intercity) shipment. Many studies (Beuthe and Bouffioux , 2008; Bergkvist and Westin, 2001; Jovicic, 1998) used shipping distance for market segmentation.

Significance et al. (2012) argued for separate estimates of VOR for shippers and carriers. The reason was that shippers are in a better position to assess the value of time and reliability related to the goods, whereas carriers are able to better relate the value of time and reliability to the cost of transport services. These statements are well justified considering that freight mangers are more focused on invested capital, value of goods, and on-time supply of raw materials for smooth production, while carrier mangers focus more on incurring transportation service related cost such as vehicle cost, staff cost, fuel cost, and so on. A few studies (Fowkes et al., 2004; Bergkvist and Westin, 2001; Jovicic, 1998; Bolis and Maggi, 2003; Danielis et al., 2005) considered firm characteristics and miscellaneous factors such as time of day, congestion versus non-congestion and regional differences.

The New Zealand Transport Agency Report (2013) recommended that market segmentation should be conducted to reflect the shippers and carriers point of view separately (Bone et al., 2013). Based on this report, in the event of significant delay the shipper's primarily concern is additional cost due to holding excess inventory, assigning extra resources, or on losses due to stock-outs. Therefore, the report proposed the following four types of market segments, as shown in Figure 2-3:

- Ordering/Delivery Time Tightness. Segmentation based on the constraint of the time available for delivery, and any constraints on the delivery window.
- Degree of Product Customization. Segmentation based on the range of products offered; ranging from undifferentiated products to supply a market on the traditional push-production stockholding approach to highly customized products using the pull-production, or lean or zero stocking approach.
- Loss of Product Value with Time. Segmentation based on the sensitivity of commodity value loss with time.
- Opportunity cost of commodity stock value. Segmentation based on the value tied to holding the commodity, which can be represented by the opportunity cost of investment per ton or other appropriate unit.

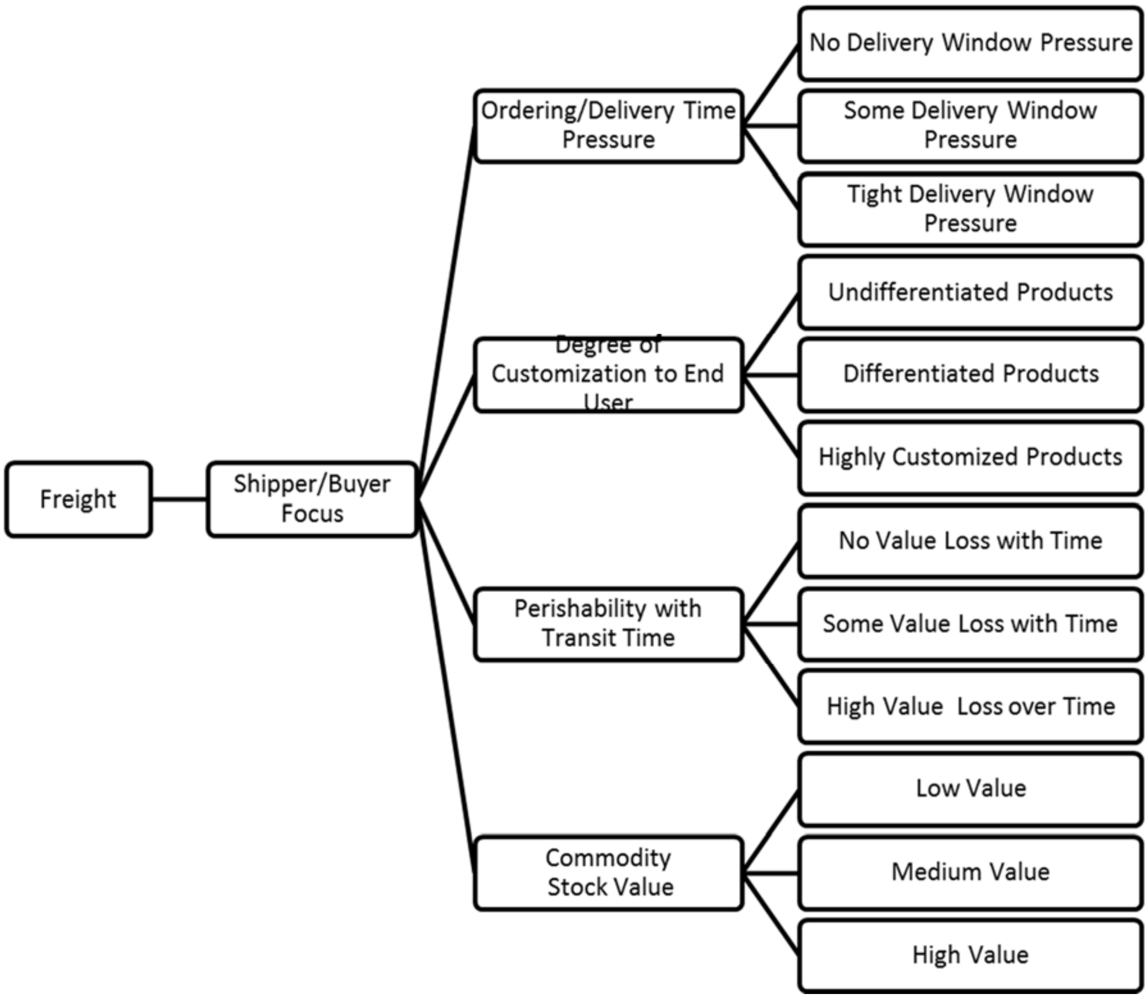


Figure 2-3: Proposed market segmentation for shipper/buyer (source: Bone et al., 2013)

On the contrary, carriers put more emphasis on minimizing vehicle/overhead cost and maximizing the utilization of transport and staff. In order to do that, carriers often take certain factors into consideration. One of these factors is the volume of shipment (full truck load or less than full) which dictates whether more shipments have to consolidate or not. Another factor considered is shipment distance and the type of commodity determines which mode (road, air, sea, inter-urban, inter-region, and international). Ultimately, the carriers decide on the route and mode to be used for a shipment.

Factors that influence the decisions on the carrier's sider are illustrated in Figure 2.4 below.

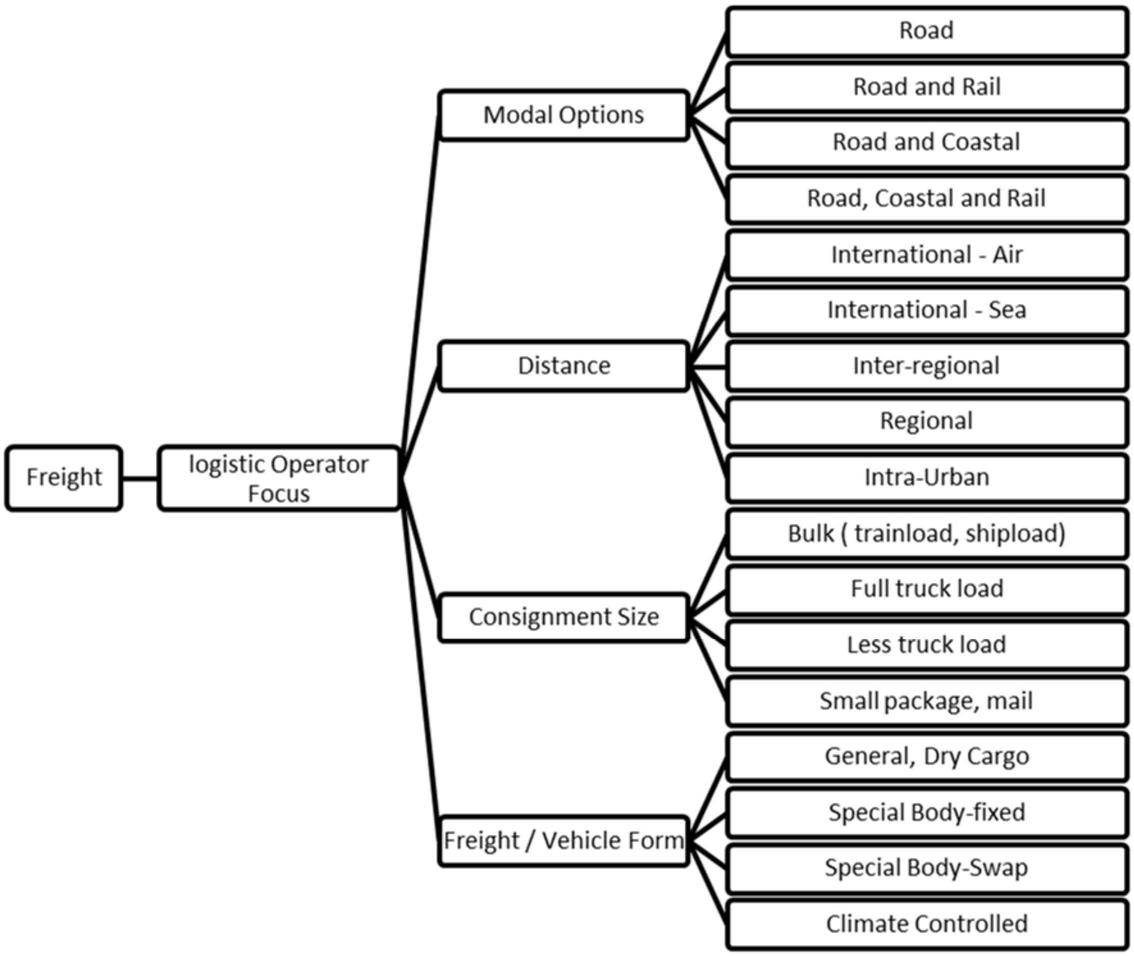


Figure 2-4: Proposed market segmentation for transport operators (source: Bone et al., 2013)

2.7 Stated Preference Survey

This section focuses on the stated preference survey techniques used in freight VOR studies. It provides an overview of the SP method, the steps involved in the survey design, and a comparative summary of the survey design drawn from previous studies. Literature shows that SP method is also referred to as "conjoint analysis" or "choice modeling" in other fields: marketing.

2.7.1 Background

Choice experiments have a long history dating back to the early nineteenth century, when Thurstone (1927) tried to estimate indifference curves experimentally by asking people to make choices between different combinations of coats, hats, and shoes. Later on, these experiments were studied extensively (e.g. Bradley and Terry, 1952; Davidson and Farquhar, 1976; Wardman, 1988) by experts from different professions (i.e. marketing, psychology, economics, etc.). Davidson (1973) and Louviere et al. (1973) were the first to publish papers in the transportation field using this technique. Following this research, many studies were conducted (Louviere and Hensher, 1982; Louviere and Woodworth, 1983; Louviere and Kocur, 1983; Green and Srinivasan, 1990), which contributed to the escalation of preference experiments to its current state.

2.7.2 Different Types of Experimental Designs

The experimental design of a SP study can be categorized into three classes based on the types of the response variables:

- **Rank based experimental design**. In this method, proposed by Chapman and Staelin (1982), individuals are asked to rank the alternatives, which are then translated into choice responses. Although this type of design allows for more information about the alternatives, the method was questioned by researchers (Ben-Akiva et al., 1992), because of the monotonic translation of ratings into utility scales.
- **Rate based experimental design**. In this method, proposed by Krantz and Tversky, 1971, all options are presented to individuals who are then required to rate the hypothetical options in order of preference, thus implying a hierarchy of utility values. This type of response requires respondents to express the strength of their preferences on numerical or "semantic" scales (preferably, 1 to 10). Like the previous method, this survey design has limitations such as the validity of monotonic translation of rating into utility scale as error components vary among models and naïve assumption that respondents can consistently rate the options. However, this approach provides the richest type of response data, if one can assume that the scores are cardinal in measurement. The power of the technique improves with the fineness of the scales used.
- **Choice based experiment design**. In this method, the individual simply selects the most preferred option from a pair or group of options that comes closest to achieving the goal. The development of suitable analytical procedures, such as the logit model, has enabled these particular types of stated preference approaches to come to the forefront of modeling.

In summary, each method of response has its own merits and limitations. Currently, there is no consensus in the literature to favor one over another. Ranking and rating methods offer the richest form of data, but offer less realistic choice exercises. In particular, the greatest drawback for rating is that respondents tend not to differentiate between perceived "good" attributes and rate them all as attractive. Rank based method captures order preference, but fails at capturing relative importance. Choice based method does not suffer from any of these deficiencies and can be easily computed.

2.7.3 Design Steps for Choice-Based Stated Preference Survey

Most of the discussion of this section is taken from Hensher et al., 2005, Louviere et al., 2000 and other studies. The SP methods involve six steps, as follows:

1) Defining the problem statement
2) Identifying the alternatives, attributes and attribute levels
3) Experimental Design considerations
4) Generating choice sets
5) Administrating surveys
6) Estimating the models

2.7.3.1 Stage 1 – Defining the Problem Statement

The first and foremost thing of SP survey design is defining the problem statements. At this stage, researchers explore all possibilities and do not bind their ideas to the limitations of the available methodological approaches. More importantly, this stage will produce all the research questions that needed to be answered to define the problem statement.

2.7.3.2 Stage 2 – Identifying Alternatives, Attributes, and Attribute Levels

This stage involves defining the universal, but finite list of alternatives available to decision makers in order to meet the utility maximizing rule. However, this prompts the chance of considering too many alternatives. The issue of too many alternatives can be dealt with by investigating problem from a contextual point of view. This allows the survey designers to omit few alternatives, which may not be relevant to the choices in that context. Another way to deal with this problem is to exclude "insignificant" alternatives from the list based on personal experience. Since the respondent eventually will put more weight on one over the other, this may not affect the experiment when insignificant alternatives are carefully selected for removal. However, the most preferred approach is to use experiments that do not name the alternatives (i.e. the analyst defines generic or unlabeled alternatives). In doing this, the possible alternatives are created by differentiating the attributes and attribute levels. One of the benefits of using unlabeled alternatives is that it does not require the identification and use of all alternatives within the universal set of alternatives, although it is not recommended when one is interested in estimating alternative-specific parameter estimates, or specific attribute.

After finalizing the list of alternatives, the survey designer identifies the attributes and the attribute levels for each alternative. The alternatives may have some common, as well as different, attributes. Then, the designer must assign the levels for each corresponding attribute. The advantage of having more attribute levels is that the utility associated with the various levels can be measured more precisely, as shown in Figure 5. However, as the number of levels goes up, so does the number of possible choice sets. This brings up another important consideration while developing the SP experiment, which is that the questionnaire should not be so long that respondents get lost in answering the questions. This problem can be easily illustrated using the possible full enumeration choice set formula: L^{MA}, where L = number of attribute levels, M = the number of alternatives, A = the number of attributes. As the attribute levels (L) increases, the number of choice sets also increases in an exponential fashion.

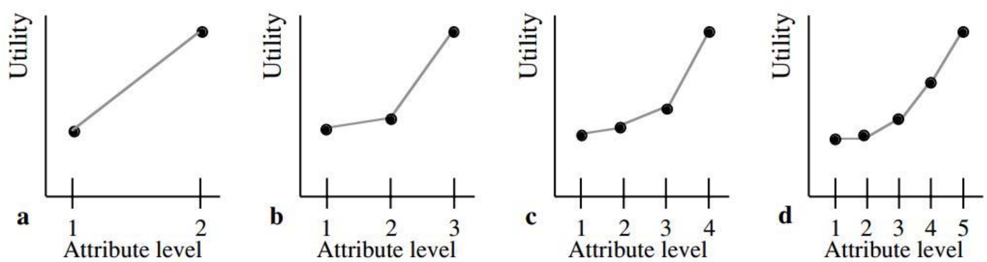


Figure 2-5 : Marginal Utility (source: Hensher et al., 2005)

2.7.3.3 Stage 3 – Experimental Design

Having identified the alternatives, attributes and the number of attribute levels, the next step is to determine the experiment design. Alternatives can be generated with the aid of statistical design theory. Table 2-3 summarizes some common designs in SP surveys

Full factorial design considers all possible scenarios defined the attributes, while the fractional factorial design allows for the reduction of insignificant factors. Both designs can be used to test main effects and interaction effects. Main effects can be defined as the effect on the experimental response of going from one level of the variable to the next given that the remaining variables do not change, whereas interaction effects can be defined as the effect of one variable upon the response depend upon the value of some other variables. On the other hand, orthogonal design only considers the main effect assuming that the attributes are statistically independent of each other.

Table 2-3: Overview of Different Types of Experimental Design

Type of Experiment	Characteristics	Effects Tested
Full Factorial Design	Each level of each attribute is combined with every other level of every other attribute. For example, a design with two, three-level attributes and two, two-level attributes would have 36 scenarios ($3^2 \cdot 2^2 = 36$). This design captures all the main effects and interaction effects of variables within the dataset.	Main effect and all kinds of interaction effects
Fractional Factorial Design	When not all interaction effects are statistically significant; the insignificant effects can be ignored. Fractional factorial design allows for the reduction of extensively large volume of scenarios created by the full factorial design. In this process, some interactions are ignored.	Main effect and some interaction effects
Orthogonal Design	Attributes are statistically independent of one another. Only main effects can be estimated as there is no interaction among the variables.	Only Main effect
Efficient/ Optimal Design	Optimizes the amount of information obtained from a design, also achieves statistical efficiency by maximizing the determinant of the variance–covariance matrix.	Main effect and some interaction effects, but statistically more efficient than fractional factorial.

The optimal design, also known as D-optimal, is a design which not only optimizes the amount of information obtained from a design, but also constitutes the most statistically efficient design by maximizing the determinant of the variance–covariance matrix (Huber and Zwerina, 1996). In determining the D-optimal design, it is common to use the inversely related measure to calculate the level of D-efficiency–that is, minimize the determinant of the inverse of the variance–covariance matrix. McFadden (1974) showed the covariance matrix (Eq 20):

$$\Omega = (X' \ P\,X) = \left[\sum_{m=1}^{M}\sum_{j=1}^{J} X_{njs}^{'} P_{njs} X_{njs}\right]$$
$$\Omega^{-1} = (X' \ P\,X)^{-1} = \left[\sum_{m=1}^{M}\sum_{j=1}^{J} X_{njs}^{'} P_{njs} X_{njs}\right]^{-1} \tag{20}$$

where P is a js×js diagonal matrix with elements equal to the choice probabilities of the alternatives (j) over choice sets (s); and M equals to total number of respondents (N) multiplies choice sets (s).

For Ω, several established summary measures of error have been shown to be useful for comparing designs. The most often used summary measure is known as D-error which is inversely related to D-efficiency:

$$\mathrm{D-error} = (\det \Omega^{-1})^{1/\mathrm{k}} \tag{21}$$

where k is the total number of generic parameters to be estimated from the design.

Minimizing this term will produce the design with the smallest possible errors around the estimated parameters.

2.7.3.4 Stage 4 – Generating Choice Set

In this stage, experiment designs are transformed into a set of real questions and are shown to the respondents to collect the data. The form of conducting surveys also influences the generation of choice sets. For instance, the use of pencil (or pen) and paper does not allow the survey designers to put the choice sets in randomized orders, which are sometimes necessary to avoid ordering bias. This is particularly important in case of partial factorial or optimal design as respondents may not trade attributes and choose alternatives based on previous choice sets. Three common types of choice set generation methods are described below.

- **Simultaneous Choice Set**
  Simultaneous choice set is a method to create alternatives and choice sets at the same time. This method also called as L^{MN} method (Sanko, 2001). The name L^{MN} stems from the fact that this is used when one wants a design whereby choice sets each contain N alternatives of M attributes of L levels.

- **Sequential Choice Set**
  Sequential choice set is a method to create one alternative at first and then create other alternatives based on the first. "Shifting" (Bunch et al., 1994) and "Fold over" (Louviere et al., 2000) are two most popular sequential choice set methods.

- **Randomized Choice Set**
  Randomized choice set is a method to create one alternative first and then randomly pick other alternatives thereafter. In this design, respondents are randomly selected to receive different versions of choice sets. For within product design (choices among alternatives from same products but varying attributes levels), the alternatives are simultaneously chosen whereas for between-product design (choices among alternatives from different products) alternatives are chosen from their alternative sets.

Other than the above, there are popular practices to randomize the experiment. One practice involves dividing the full choice sets into different subsets (blocking) for two or more times, then sort and prepare questions for different combinations of choice sets (Louviere et al., 2000).

2.7.3.5 Stage 5 – Survey Administration

SP surveys may be administered by interviewers in a face-to-face format or by completion of questionnaires that may be returned by mail, or internet. The decision on which method to use depends on the complexity of the SP survey.

This stage involves the determination of survey method, desired sample size with segments, recruitment of respondents, collection of respondent background information for screening and other purposes, survey implementation, retrieval of survey response, initial data processing and monitoring, and revision of the survey questionnaire if necessary.

2.7.3.6 Stage 6 – Model estimation

The final stage of the SP method is data processing and model estimation. Different forms of Logit and Probit models have been used for estimation of the stated preference such as Binary Logit, Multinomial Logit, Mixed Logit, and Probit Model.

2.7.4 Revealed Preference vs. Stated Preference

To evaluate the impact of different policies, Revealed Preference (RP) data are often collected and analyzed. RP data are observations of actual behavior and choices in real-world conditions. However, when it is a completely new policy or alternative, real responses to the policy do not exist as it has not been implemented. There other cases where collecting revealed data is impossible or extremely costly or difficult. Under this situation, SP techniques are developed to gather information on how respondents would react to different policies or choices in hypothetical scenarios. In SP survey, the researchers have full control over the design of the choice questions and have the freedom to modify these in order to evaluate the trade-off between attributes. Simultaneously, researchers can check for the associated correlation among variables. Other advantage of SP data is that it can be used to evaluate policy for areas where there is little or no RP data. Also, SP data requires a smaller sample size, if survey is designed efficiently. However, the success of this technique depends on how well and how realistic the choice questions appear to the respondents.

2.7.5 Adaptive Stated Preference

This method, developed by Fowkes and Tweddle (1996), is very useful for studies which suffer from a small sample size. This method takes advantage of computer technology and applies adaptive algorithms to develop choice sets; here, trade-offs between the attributes is based on the stated preference in previous questions. This gives enough information to calibrate a model for each respondent. Adaptive stated preference is particularly useful for freight studies as data are scarce in the freight industry because freight movement data tend to be proprietary in nature and it is difficult to collect information from the private sector.

Fowkes et al. (2004) estimated the values for different types of delays using Leeds adaptive stated preference (LASP) methods with a sample size of 40 respondents from different industries in the United Kingdom. While designing the survey, this study used four attributes to describe the alternatives:

- Travel cost
- Delay time (i.e. an increase in free flow time for a given departure time) which is calculated by the difference between earliest possible arrival and departure time
- An increase of spread of arrival times (98% of deliveries arrival time - earliest arrival)
- Schedule delays (greater than the departure times)

The study collected the survey data in two stages. First all the background information about the company and a detailed description of a typical shipment was gathered. Then, based on the information, the LASP software asked the respondents to rank four choices, including one option stating the typical shipment. The respondents were presented with more attractive alternatives than the typical flow and ultimately guided through different choice sets which become less attractive.

Bolis and Maggi (2003) estimated the reliability in freight services for regions in Italy and Switzerland using adaptive stated preference method. Unlike other studies that focused only on mode or route alternatives, this paper attempted to find out the values from an integrated approach (transport modes, logistics services, and production rates). This was done by efficiently designing the survey questions in such a fashion that questions were presented with the intention of discovering whether transportation decisions were separate from logistics decisions. This study used a sample size of 41 and considered seven attributes in the models. These attributes included:

- Cost
- Journey time
- Reliability (percent of shipments per year arriving on time)
- Frequency (number of shipments per months)

- Notice (minimal notice time for transport orders in hours)
- Multiple dummy variables of using road transport or not and multimodal transport or not

Danielis et al. (2005) also used Adaptive Conjoint Analysis (ACA), but used software developed by the Sawtooth Software Inc. to estimate the values for attributes and attribute levels. This study used data from 65 manufacturing firms and followed the same procedure mentioned in the previous study. The results indicated a strong preference of shippers for reliability, safety and journey times as opposed to cost.

Although there are some concerns regarding the adaptive SP method and its use since many details are not shared by the software developers, the results from the studies were found to be plausible (Small, 1999).

2.7.6 Review of Survey Design Used in Freight Transportation

This section summarizes the survey design methods adopted by previous studies. While reviewing the studies, particular attention was given to critical components in survey design, such as sample size, number and level of attributes, ranges of the attribute level, and types of choice sets considered, experiment design method, survey administration, or any other unique protocol followed by the researchers. Many reports didn't provide much information about their survey methods; therefore, this section mainly focuses on those papers that gave sufficient details concerning survey design.

Wigan et al. (2000) used a Contextual Stated Preference (CSP) survey method to investigate the values of freight travel time and reliability in Australia. The study considered four attributes (costs, delays, freight damage, and reliability) and was able to collect 129 responses from 43 firms in four industries. A few of the represented industries were automotive parts, food and beverages, building materials, and packaging. This study defined reliability as the percentage of deliveries which reached the destination at the scheduled time. For the purpose of conducting the survey, this study assembled possible respondents by inviting them through a postal survey and also asked them to give detailed descriptions of a typical flow. Later, the main survey was conducted in person. This study followed the fractional factorial design. The variation in the attribute values were ±20% of the mean values. The paper did not provide much information about the generation of choice sets.

Halse et al. (2010) estimated the VOR in freight transport in Norwegian using SP survey data. Their sample consisted of shippers (640) and carriers (117). This study considered both forms of reliability measures: variation of travel time and probability of delay. The study designed the survey in such a way that the respondents were forced to trade-off between transport time, cost, and reliability. The study also considered the following coefficients for differentiating the alternatives in choice tasks, as shown in Table 2-4.

Table 2-4: Range of Attribute Levels used by Halse et al. 2010)

Attributes	Experiment-1	Experiment-2	Experiment-3
Cost	8 intervals 5-60% for decrease 5-300% for increase	6 intervals 5-35%	6 intervals 3-50%
Time	Minimum -50% Maximum +200%	Minimum -50% Maximum +100%	
Distribution		5 different degrees of variability	
Probability of delay			0-40% (Increments of 5%)
Delay length			Minimum 3% of reference transport time, Maximum 100%

The questionnaires were divided into three parts. First, the respondents were asked about a typical shipment or transport. Next, they were presented with the main survey questions. Finally, respondents were asked which attributes were more important during the decision-making process. The purpose of the final part is to verify whether the respondents have actually traded-off or not. Another unique feature of this study was that they discarded responses that took less than 10 minutes to fill out the survey, which were considered invalid.

Significance et al. (2012) conducted a SP survey to estimate the value of travel time and value of reliability in freight for the Dutch Ministry of Infrastructure and the Environment. This study was able to collect 812 total responses, although it fell short from the target sample size for some of the sub-segments. However, the study reported that it was not a reason for much concern after consultation with the experts and clients. In terms of survey design, this study performed three experiments. The first experiment considered two attributes: transport time and cost. The next experiment considered four: reliability, arrival time, transport time, and cost. The last experiment considered three attributes: travel time, cost, and reliability. In terms of conducting three experiments instead of one, the study argued that respondents would not get bored (which may lead to higher chances of stop making trade-offs) since he/she would face new forms of questions at each experiment. Besides, the sequence of these three experiments will also work as a gradual learning curve, and VOT or VOR from these three experiments can be compared and cross checked. While selecting the attribute levels, the study considered three levels (-14%, 0%, +20%) for the travel time attributes, and five levels (85%, 95%, 100%, 110%, 125%) for the cost, reliability, and arrival time attributes. The study adopted the Bradley Design method for two of the experiments, which produces alternatives in such a way that no dominant alternative exists. Orthogonal design, which considers only main effects, was used for the experiment which had four attributes. Finally, respondents were interviewed in person and asked to reply to 19 pairs of choice questions. One dominant question was included to check the rationality of respondents using computer graphics.

Small (1999) also conducted a SP survey in California. According to the report, only 20 respondents were able to participate due to budget constraints. This had a significant impact on the plausibility of the results. For survey design, this study considered four attributes: travel time, cost, coefficient of variation of travel time, and time between departure and desired arrivals. Reliability variables can be derived from these data in the form of standard deviation and scheduled delay (early and late). However, this repot did not mention much information concerning the attribute levels for freight studies, but provided information on the attribute ranges used for passenger studies as shown in Table 2-5. The calculations are shown in equation 22 below.

$$\begin{aligned} Low\ level &= current - cofficient \cdot (current - free\ flow) \\ High\ level &= current + cofficient \cdot (current - free\ flow) \end{aligned} \tag{22}$$

Table 2-5: Range of Simulation Coefficients Used by Small (1999)

Attribute	Low	Medium	High
Cost	-0.5	-1	-2
Mean Travel time	-0.05	-0.1	-0.25
Standard deviation	-0.06	-0.13	-0.27
Departure time	-0.025	-0.05	-0.1
Stop-to-go	-0.06	-0.13	-0.27

For the passenger study, it first designed a full factorial design with 81 possible combinations ($3^4 = 81$). Then dominant choices were removed in such a way that no row possessed a dominant choice among the treatments/choices, but each row was dominated by at least one treatment in the row above and the row below. This brought down the number of pairs to 19, of which 7 were discarded based on their correlation matrix. Finally, the study assigned 6 pair-wise choice questions randomly for each respondents. For the freight study, the report followed the same procedure, but came up with only 10 choice questions. Then it added 6 more treatments in order to make the design statistically stable. The survey was conducted over the telephone.

Beuthe and Bouffioux (2008) estimated the value, for freight shippers, of qualitative factors that characterize transport solutions. The qualitative factors estimated by this study were service frequency, transport time, reliability of delivery, carrier's flexibility, and safety using ranked based conjoint analysis. First, a preliminary face-to-face interview was conducted to determine the characteristics of the firm and its transport organization. Then respondents were asked to describe a typical shipment which was used as a reference in the survey. For the survey design, this study considered six transport attributes:

- Frequency of service per week
- Travel time (door to door transport time including loading and unloading)
- Reliability (% of deliveries reaching the destination at the scheduled time)
- Flexibility (% of unplanned shipments serviced without undue delay)
- Loss (% of commercial value lost from damages, stealing, and accidents)
- Cost (out of pocket door to door cost including loading and unloading)

The study only considered the main effect (orthogonal) with five levels of attributes (-20%, -10%, 0%, +10%, +20%) and 25 alternatives. Moreover, this study asked respondents to rank the alternatives presented during the survey. One unique feature of this study is that it used cards for each alternative so that respondents could go back to previous cards and changed the ranking if desired.

Table 2-6 below presents a brief summary of freight studies in terms of various aspects in survey design. The summary is developed based on the literature that provided enough details on survey methods employed.

Table 2-6: Summary of Survey Design among Existing Freight VOR Studies

Author	Location	Survey Method	Sample Size	Market Segment	Alternatives	Experiment Design	Attribute Level	Choice Set
Small, 1999	USA	Stated Preference	20 firms	Commodity value with respect to time sensitivity	Within mode experiments (road only)	Full factorial design, then removing dominant choices	3 levels for each attribute	10 pair choice set
Wigan et al., 2000	Australia	Contextual Stated Preference	43 firms	Mode (Road, All); Shipper type (with Transport, w/o transport, Carriers)	Within mode experiments (road only)	fractional factorial design	-0.2	NA
Kurri et al. 2000	Finland	Choice based Stated Preference	236 Road shipments, 162 Rail shipments	Mode (Road & Rail) and commodity types	Two separate within-mode experiments (road, rail)	fractional factorial design	4 levels (-15% to 20%) for cost, time (< 10%) and reliability (either 10% and 5%, or 5% and 2%)	120 different choice sets, with each respondent answer 12 to 15 pairwise choice questions
Bolis and Maggi, 2003	Italy & Switzerland	Adaptive stated preference	24 firms	By weight limit (Swiss weight limit, 15 ton ; Eu weight limit 27 ton net weight)	Integrated approach	Adaptive	First, attributes related to transport change followed by changes in logistics (flexibility, frequency) and finally by mode	40 binary choices per firm
Fowkes et al. 2004	UK	Adaptive stated preference	40 firms	By Shipment type, Ownership of transport, JIT or not, Commodity type, Intermodal or not, Daytime or not, Distribution or not,	Unlabeled Alternatives	Adaptive	Cost, departure time, spread (earliest arrival time), scheduled delay	NA

Table 2-6: Summary of Survey Design among Existing Freight VOR Studies (continued)

Author	Location	Survey Method	Sample Size	Market Segment	Alternatives	Experiment Design	Attribute Level	Choice Set
Beuthe and Bouffioux, 2008	Belgium	Ranked based Stated Preference	113 firms	Mode (road, rail, Inland waterways, others); Shipping distance; Goods value; Commodity Type; Weight	25 unlabeled alternatives	fractional factorial design	5 levels (+-10 & +-20 with respect to status quo)	NA
Halse et al., 2010	Norwegian	Stated Preference	117 transport firms and 640 shippers	Mode (road, all modes), and Shipper Types(shippers or carriers)	Within mode experiments	Randomized block design	For Experiment 1: 8 levels for cost, 5 levels for travel time; For Experiment 2 : 6 levels for cost, 5 levels for travel time, 5 levels for reliability; For Experiment 3 : 6 levels for cost, 7 levels for probability of delay, 5 levels for reliability	20 (8+6+6) choice situations
Zamparini, et al. 2011	Tanzania	Ranked based Stated Preference	24 firms	Transport provider (internal, external) and value density of goods	Within mode	NA	NA	NA
Significance et al., 2012	Netherland	Stated Preference	812 firms	Transport mode (road, rail, air, sea, inland waterways); Shipment type (container, non-container); Transport ownership	Within-mode	Orthogonal, fractional factorial design	Three levels for travel time, and five levels for cost, reliability, and arrival time attributes.	19 (6+6+7) choice situations
Gong et al.. 2012	USA	Stated Preference	24 firms	By route (congested road , toll road)	Routes	NA	3 levels for delay	12 choice situations

2.7.7 Available Commercial Software

There are a number of software packages available for the developing a survey design. Some examples of this software are:

- Ngene
- Sawtooth's Adaptive Conjoint Analysis
- SPSS
- SAS
- Survey Analytics

Similarly, a vast number of commercial statistical software are available to process and analyze the models, such as:

- NLOGIT
- SPSS
- SAS
- Biogeme
- R

2.8 Findings

This section of the report summarizes the major findings from literature review.

Reliability Measures

Reliability in freight transport has been defined in a variety of ways. It has been measured as the absolute or relative variations in travel times, the delay from the preferred/scheduled arrival time, or the percentage of deliveries/shipments that arrive within a scheduled time. Similar to passenger transport, recent studies have adopted both the mean variance and scheduled based delay approaches for the estimation. However, the greatest challenge encountered when using variation of travel time in the SP design is to make the respondents understand the magnitude of the trade-offs. One solution is to present the variation of travel time as well as the equivalent likely travel times at the same time.

Value of Reliability from a Logistics Point of View

The importance of reliability has been realized by all types of freight transport users. While shippers are more concerned with delivering shipments within an agreed scheduled time, carriers try to minimize the vehicle, staff, and fuel cost. To date, none of the previous studies explored the estimates of reliability in freight transport from the customer's point of view. This is most critical when the customers are the inventory managers of firms that order goods based on internal inventory policy.

Market Segmentation

Previous studies considered mostly mode choice or route choice while estimating the VOT and VOR in freight transport. These estimated values are then further segmented by different shipment characteristics, commodity types, firm's characteristics, and others factors.

However, recent studies suggested the development of separate estimates for shippers and carriers as shippers care more about the shipment and associated losses due to delay in shipment while carriers are more worried about incurring transport service- related cost such as vehicle, staff, and fuel cost.

Model Specification

The most commonly used factors in the model include cost, travel time, reliability, loss and/or damage, frequency, and flexibility.

Model Structure

Different forms of logit, such as binary, multinomial, or mixed, have been applied to estimate the VOR in freight studies. In terms of model assumption, SP design violates the independent and identical distribution (IID) across individuals, alternatives, and choice situations as responses are collected multiple times from the same individuals. Previous studies considered each response as independent and estimated the MNL in a traditional way.

However, recent studies took this into consideration and proposed different approaches to estimate the model. One easy solution is to estimate the models after applying bootstrapping, which involves taking mean values of estimated coefficients for the random samples.

Mixed logit model is another way to take into account the random taste of individuals and to overcome the aforementioned limitation. However, estimation of this model requires great expertise in statistics and large sample sizes. The latter can be problematic as the few freight studies that have used ML models have produced poor estimates because of insufficient data.

Survey design

Insufficient sample data has been a great concern for conducting freight studies. Most studies reported the difficulty of getting a large enough sample size. Possible reasons may include the fear of giving commercially sensitive data to competitors, lack of culture of sharing information, a limited numbers of firms, and a lack of financial incentive for participation in the surveys.

The task of designing survey questionnaire is a trade-off between statistical efficiency and quality of responses. A higher number of choice questions, results in more efficient survey, but this come with the risk of low participation rates and/or respondents becoming bored and failing to make trade-offs. Studies tend to adopt an orthogonal design whenever the number of attributes becomes large. There exists a trend of employing personal experience or expert insight in order to further reduce choices. Literature suggests investing a great deal of time and effort into designing and testing SP surveys.

Several studies have applied the Adaptive Stated Preference (ASP) method to overcome the limitations of a small sample size. Although this method does not have any significant advantages over the traditional SP methods (Small, 1999), this method can be used to cross check the values.

Comparison of VOR Data

Table 2-7 shows a summary of VOR estimates from various freight studies. These values are not directly comparable due to differences in the measure of reliability, shipment weight, and market segments. This highlights the necessity for a uniform approach towards the estimation of VOR.

Table 2-7: Summary of VOR Estimates from Selected Freight Studies

Author(s)	Country	Mode	Measure of Reliability (unit)	Value of Reliability (2010 $US)
Winston, 1981	USA	Road	Standard deviation (day)	$404
Wigan et al., 2000	Australia	Road	Scheduled delay (hour per ton)	$1.3 to $1.6
Small , 1999	USA	Road	Scheduled delay (hour per shipment)	$497
Kurri et al., 2000	Finland	Road, Rail	Scheduled delay (hour per shipment)	$460
Fowkes et al., 2004	UK	Road	Scheduled delay (hour per shipment)	$52.85
Bolis and Maggi, 2003	Switzerland	Road	% the number of shipments on scheduled time (1% unit) (hour per ton)	$28 to $51.0
Beuthe and Bouffioux, 2008	Italy, Switzerland	Road	% the number of shipments on scheduled time (1% unit) (hour per ton)	$5.50
		Rail		$0.60
		Inland navigation		$0.02
Halse et al., 2010	Norway	Road. Rail	Both Scheduled delay and standard deviation (hour per shipment)	$11.83 to $387
Zamparini et al., 2011	Tanzania	Road	% of shipment within scheduled window (1%) (hour per ton)	$0.12
Significance et al., 2012	Netherland	Road	Standard deviation & Scheduled delay (hour per shipment)	$18
		Rail		$290
		Air		$2144
		Inland waterways		$402
		Sea		$80

3 STATED PREFERENCE SURVEY DESIGN

This chapter of the report summarizes the stated preference survey design process. This chapter builds upon the previous chapter of literature review, and discusses the approaches and survey design elements adopted for this project. More specifically, this chapter discusses the following aspects in survey design:

- Market Segmentation
- Sample Design
- Survey Approach
- Recruitment Instrument Design
- Stated Preference Choice Experiment Design

3.1 Proposed Market Segmentation

Market segmentation is a marketing strategy that divides the users into subgroups who have common needs, priorities, and demand characteristics. It implies that individuals within a subgroup will behave more or less the same way in responding to changes in the market, while preferences among the groups differ. Market segmentation enables the differential design and implementation of strategies targeting different users. In travel behavior analysis, market segmentation has been widely used as an effective means to identify relative homogenous users so that better descriptions of the travel behavior can be obtained. This is critical for demand analysis and policy decision-making as it accommodates user heterogeneity; and the estimated parameters are able to represent the true sensitivity of the market. In addition, market segmentation plays an important role in sample design.

This study proposes separate experiments for shippers and carriers, given their distinct nature of business. Shippers are in a better position to assess the value of time and reliability related to the value of the goods, whereas carriers are in a better position to relate the value of time and reliability to the cost of the transport services.

In the literature, various other factors have been considered of having influence on the willingness to pay to save travel time and improve travel time reliability, such as commodity type (perishable or not), whether there is delivery window pressure, shipping distance, commodity weight, whether it is containerized, and the departure time of the shipment. These factors could serve as potential market segments to analyze VOT and VOR. A complete summary of market segmentation strategies in the literature has been provided in the previous report.

Although more market segments could lead to better understanding of the market, it also requires a larger sample size to support the analysis. Considering the balance between market segments and the sampling cost, this study recommends the following factors for segmentation, also illustrated in Table 3-1:

1. Commodity Type for shippers: Perishable Commodity, Time Sensitivity
2. Shipping Distance for carriers: <50 miles, 50-300 miles, and 300+ miles.
3. Shipment Type: Containerized or Non-Containerized
4. Mode: Truck (Light, Medium, and Heavy), Rail, Sea and Air

Table 3-1: Proposed Market Segmentation

Shippers							
	Delivery Window Pressure	Truck			Rail	Water ways	Air
		Light	Medium	Heavy			
Perishable	No	X	X	X	X	X	X
	Yes	X	X	X	X	X	X
Non-perishable	No	X	X	X	X	X	X
	Yes	X	X	X	X	X	X

Carriers							
	Shipping Distance	Truck			Rail	Water ways	Air
		Light	Medium	Heavy			
Containerized	<50 Miles	X	X	X	-	-	-
	50-300 Miles	X	X	X	--	-	--
	300+ Miles	X	X	X	-	-	-
Non-Containerized	<50 Miles	X	X	X	-	-	-
	50-300 Miles	X	X	X	-	-	-
	300+ Miles	X	X	X	X	X	X

The classifications for truck types are obtained from the Florida Intermodal Statewide Highway Model (FISHFM), as shown in Table 3-2 below.

Table 3-2: Truck Type Definition from the FISHFM

Classification	Description
Light	Pick-ups and Vans
Medium	Two-Axle, Six-Tire Single-Unit Trucks
Heavy	Three or more single unit/trailer/multi-trailer trucks

3.2 Sample Design

In order to incorporate market segmentation into the VOT and VOR analysis for freight users as discussed above, this study proposes a stratification-based random sampling strategy. In other words, survey participants will be randomly selected from the sample frame, while close monitoring will be enforced to make sure there are enough observations for each cell in the segmentation table. The rule of thumb for minimal sample size is 10 observations for each stratum to support the behavior modeling purpose.

The overall sample size needed to estimate the proportion of the population in preference to one choice (such as the willingness to pay tolls) is based on the acceptable confidence level, the margin of error, and the variance of the proportion, as shown in the formula below (Eq 23):

$$N = \frac{Z^2 \times P \times (1-P)}{ME^2} \tag{23}$$

where

N= the sample size needed,

z= the z value corresponding to a certain confidence level, e.g. 1.96 for a 95% confidence level, 2.58 for a 99% confidence level,

p = the proportion of the population picking a choice, use 0.5 for sample size purpose, which yields the largest sample size,

ME = margin of error, e.g. 0.04 means $\pm$4% of the estimated value.

Based on the above formula, with a 95% confidence level, and a margin of error at $\pm$5%, N equals to 384.17. Considering earlier discussions on stratified sampling, 10 observations for each stratum times 45 strata identified in Table 1, the total sample needed is 450 for market segment purpose. Combining the two purposes, the proposed target for total sample size would be 450 for this study.

3.3 Survey Administration Mode

The survey employed both online and paper format to administer the survey, although it was initially designed for online only. The study used the “Qualtrics”, a web based commercial software, to build up and administer the online survey.

Figure 3-1 below presents a flowchart describing the proposed survey approach, including major components in survey design and implementation. The framework has three major phases: Recruitment, Pilot and Main survey. The Recruitment step mainly focuses on recruiting participants and collecting background information from the firms, whereas the Pilot survey involves mainly the SP survey design and testing the adequacy of the design. Once the choice questions are finalized and enough respondents are recruited, the next phase is to implement the main survey.

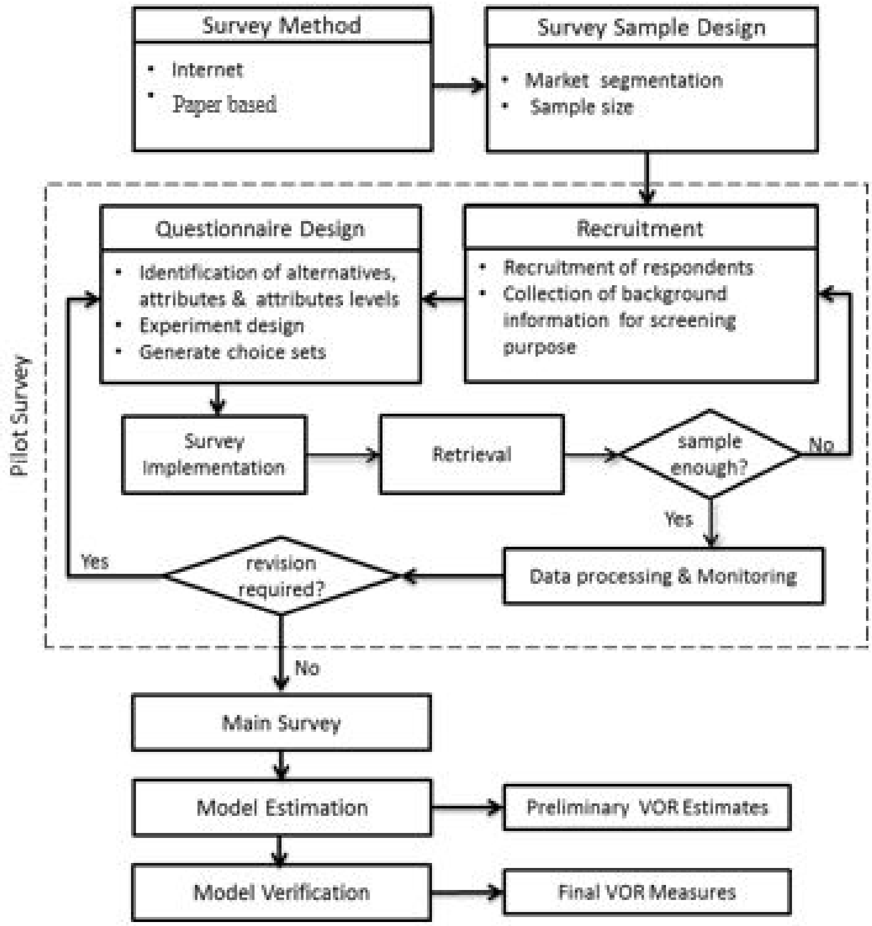


Figure 3-1: Proposed approach for the SP survey

3.4 Recruitment Instrument Design

This is the initial step of the stated preference study, which collects background information from the firms. The subjects of the questions typically fall into the following two categories:

- Information describing the firm, such as commodity type, major customers, number of employees, whether uses own transportation, measures of late delivery, etc.
- Characteristics of a typical shipment, such as shipping distance, transportation cost, monetary value of shipment, shipment size or weight, shipping duration, transport mode, use carrier or own fleet, legal terms on delivery time agreement, frequency and magnitude of late shipments.

This information will be used to customize the attribute values in the choice sets for each respondent, so that the scenarios presented to the survey participants would be realistic and meaningful for them to assess the trade-offs among the alternatives.

Appendix A presents the instrument for recruitment. It consists of three sections. The first section collects background information concerning the firm's characteristics and services; the second section asks the respondents to provide detailed information on one or more typical shipments; and the third section focuses on attitudes and preferences towards delay, mode shifting, and departure time shifting, etc., which will be used to assign the respondents to different choice experiments as described in the next section.

3.5 Stated Preference Choice Experiment Design

Choice experiment design refers to the construction of hypothetic scenarios to be presented to the respondents. Each scenario is comprised of the alternatives, as well as the attribute values describing the alternatives, such as shipping time, cost, and reliability, etc. Each respondents will be facing multiple scenarios, where attribute values vary for one or more of the attributes corresponding to one or more of the alternatives. Therefore the choice sets in the scenarios need to be carefully designed, in order to accommodate a variety of combinations of attribute values to reflect the subtle trade-offs among the alternatives.

This study focuses on four types of trade-offs, therefore four distinct choice experiments

- C1 – focuses on the trade-off between travel time, cost, and reliability.
- C2 – focuses on the willingness to shift to off-peak hours to save transport cost (may consist of time, monetary cost, and reliability). Only for shipments currently happening during peak hours and when the respondents indicated the possibility of shifting departure time.
- C3 - focuses on the willingness to shift mode. Only for shipments currently carried via trucks or rail.
- C4 – involves shifting both mode and departure time.

The process of assigning respondents to one of the four experiments is illustrated in Figure 3-2 below. Air and Waterway shipments will always participant in C1 experiment, as it is considered unrealistic to shift mode and departure time. As for shipping carried by Road and Rail, the respondents will be assigned to: C1, if there is no possibility to shift neither mode nor departure time; C2 or C3, if it is possible to shift either departure time or mode; and C4, if it is possible to shift both mode and departure time for the shipment.

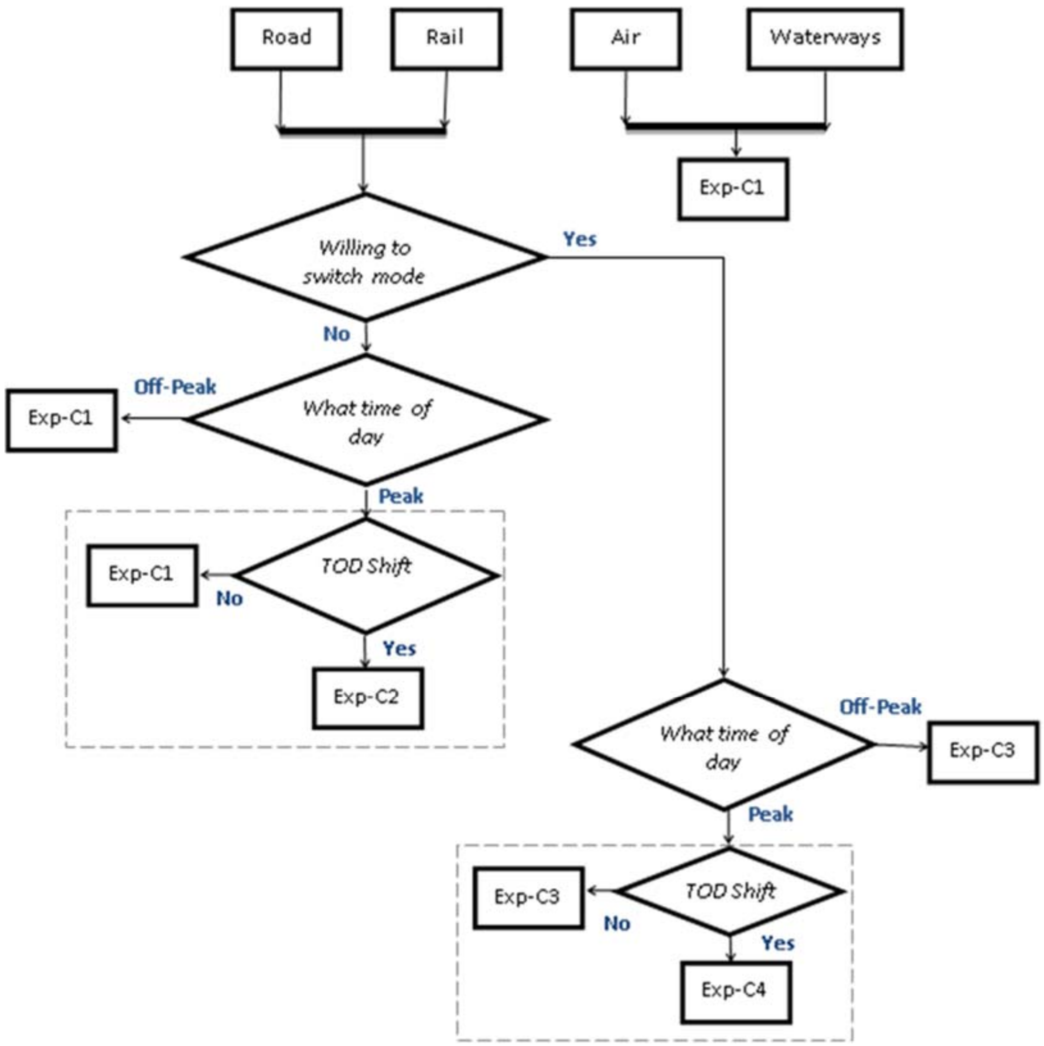


Figure 3-2: Classification of experiment design

As a result, the attributes involved in the four experiments would be different. While C1 primarily concerns travel time, cost and reliability, experiment C2 considers an additional attribute – departure time; whereas experiment C3 and C4 considers other mode-related attributes (such as, property damage, and service flexibility, etc.), without and with the consideration of departure time shift, respectively.

3.5.1 Determining Attributes and Attribute Levels

This section describes the six attributes and corresponding attribute levels employed in the survey, including travel time, travel cost, reliability, departure time, service flexibility and probability of property damage.

- **Travel Time:** This includes the time spent for door-to-door shipping (including transfer time and the average delay the respondent normally encounters).
- **Travel Cost:** This study adopts two different definitions of travel costs, one for shippers with own transport and carriers and another for shippers who hire others for transport and 3PL groups. For carriers and own account shippers, this refers to door-to-door transport costs (including fuel, staff, depreciation and maintenance of equipment used, administration, insurance, social security payments, and taxes charged), including possible transshipment costs, but excluding initial loading and final unloading. For shippers that contract out transport services and 3PL groups, it is the price paid for the door-to-door transport services, including trans-shipments.
- **Reliability:** This study adopts the standard deviation of travel time as reliability measure since the estimated values can be easily integrated into travel demand models for benefit-cost analysis.
- **Departure Time:** This is the time when shipment departs. This attribute is used to reflect the schedule constraints faced by the respondents. This study limits the shifts between peak hours and off-peak hours.
- **Service Flexibility:** This attribute signifies the ability to start shipping without any prior notice. It is often important to shippers and carriers while choosing the freight mode.
- **Probability of Shipment Property Damage:** This attribute denotes the probability of property damage during the shipment. It is a qualitative attribute, which often reflects the freight users' attitude towards modes.

Table 3-4 shows the summary of the attribute levels and the modifiers (additive and deductive) employed by this study. After constructing the "base table" using typical shipment information collected from the recruitment survey, these modifiers were used to get the values for different attribute levels.

Considering that the base values from the respondents may have a wide range, the same level of variations around the base value may not be realistic for every respondent. Therefore, this survey employed two sets of variations for travel time and travel cost based on the shipping distance and duration. Set 1 was designed for shipments that are within 300 miles, which typically take less than 10 hours; whereas Set 2 includes shipments that are beyond 300 miles in shipping distance that usually takes more than a day.

Table 3-3: Attribute Level and the Values Considered in the Experiments

Attribute	Set	Values	Unit
Transit Time	Set 1 – 0-10 hours	-5 , -2.5 , Current, +2.5, +5	hours
	Set 2 – multiple days	-1-, -½ , Current, +½ , +1	days
Travel Cost	Set 1 – 0-300 miles	-200, -100, Current, +100, +200	US dollar ($)
	Set 2 – 300+ miles	-600, -250, Current, +300, +600	

Regarding reliability attribute, five levels of pre-determined values are employed for each set, as shown in Table 3.4 and Table 3.-5. This format is a modified version of Small (1999), where only on-time and late delays were considered. It is important to mention that these attribute values were carefully chosen based on experience from the pilot study and also in consultation with freight professionals.

Table 3-4: Attribute Values of Transit time reliability considered for Set 1

Very High	High	Medium	Low	Very Low
4 out of 5 times On time	3 out of 5 times On time	2 out of 5 times On time	2 out of 5 times On time	1 out of 5 times On time
1 out of 5 times 2 hours late	2 out of 5 times 2-4 hours late	3 out of 5 times 2-4 hours late	3 out of 5 times 4-8 hours late	4 out of 5 times 6-8 hours late

Table 3-5: Attribute Values of Transit time reliability considered for Set 2

Very High	High	Medium	Low	Very Low
4 out of 5 times On time	3 out of 5 times On time	2 out of 5 times On time	2 out of 5 times On time	1 out of 5 times On time
1 out of 5 times ½ day late	1 out of 5 times 1 day late	3 out of 5 times 1-2 days late	3 out of 5 times 2 days late	4 out of 5 times 2-4 days late

3.5.2 Experiment Design for C1

This experiment focuses mainly on within-mode choices with alternatives characterized by three attributes: Travel time, Travel cost and Reliability. Sequential orthogonal design is adopted for this experiment. Such an orthogonal design for five levels of three attributes consists of 25 treatment combinations as shown in Table 3-6. Orthogonal design yields no correlation among the attributes, while avoids the large number of combinations as resulted from full factorial design (where each level of each attribute is combined with every other level of every other attribute).

Table 3-6: Orthogonal Factorial Design for Experiment C1

Treatment Combination	Travel Time	Travel Cost	Reliability
1	Very Low	Base	Base
2	Very Low	Low	Low
3	Low	Base	Very Low
4	Base	Very Low	Low
5	High	Base	Low
6	Base	Very High	Very Low
7	Base	Base	High
8	High	High	Base
9	Very High	High	Very Low
10	Low	High	Low
11	Base	High	Very High
12	High	Very Low	Very High
13	Very High	Low	High
14	Very High	Base	Very High
15	Low	Very High	Base
16	Very High	Very High	Low
17	Very Low	High	High
18	Very Low	Very High	Very High
19	Very Low	Very Low	Very Low
20	High	Very High	High
21	Very High	Very Low	Base
22	Low	Low	Very High
23	Base	Low	Base
24	High	Low	Very Low
25	Low	Very Low	High

Each treatment represents one combination of attribute values describing one alternative, while each scenario needs to present multiple alternatives for the respondents to evaluate the trade-offs among the attribute values. Therefore, subsequent alternatives need to be generated, which is shown in Table 3-7.

Here the same design (Table 3-6) is used to construct subsequent alternatives by systematically changing the attribute levels (Street et al., 2005). This method is more efficient and better than those that come from random sampling, or simultaneous alternatives construction; as the former runs the risk of being either zero difference or unbalanced (unequal number of the attribute levels) and the latter requires significantly larger number of choice-sets (Street et al., 2005). However, this design is sometimes prone to generate unrealistic and dominant alternatives, which can be overcome by rotating the attribute levels within choice sets until there is no dominant alternative (Huber and Zwerina). For example, if the travel time of alternative A is very shorter than the travel time of other alternatives (B, or C), then at least one of the attributes, such as travel cost and reliability will be worse than the other alternatives.

Table 3-7: Choice Sets Using the Sequential Orthogonal Design for Experiment C1

	Alternative 1			Alterative 2			Alternative 3		
Block	TT	TC	Rel.	TT	TC	Rel.	TT	TC	Rel.
1	Base	VH	VL	VH	VL	L	H	L	Base
1	VL	VH	VL	Base	H	L	H	Base	Base
1	VL	H	Base	L	VH	VH	Base	Base	H
1	VL	H	Base	L	Base	H	Base	L	L
1	Base	Base	H	H	L	Base	VH	VL	L
1	H	Base	L	VH	H	Base	VL	VH	H
1	Base	VH	H	H	H	VH	VH	Base	VL
1	H	H	H	VH	VL	Base	VL	VH	VH
2	VH	VL	VL	VL	VH	L	L	H	Base
2	L	VH	L	Base	H	Base	H	VL	H
2	Base	H	VL	H	VH	VH	VH	VL	L
2	H	VL	VL	VH	L	VH	VL	Base	L
2	VH	L	H	VL	Base	VL	L	VH	VH
2	VH	Base	L	VL	H	VL	L	VH	VH
2	L	VH	VH	Base	L	H	H	VL	Base
2	VH	VL	Base	VL	VH	L	L	L	H
3	VL	H	VL	L	VH	VH	Base	VL	H
3	VL	VH	VH	L	VL	VL	Base	L	L
3	VL	Base	Base	L	L	L	Base	VL	VL
3	H	L	VH	VH	VL	H	VL	VH	VL
3	VH	VL	VH	VL	Base	VH	L	L	Base
3	L	H	VH	Base	Base	VL	H	L	L
3	Base	H	Base	H	Base	H	VH	L	VH
3	H	L	VL	VH	Base	Base	VL	H	L
3	L	L	H	Base	Base	VH	H	VL	VL

3.5.3 Experiment Design for C2

C2 is the extension of the previous experiment C1, with an additional attribute: departure time. The alternatives of this experiment are characterized by five levels of three attributes (Travel time, travel cost and reliability) and two levels of one attribute (departure time). Nearly Orthogonal design is employed instead of fully orthogonal design. The justification of doing this is to lessen the burden of over sampling at the cost of very little statistical efficiency (D-efficiency 99.7%). The treatment combinations are shown in Table 3-8.

Table 3-8: Orthogonal Factorial Design for Experiment C2

Treatment Combination	Travel Time	Travel Cost	Reliability	Departure time
1	Low	Low	High	Off-peak
2	Very High	Very Low	Low	Off-peak
3	High	Very Low	Base	Peak
4	Very Low	Low	Very High	Peak
5	Base	Very Low	High	Off-peak
6	Low	Base	Base	Off-peak
7	High	Low	Low	Peak
8	Very High	Low	Very Low	Off-peak
9	Very High	High	High	Peak
10	High	High	Very High	Off-peak
11	Base	High	Very Low	Peak
12	Low	High	Low	Peak
13	Low	Very Low	Very High	Peak
14	High	Base	Very Low	Off-peak
15	Very Low	Base	High	Peak
16	Very Low	Very Low	Very Low	Peak
17	Base	Low	Base	Peak
18	Very High	Very High	Base	Peak
19	Very Low	High	Base	Off-peak
20	Base	Very High	Very High	Off-peak
21	Low	Very High	Very Low	Peak
22	High	Very High	High	Peak
23	Very High	Base	Very High	Peak
24	Very Low	Very High	Low	Off-peak
25	Base	Base	Low	Peak

The choice sets of three alternatives are constructed following similar approach taken in C1, as shown in Table 3-9. Additionally, to make the scenarios more realistic, the travel time during peak hours is always greater than the travel time during off-peak hours.

Table 3-9: Choice Sets Using the Sequential Orthogonal Design for Experiment C2

	Alternative 1				Alternative 2				Alternative 3			
Block	TT	TC	Rel.	Dept time	TT	TC	Rel.	Dept time	TT	TC	Rel.	Dept time
1	L	Base	H	Off-P	H	L	VL	P	Base	H	VH	Off-P
1	VL	L	L	Off-P	VH	VL	Base	P	L	Base	H	Off-P
1	H	Base	Base	P	VL	VL	H	Off-P	VH	VL	VH	P
1	VL	Base	VL	P	VL	H	H	Off-P	Base	L	L	P
1	Base	L	H	Off-P	VH	VL	VL	P	H	Base	VH	Off-P
1	L	H	Base	Off-P	H	Base	H	P	Base	VH	VH	Off-P
1	H	Base	Base	P	VL	H	L	Off-P	VH	L	L	P
1	VL	Base	VL	Off-P	VH	L	L	P	L	H	Base	Off-P
2	VH	VL	VH	P	VL	VH	VL	Off-P	L	VH	VH	P
2	H	H	VL	Off-P	VH	VL	VH	P	VL	VH	L	Off-P
2	H	H	VL	P	Base	VH	Base	Off-P	VH	VL	L	P
2	Base	H	L	P	L	VH	H	Off-P	H	VL	Base	P
2	Base	Base	VH	P	L	L	L	Off-P	H	VL	VL	P
2	H	H	L	Off-P	VH	Base	VL	P	VL	VH	Base	Off-P
2	L	H	H	P	VL	VH	VH	Off-P	Base	Base	VL	P
2	L	VL	VL	P	VL	Base	Base	Off-P	Base	L	L	P
3	H	L	Base	P	Base	H	H	Off-P	VH	Base	VH	P
3	VH	VL	Base	P	VL	VH	VH	Off-P	L	L	H	P
3	VL	H	H	Off-P	Base	VL	Base	P	L	VH	VH	Off-P
3	Base	VH	VH	Off-P	VH	VL	VL	P	H	L	L	Off-P
3	Base	VL	VL	P	L	VH	L	Off-P	VH	L	Base	P
3	H	VH	H	P	VL	L	VH	Off-P	VH	VL	VL	P
3	VH	Base	VH	P	VL	VH	VL	Off-P	L	H	L	P
3	VL	VH	L	Off-P	Base	VL	H	P	L	L	Base	Off-P
3	H	H	L	P	Base	VH	H	Off-P	VH	Base	Base	P

3.5.4 Experiment Design for C3

This experiment is designed primarily for shippers and carriers who are willing to change mode, but not to shift their current departure time. Hence, the alternatives of this experiment are mainly road and rail modes, characterized by three attributes: Travel time, Travel cost and Reliability.

Unlike C1 and C2, this experiment is developed based on the so-called "Bradley-design" rather than the orthogonal design. It is because orthogonal design generates too many unrealistic and dominant alternatives, whereas Bradley-design does not allow any dominant alternatives by default. According to the Bradley design, the base level for each attribute will always be present in the choice pair, in either alternative. Here, the third level (out of five) of the travel cost, travel time and reliability is considered as the base level.

Table 3-10 shows the constructed choice pairs, wherein travel time always increases on the Rail alternative. Additional choice pairs can be easily generated by mirroring the left and right alternatives and by replacing all increases with decreases and vice versa.

Table 3-10: Choice Sets Using the Bradley Design for Experiment C3

Road		Rail			Road		Rail			Road		Rail			Road		Rail	
TT	0	TT	↑		TT	0	TT	↑		TT	0	TT	↑		TT	0	TT	↑
TC	0	TC	↑		TC	0	TC	↑		TC	↑	TC	0		TC	↑	TC	0
Rel	0	Rel	↑		Rel	↑	Rel	0		Rel	↑	Rel	0		Rel	↑	Rel	0
SF	0	SF	↓		SF	0	SF	↓		SF	0	SF	↓		SF	0	SF	↓
PD	0	PD	↓		PD	0	PD	↓		PD	0	PD	↓		PD	↓	PD	0
Road		**Rail**			**Road**		**Rail**			**Road**		**Rail**			**Road**		**Rail**	
TT	0	TT	↑		TT	0	TT	↑		TT	0	TT	↑		TT	0	TT	↑
TC	0	TC	↓		TC	0	TC	↓		TC	↓	TC	0		TC	↓	TC	0
Rel	0	Rel	↑		Rel	↑	Rel	0		Rel	↑	Rel	0		Rel	↑	Rel	0
SF	0	SF	↑		SF	0	SF	↑		SF	0	SF	↑		SF	0	SF	↑
PD	0	PD	↓		PD	0	PD	↓		PD	0	PD	↓		PD	↓	PD	0
Road		Rail			Road		Rail			Road		Rail			Road		Rail	
TT	0	TT	↑		TT	0	TT	↑		TT	0	TT	↑		TT	0	TT	↑
TC	0	TC	↓		TC	0	TC	↓		TC	↓	TC	0		TC	↓	TC	0
Rel	0	Rel	↑		Rel	↑	Rel	0		Rel	↑	Rel	0		Rel	↑	Rel	0
SF	0	SF	↓		SF	0	SF	↓		SF	0	SF	↓		SF	0	SF	↓
PD	0	PD	↑		PD	0	PD	↑		PD	0	PD	↑		PD	↑	PD	0
Road		Rail			Road		Rail			Road		Rail			Road		Rail	
TT	0	TT	↑		TT	0	TT	↑		TT	0	TT	↑		TT	0	TT	↑
TC	0	TC	↓		TC	0	TC	↓		TC	↓	TC	0		TC	↓	TC	0
Rel	0	Rel	↓		Rel	↓	Rel	0		Rel	↓	Rel	0		Rel	↓	Rel	0
SF	0	SF	↑		SF	0	SF	↑		SF	0	SF	↑		SF	0	SF	↑

PD	0	PD	↑		PD	0	PD	↑		PD	0	PD	↑		PD	↑	PD	0
Road		**Rail**			Road		Rail			Road		Rail			Road		Rail	
TT	0	TT	↑		TT	0	TT	↑		TT	0	TT	↑		TT	0	TT	↑
TC	↑	TC	0		TC	↑	TC	0		TC	↑	TC	0		TC	↓	TC	0
Rel	↑	Rel	0		Rel	↑	Rel	0		Rel	↑	Rel	0		Rel	↑	Rel	0
SF	0	SF	↓		SF	↓	SF	0		SF	↓	SF	0		SF	0	SF	↑
PD	0	PD	↓		PD	0	PD	↓		PD	↓	PD	0		PD	0	PD	↓
Road		Rail			Road		Rail			Road		Rail			Road		Rail	
TT	0	TT	↑		TT	0	TT	↑		TT	0	TT	↑		TT	0	TT	↑
TC	↓	TC	0		TC	↓	TC	0		TC	↓	TC	0		TC	↓	TC	0
Rel	↑	Rel	0		Rel	↑	Rel	0		Rel	↑	Rel	0		Rel	↑	Rel	0
SF	0	SF	↓		SF	↓	SF	0		SF	↓	SF	0		SF	↑	SF	0
PD	0	PD	↑		PD	0	PD	↑		PD	↑	PD	0		PD	0	PD	↓
Road		Rail			Road		Rail			Road		Rail			Road		Rail	
TT	0	TT	↑		TT	0	TT	↑		TT	0	TT	↑		TT	0	TT	↑
TC	↓	TC	0		TC	↓	TC	0		TC	↓	TC	0		TC	↓	TC	0
Rel	↓	Rel	0		Rel	↑	Rel	0		Rel	↑	Rel	0		Rel	↑	Rel	0
SF	0	SF	↑		SF	↑	SF	0		SF	↑	SF	0		SF	↑	SF	0
PD	0	PD	↑		PD	0	PD	↑		PD	↑	PD	0		PD	↓	PD	0

In summary, the basic characteristics of this design are:

- Each choice pair has the base level of all the attributes in either of the alternatives.
- For all attributes, there are two levels with higher value than the base level, and there are two levels with lower value than the base level.
- These base values and increased or decreased values are combined in the choice pairs in such a way that none of the pairs has a dominant alternative.

3.5.5 Experiment Design for C4

This experiment involves both mode and departure time shifts. Similar to experiment C2, nearly orthogonal design is applied. The treatment combinations concerning travel time, travel cost, reliability, departure time, service flexibility, and shipment property damage are presented in Table 3-11.

The same method for C1 and C2 is applied to develop choice sets for C4, through systematically changing the attribute levels. Each scenario consists of three alternatives, one by Road, one by Rail, and one by Road or Rail (randomly selected). Table 3-12 shows all hypothetical choice sets, which are divided into five blocks, so each respondent will be facing a set of six hypothetical scenarios.

Table 3-11: Orthogonal Factorial Design for Experiment C4

Treatment Combination	Travel Time	Travel Cost	Reliability	Departure time	Service Flexibility	Shipment Property damage
1	Very Low	Very Low	Very High	Off-Peak	Low	Low
2	Very Low	Low	Base	Off-Peak	Base	Base
3	Very Low	Base	Very Low	Peak	High	High
4	Very Low	Base	High	Off-Peak	Base	Base
5	Very Low	High	Low	Peak	High	High
6	Very Low	Very High	Very Low	Peak	Low	Low
7	Low	Very Low	Very Low	Off-Peak	Base	Base
8	Low	Very Low	Low	Peak	High	Base
9	Low	Low	Very High	Peak	Base	High
10	Low	Base	Base	Peak	Low	Low
11	Low	High	Very Low	Off-Peak	High	Low
12	Low	Very High	High	Off-Peak	Low	High
13	Base	Very Low	High	Peak	Low	High
14	Base	Low	Low	Off-Peak	Low	High
15	Base	Base	Very High	Peak	Base	Low
16	Base	High	Very Low	Off-Peak	Base	Low
17	Base	Very High	Base	Peak	High	Base
18	Base	Very High	Very High	Off-Peak	High	Base
19	High	Very Low	Base	Peak	Base	High
20	High	Low	High	Off-Peak	High	Low
21	High	Low	High	Peak	High	Low
22	High	Base	Low	Off-Peak	Low	Base
23	High	High	Very High	Peak	Low	Base
24	High	Very High	Very Low	Off-Peak	Base	High
25	Very High	Very Low	Base	Off-Peak	High	Low
26	Very High	Low	Very Low	Peak	Low	Base
27	Very High	Base	Very High	Off-Peak	High	High
28	Very High	High	Base	Off-Peak	Low	High
29	Very High	High	High	Peak	Base	Base
30	Very High	Very High	Low	Peak	Base	Low

Table 3-12: Choice sets using the sequential orthogonal design for Experiment C4

Block	Alternative 1 (Road)						Alternative 2 (Rail)						Alternative 3 (Road or Rail)					
1	TT	TC	Rel	Dep.	Flex	PD	TT	TC	Rel	Dep.	Flex	PD	TT	TC	Rel	Dep.	Flex	PD
1	VL	VH	VH	Off-P	L	L	B	B	L	P	B	B	H	H	L	P	H	B
1	VL	H	B	Off-P	`	B	B	B	L	VH	P	H	H	B	H	P	L	H
1	B	VH	VL	P	H	H	L	B	B	Off-P	L	L	VL	H	B	Off-P	H	L
1	VL	VH	H	Off-P	B	B	B	B	L	P	H	H	H	H	VL	P	L	H
1	B	H	L	P	H	H	L	VL	H	Off-P	L	L	VL	B	L	Off-P	H	L
1	L	H	VL	Off-P	B	B	VH	VL	B	P	H	H	H	B	H	P	L	L
1	H	B	L	P	H	B	L	VL	H	Off-P	L	H	B	L	VH	Off-P	L	H
1	H	L	L	P	B	H	L	H	VH	Off-P	H	L	B	B	B	Off-P	VH	L
1	H	B	B	P	L	L	B	VH	VH	Off-P	B	B	L	H	H	Off-P	L	B
2	L	H	VL	Off-P	H	L	H	VL	B	P	L	B	VH	B	H	P	VL	B
2	L	VH	H	Off-P	L	H	H	L	VL	P	B	L	B	L	B	P	H	L
2	VH	B	L	P	L	H	B	VL	VL	Off-P	B	L	L	VH	B	Off-P	L	L
2	B	L	L	Off-P	L	H	VH	H	H	P	B	L	H	VH	B	P	L	L
2	VH	B	VH	P	B	L	B	H	L	Off-P	H	B	L	VH	B	Off-P	L	B
2	B	L	VL	Off-P	B	L	VH	H	B	P	H	B	H	L	H	P	VH	B
2	H	B	H	P	L	B	VH	L	B	P	H	B	B	VH	VH	Off-P	L	H
2	H	B	B	Off-P	B	B	B	VH	VH	Off-P	H	B	VH	L	L	P	L	H
2	H	L	VL	P	H	H	L	H	B	P	B	H	VL	B	VH	Off-P	H	L
2	VL	B	B	Off-P	B	L	L	H	H	Off-P	H	L	H	L	VL	P	L	B
3	B	B	B	Off-P	B	L	B	L	VL	P	H	L	VL	H	H	Off-P	L	B
3	VL	L	L	Off-P	H	B	L	B	H	Off-P	L	B	H	VH	VL	P	B	H
3	L	VL	VL	Off-P	H	B	H	H	H	P	L	B	VL	B	L	Off-P	B	H
3	VL	B	H	Off-P	VH	H	L	VH	VL	Off-P	B	H	H	L	B	P	H	L
3	B	VL	VL	Off-P	B	H	L	B	B	Off-P	H	L	VH	B	VH	P	L	B
3	VH	L	H	Off-P	B	B	B	H	VL	P	H	B	L	VH	B	Off-P	L	H
3	B	L	B	P	H	H	L	H	L	Off-P	L	H	VH	VL	VH	P	B	L
3	VH	VL	L	P	B	B	B	L	VL	P	H	B	L	H	H	Off-P	VH	H
3	VH	B	VH	P	VH	L	B	VH	L	P	B	L	L	B	L	Off-P	H	B

3.6 Summary

Four different stated preference experiments were tested among the survey respondents, each focused on the trade-offs among distinct combination of alternatives. C1 was within-mode experiment, which primarily considered the trade-off among travel time, cost and reliability, experiment C2 was an extension of C1, which considered an additional attribute – departure time, whereas C3 and C4 were cross-mode experiments, which considered other mode-related attributes (such as, property damage, and service flexibility, etc.), without and with the consideration of departure time shift, respectively. Table 3-13 summarizes the applicability of the experiments by mode.

In terms of survey approach, this study employed stratification-based random sampling strategy in order to incorporate market segmentation into the VOT and VOR analysis.

Table 3-13: Proposed Experiments by Mode

Experiment Type	Road	Rail	Air	Waterways
C1	√		√	√
C2	√			
C3	√	√		
C4	√	√		

The survey consists of three stages: Recruitment, Pilot, and Main survey. The recruitment stage collects critical background information about the firm and detailed typical shipment information that inform the sample monitoring and the stated preference questionnaire design. The pilot survey provides an opportunity to evaluate the structure and design of the survey instrument. Based on the feedback from the pilot survey, the stated preference questions may be revised.

4 RECRUITMENT EFFORTS AND PILOT SURVEY

This chapter of the report mainly presents the recruitment efforts and the key lessons learned from the pilot survey. For recruitment purposes, the research team focused on reaching out to potential participants and industry experts to get feedback on the effectiveness of the survey questionnaires. As part of the effort, the research team also attended freight users' conferences and social events. Based on the feedback and input gained through these activities, the survey questionnaire was then further enhanced for the full survey.

4.1 Pilot Survey

4.1.1 Individual Contacts

The research team compiled a database of about 600 firms in south Florida region through internet search and other means. Individual companies were contacted via phone calls and emails to introduce the purpose of the survey and invite them to participate. During this stage, only those who showed interest in the survey were kept for further contact; others were taken off from the list.

At the end, responses were collected from 15 firms who also agreed to participate in the final survey. Meanwhile, the details of feedback were received from some respondents regarding the survey instrument, mainly related to the applicability of a few questions from their perspective. Although a good number of respondents agreed to do the survey initially, most of them did not participate in the main survey, despite a few reminders. This indicates the challenges in implementing a two-stage survey.

4.1.2 FTA Annual Conference

The survey team attended the annual conference of Florida Trucking Association (FTA) on 23-24 July 2016 at Palm Beach, Florida. Approximately, 100 people attended the event, which gave the team a unique opportunity to interact with potential participants. At the end of the conference, the survey team was able to collect 10 complete responses. Additional email invitations were sent to the conference participants (from whom we were able to collect contact information). Below are a few major observations from the conference:

- Although the attendees showed intent to participate in the recruitment survey, most of them were reluctant to provide information for further contact. This was a setback for the survey, as the survey was initially planned with a two-stage data collection method: collects typical shipment information first from respondents, then customized choice questions be sent to collect their choice preferences towards different freight transportation attributes.

- Some attendees expressed concerns in understanding the typical shipment definition, which is not surprising as there can be numerous possibilities of shipment in real scenarios i.e. single or multiple drops, usual or emergency situations, special or normal arrangement, etc. It should be noted here that, from the practical perspective, it is not possible to generate questions for all possible scenarios for all groups.
- The interest in participating in the survey was generally low without attractive incentives.

4.2 Outreach to the Industry

In order to disseminate the survey information among different stakeholders involved in freight transportation, the research team also made a presentation at the Freight Transportation Advisory Committee (FTAC)'s meeting on 14 October, 2016 at Doral. The participants came from different agencies, including the Miami-Dade Metropolitan Planning Organization, Port of Miami, Florida Department of Transportation district offices, Consultants, the business community, the Florida Customs Brokers and Forwarders Association (FCBF), and general citizens. In the presentation, the research team explained the purpose and importance of the survey, and also shared the survey choice questions with the attendees to gather their feedback. The presentation was successful in the sense that the committee members actively participated in the discussion, and also put forth their opinions and suggestions to the team.

Two major issues raised by the committee are:

- The choice questions/scenarios may be too complicated for some potential participants, which eventually may discourage survey participation.
- The technical terms used to describe the choices/scenarios, such as transit time and cost, need to be clearly defined, since every contract varies depending on the merit of client and situations.

To address these concerns properly, the research team was able to establish connections with the FCBF and other freight professional associations, to further discuss these issues and help enhance and promote the survey, as detailed in the next section.

4.3 Survey Revisions

Combining all the details of feedback obtained through the pilot survey and discussions with the freight industry, the major revisions to the survey are summarized here.

4.3.1 Survey Approach

Initially the survey was designed with a two-stage approach, where participants would be recruited in the first stage by completing a short questionnaire about the firm and one typical or recent shipment, then a stated preference survey questionnaire would be developed based on the information collected from the first stage and sent to the participants. This approach would yield choice scenarios that are customized for each participant, but the details of feedback from the pilot survey and the industry indicate that the retention rate would be very low. Therefore, it is determined to combine the two stages into one to minimize dropout rate. As a result, instead of using typical shipment information collected from the first stage to customize the choice scenarios in the second stage, three sets of pre-defined attribute values (based on shipment distance) were developed to describe the choice alternatives. This may affect the effectiveness of the survey design; but under the circumstances, this is the most suitable approach to attract as many participants and reduce dropouts. Table 4-1 below shows the pre-defined ranges of attribute values that are employed.

Table 4-1: Pre-Defined Attribute Value Ranges by Segment

Mode	Distance	In-Transit Time	Shipping cost	Reliability (as standard deviation)
Road	Short (0-50 miles)	<6 hrs	\$100 to \$225	1 hour to 7 hour
	Medium (50-350 miles)	6-15 hrs	\$300 to \$700	1 hour to 7 hour
	Long (350+ miles)	1-3 day	\$900 to \$2100	12 hour - 1.5 days
Rail	Short (<300 miles)	6-15 hrs	\$300 to \$700	1 hour to 7 hour
	Long (300-1000 miles)	1-3 day	\$900 to \$2100	12 hour - 1.5 days
Air	Within FL	<6 hrs	\$100 to \$225	1 hour to 7 hour
	Outside FL	6-15 hrs	\$300 to \$700	1 hour to 7 hour
Waterways		1-3 day	\$900 to \$2100	12 hour - 1.5 days

4.3.2 Survey Questionnaire

The recruitment questionnaire was shortened to include only essential questions concerning one typical shipment, and attitudinal questions were move to the end of the survey for optional participation.

Clarifications were added for key definitions (shipment, cost, etc.), as different parties may have various interpretations for “one shipment”, which will affect their responses to the choice questions. The same goes for “shipping distance” and “cost”. To provide better clarification, additional illustration and explanation were added at the beginning of the survey, as shown in the screenshot (Figure 4-1) below.

To avoid any kind of ambiguity, please read the following instructions before you fill up the questions:

1) *Your typical shipment may consists of many types of commodity, such as agricultural, minerals, food products, heavy construction materials, etc., but please select any one of these commodities.*
2) *If you use more than one mode for that shipment, please select the primary mode, which carries the majority of the shipment duration. For example, trucks are often used to transport goods to and from rail stations, but "Rail" is considered as the primary mode.*
3) *Your shipment consists of a one-way distance (or duration), traveled (or spent) from your departure location (typically includes your distribution center or your client's pick up location) to the designated arrival location (client's specified, customer's location). It includes all the intermediary times or distance spent between these points.*

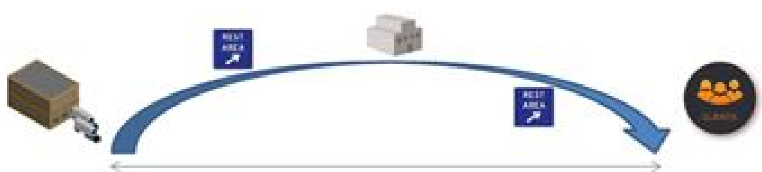


Figure : One way Shipment

4) *You may have multiple drops for a single shipment. In that case, please select first drop as your typical shipment (in case you are not sure about the first drop, please take your best guess!).*

Figure : One way Shipment (Multi drops)

5) *Shipment cost amounts to the price paid for the transportation services, including transshipments (for shippers, 3PL or forwarding companies) or transportation operating costs (which may include fuel, driver, administration, insurance, etc.) and possible transshipment costs (excluding initial loading and final unloading).* **We understand that it is hard to give a single shipment information (in particular, freight rate, transit time, etc.) since every contract varies depending on the merit of client and situations. Please provide a typical one with no case of special arrangement or emergency situation, which will only be used to ask your further questions.**

Figure 4-1: Explanatory notes and illustrations to define a shipment

Furthermore, presentation of the choice scenarios was modified, especially the representation for travel time reliability. Figure 4-2 below shows the original (a) and the revised format (b) of the choice questions.

Alternative 1	Alternative 2
Transit time : 10 hrs	Transit time : 12.5 hrs
You have an equal probability of each of these 5 transit times (hrs) On time On time On time On time 30 minutes late (Hints : Very High Reliability)	You have an equal probability of each of these 5 transit times (hrs) 1 hour early On time On time 1 hour late 2 hours late (Hints : Medium Reliability)
Shipping cost : $600 (20% more than standard)	Shipping cost : $400 (20% less than standard)
I prefer this option ○	I prefer this option ○

(a) Original hypothetical choice question

Alternative 1	Alternative 2
Actual transit time	2.5 hours more than Actual transit time
Your shipment has the following risk of delay On time: 4 out of 5 times Late : 1 out of 5 times, with a possible delay of 2 hrs (Hints : Very High Reliability)	Your shipment has the following risk of delay On time: 2 out of 5 times Late : 3 out of 5 times, with a possible delay of 2-4 hrs (Hints : Medium Reliability)
$100 more than Actual shipping cost	$100 less than Actual shipping cost
I prefer this option ○	I prefer this option ○

(b) Revised hypothetical choice question

Figure 4-2: A set of hypothetical examples of choice sets

Additionally, a short tutorial was added before the choice question to aid the respondents in understanding the question setting, as shown in the screenshot (Figure 4-3) below.

Before we start our main survey, this is a short tutorial that will walk you through the choice process.

Suppose you have a typical shipment, which takes about **10 hours** to delivery to the customer at the designated destination and you charge about **$500** for the shipment. However, due to congestion, accident, work zone or adverse weather, your shipment sometimes gets delay.

Florida Department of Transportation (FDOT) is considering different project or policy strategies, which may result in reduced shippingtime, or cost or uncertainty but not altogether.

Now, if you have to choose from the following two options, which one would you prefer?

Alternative 1	Alternative 2
Transit time : 10 hrs (standard)	Transit time : 12.5 hrs (25% more than standard)
Your shipment has the following risk of delay On time: 4 out of 5 times Late : 1 out of 5 times, with a possible delay of 30 min (Hints : Very High Reliability)	Your shipment has the following risk of delay On time: 2 out of 5 times Late : 3 out of 5 times, with a possible delay of 1-2 hrs (Hints : Medium Reliability)
Shipping cost : $600 (20% more than standard)	Shipping cost : $400 (20% less than standard)
I prefer this option	I prefer this option

Tips:

If you have chosen Alternative 1, it means that you prefer to pay more than the current cost for improved reliability.

Or,

you have chosen Alternative 2, it means that you ready to accept longer transit time than the regular one in return of lower operation cost.

Figure 4-3: A short tutorial to aid the participants

The survey process was made as dynamic as possible, so that participants only face questions that are applicable to them based on their previous answers. In the final format, the survey is designed to take about 15-20 minutes for each participant, where it will take 5-10 minutes to fill the recruitment questions, and 7-10 minutes to take part in the hypothetical choice questions, with few optional questions at the end.

Another important aspect that came from the pilot survey was the importance of involvement or engagement of various freight associations who work for the rights or benefits of the freight communities. A direct invitation to freight firms or personnel did not generate much enthusiasm, rather distributing survey through these organizations was found more effective. This could be attributed to the issue of trust and privacy, as highlighted before, stressing the importance of bringing various freight stakeholder organizations into the freight planning committee.

5 SURVEY QUESTIONNAIRE

5.1 Survey Components

This survey was primarily designed to quantify the users' willingness to pay for the improvement of travel related attributes, such as travel time reliability and travel time saving, in their transportation choices. Considering heterogeneity among the users, this study intends to cover a variety of users groups, including shippers, carriers, and third party logistics providers (3PL) and freight brokers. The survey consisted of four major sections:

- Part 1:Introduction and qualification questions
- Part 2: Information on a recent / typical shipment
- Part 3: Stated preference questions and validation question
- Part 4: Background and attitude questions (optional)

In addition, based on the users' willingness to switch mode or switch to off-peak hours, the respondents are automatically assigned to one of the four experiment designs, which are discussed further in the previous sections.

The complete survey questionnaire is presented in Appendix A. Survey screenshots are presented in Appendix B.

5.1.1 Part 1: Introduction and Qualification Questions

At the beginning of the survey, the respondents were presented a qualification question asking about their nature of business and requested them to choose one of the following categories:

- Shippers
- Carriers
- Third party logistics providers or freight forwarders
- None of the Above

Respondents who chose "none of the above" were disqualified from the survey. Figure 5-1 shows the screen capture of the shipment qualification question.

Respondents who were qualified for the survey were proceeded to answer a series of questions about their most recent/typical shipment. Additionally, the respondents who identified themselves as "Shipper" were further asked whether they used their own vehicle, or hired transport or third party for shipping the goods.

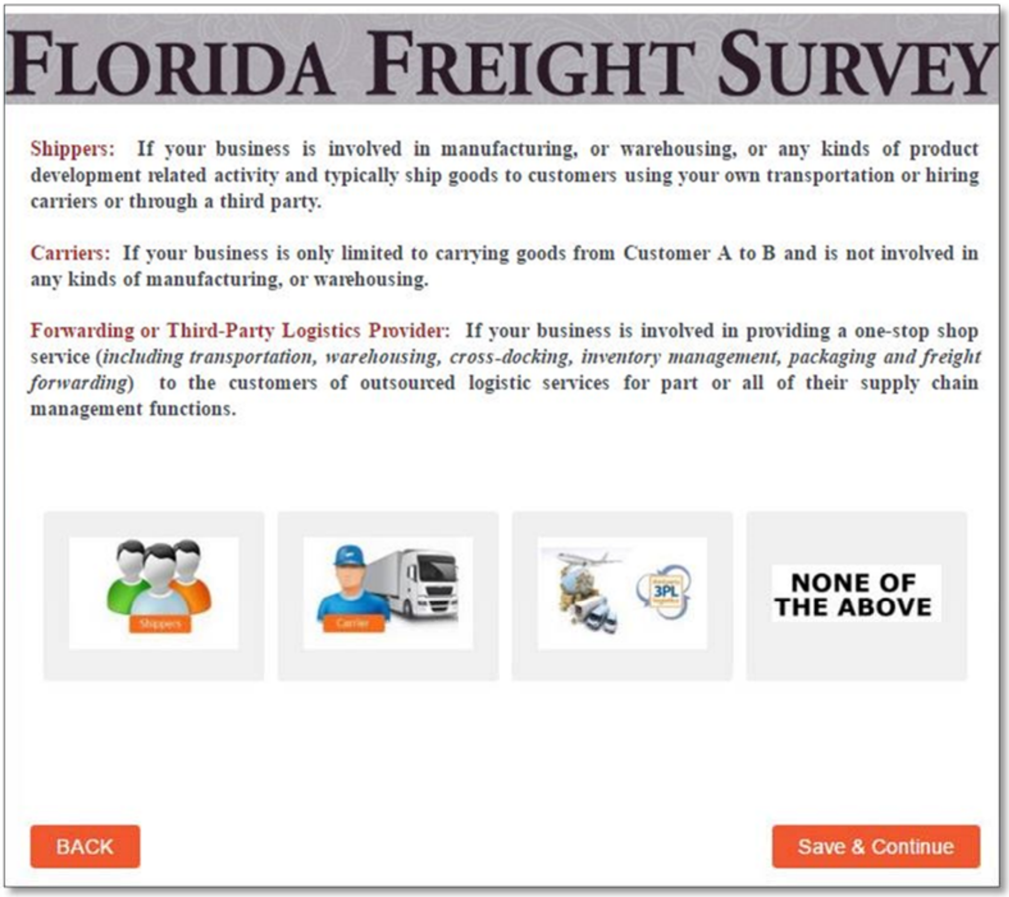


Figure 5-1: Sample screen capture: qualification question

5.1.2 Part 2: Base Shipment Characteristics

The main purpose of "Base Shipment Characteristics" part was to collect information regarding their recent/typical shipment, which could be used as a reference shipment. The information collected from this stage also provided a frame of reference for respondents when completing the stated preference scenarios in the next section of the survey. Below is the list of shipment characteristics collected in the survey:

- Primary mode used to transport
- Types of commodity transported
- Shipping distance, duration and cost
- Shipment size
- Trucking type and truck type used to transport
- Delivery time defined by clients or contract
- Provision of monetary penalty for the late delivery

5.1.2.1 *Pre-survey Instruction*

An introductory instruction was presented before the respondents were asked to answer the questions. The instruction was intended to educate participants beforehand about the survey and also clear potential ambiguity on the terms used in the survey.

The instruction mainly provided the definition of shipment and provided guidelines to the respondents when there were multiple modes, or commodities, or drops involved in a single shipment. As an example, users who used two or more modes were asked to select the mode which carried most of the shipment duration. This was defined as the "primary mode" for the shipment. Similarly, participants were asked to choose the commodity type which consisted of the major share in the shipment. This detailed explanation was particularly helpful for carriers and 3PLs since they often use more than one mode or handle multiple commodities in one shipment.

Finally, the survey asked the respondents to think of a regular shipment, not a special or emergency arrangement, when answering the questions in the survey. Figure 5-2 shows the screen capture of the instruction.

Figure 5-2: Sample screen capture: pre-survey instructions

5.1.2.2 Shipment Related Questions

A series of questions regarding their recent or typical shipments were presented to the respondents. Information on the primary mode and commodity type of the shipment was collected, as shown in Figure 5-3.

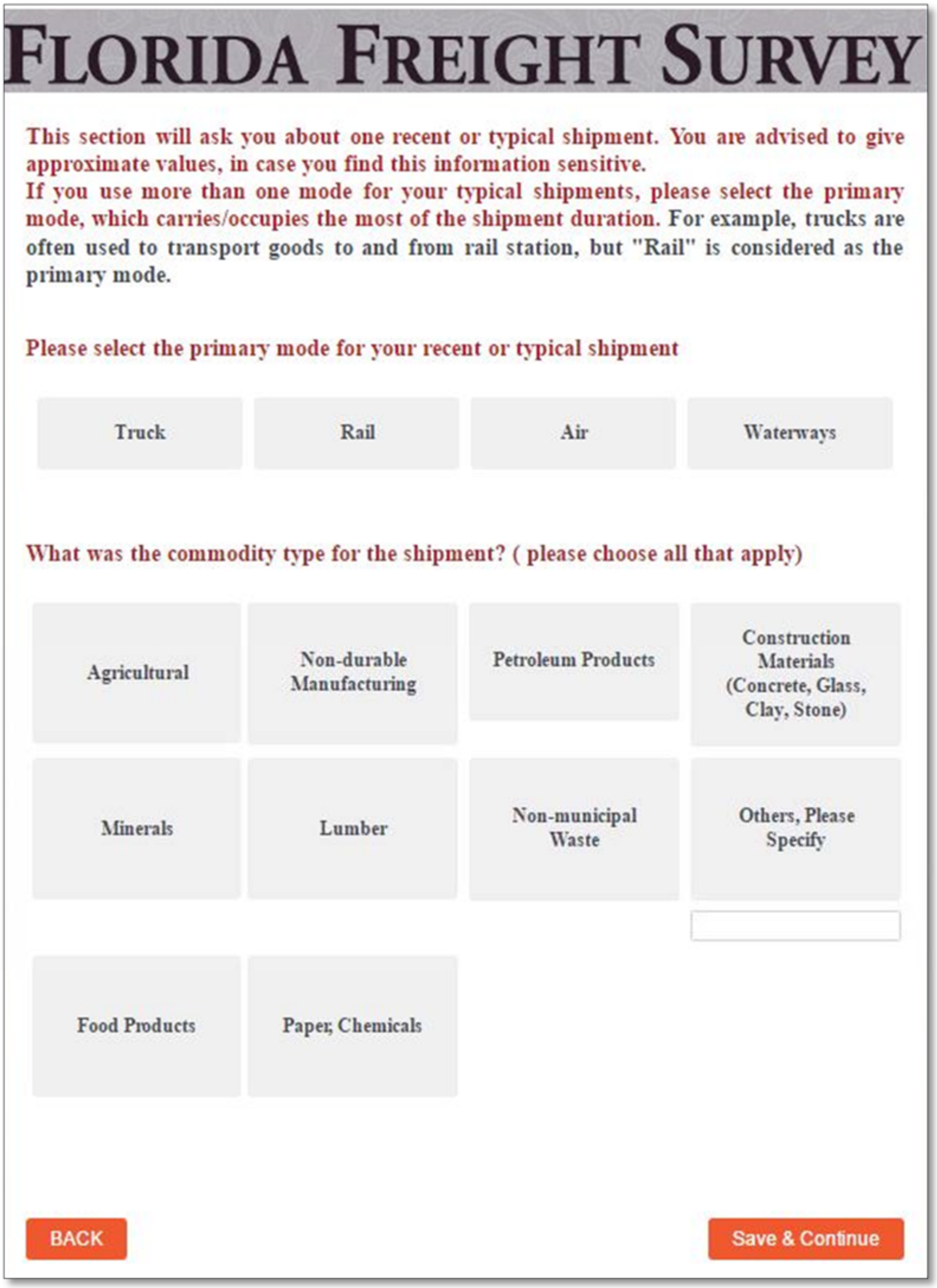


Figure 5-3: Sample screen capture: mode and commodity type

Later, the participants were asked to provide information about their shipping distance. This study used a range of pre-determined values to collect this information from the respondents. This approach avoided the risk of asking commercially sensitive information and made the survey more appealing at a loss of little statistical accuracy. Different sets of selections for shipping distance were shown to the respondents based on the primary mode they chose, as shown in Figure 5-4 and Figure 5-5 below:

Figure 5-4: Sample screen capture: shipping distance for road mode

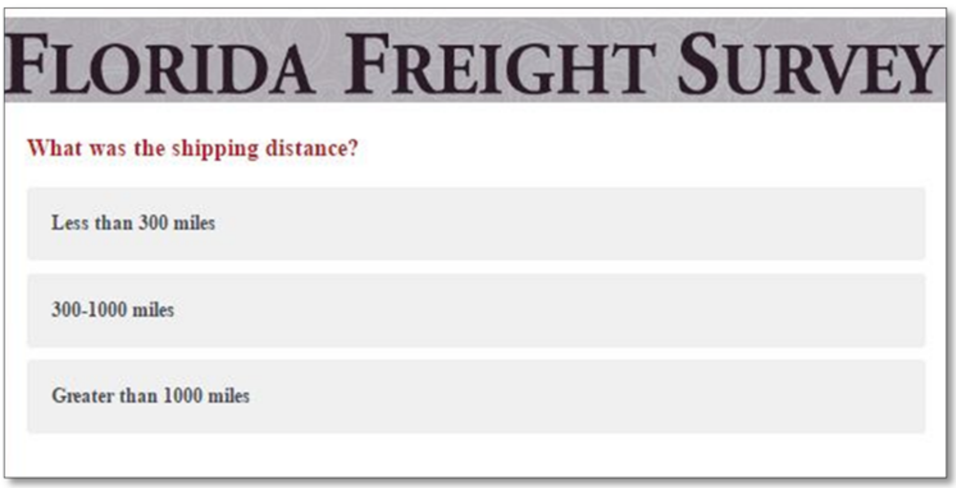


Figure 5-5: Sample screen capture: shipping distance for rail mode

For air and waterway modes, the participants were asked whether their shipment ended within or outside of Florida, as shown in Figure 5-6. If they chose outside of Florida, they were then asked to provide the origin and destination cities for the shipment.

Figure 5-6: Sample screen capture: shipping distance for air and waterway modes

Then the respondents were asked to provide the cost for their recent or typical shipment. Similarly, a range of values were provided to the respondents instead of asking for a directly value which may be deemed sensitive information. The survey also used different cost definitions for different users. For carriers and shippers with own transport, shipping cost included the operating cost (i.e. fuel, driver, administration, insurance) and possible transshipment cost, if applicable. The cost for 3PLs and shippers without own transport amounted to the price paid for the transport service. Figure 5-7 and 5-8 show the screen capture of the shipping cost for different users.

Figure 5-7: Sample screen capture: shipping cost (carriers & shippers with own transport)

Figure 5-8: Sample screen capture: shipping cost (3PL & shippers without own transport)

Information about other features of the shipment was collected next, including shipping duration and shipment size, as shown in Figure 5-9.

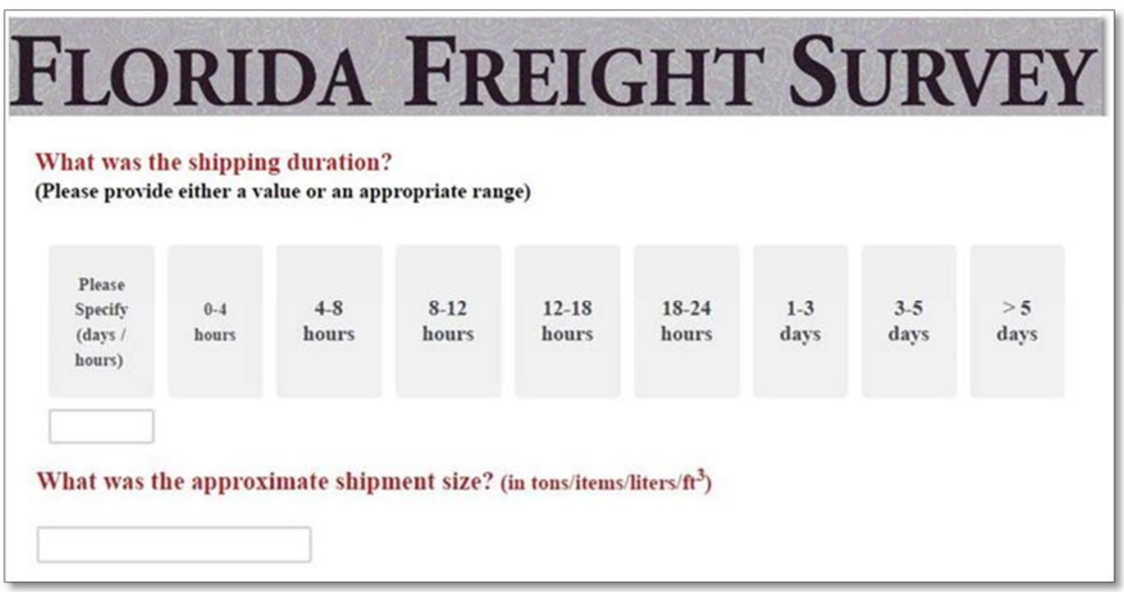


Figure 5-9: Sample screen capture: shipping duration and shipment size

Finally, the details of delivery time or any provision for monetary penalty for late delivery specified in the contract were asked. Figure 5-10 shows the screen capture of these questions.

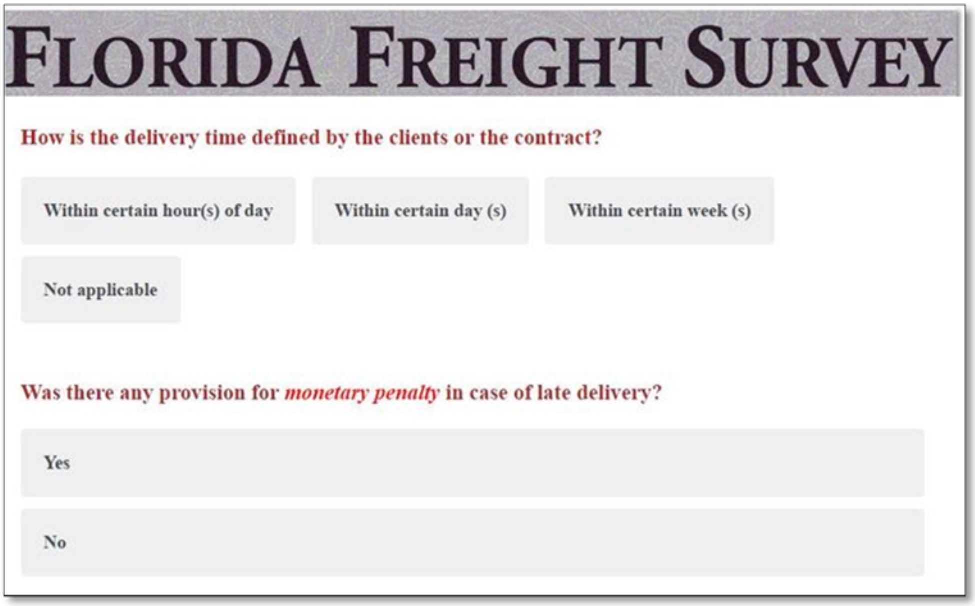


Figure 5-10: Sample screen capture: delivery time and delay penalty

Figure 5-11: Sample screen capture: trucking type and truck size

As indicated earlier, this survey also included user specific questions. As an example, “Carriers” or “Shippers with own transport” who selected road as the primary mode were asked about the types of trucks and trucing type they used. Figure 5-11 shows the screen capture of the question.

5.1.3 Part 3: Stated Preference Questions

The SP questionnaires were primarily developed to gather information on how respondents would react to choices defined in the hypothetical scenarios. Each respondent was presented 6 or 7 SP choice questions based on the information provided by them in the “Base Shipment Information” section. Based on their preferences, this study assigned the respondent to the most appropriate set of questions (experiments), which differ by the number of attributes shown in the choice questions. Mainly, each respondent was asked whether they were willing to shift departure time or mode, then the survey took them to one of the four choice experiments accordingly:

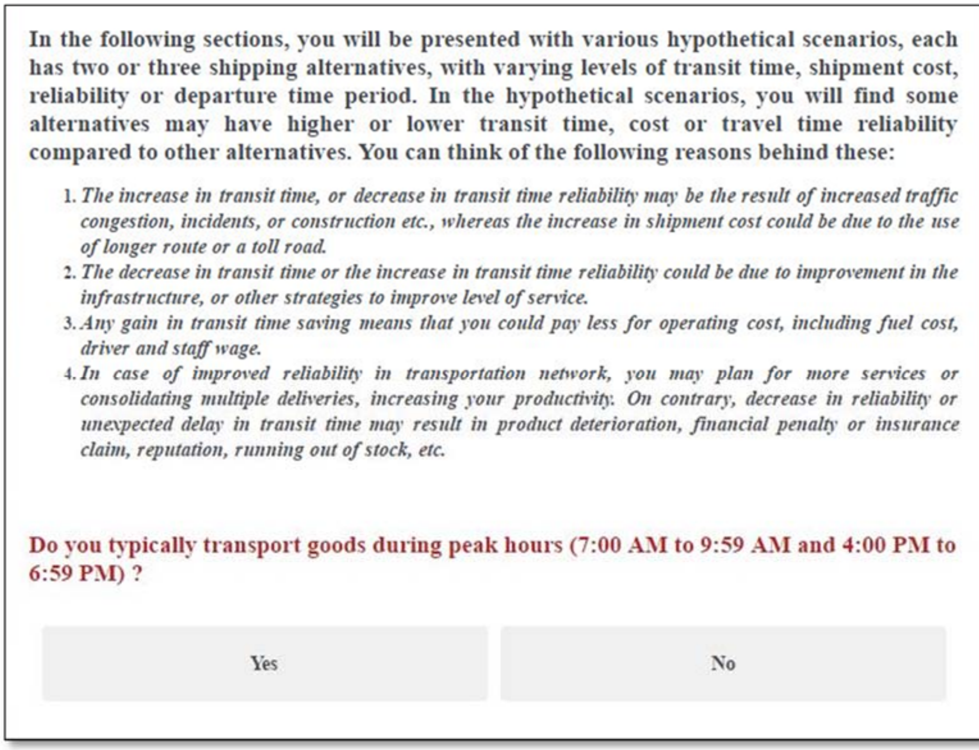
- C1 – focuses on within-mode trade-offs among transit time, cost and reliability;
- C2 – focuses on within-mode trade-offs among transit time, cost, reliability, and departure time;
- C3 – focuses on cross-mode trade-offs between roadway and railway shipment based on transit time, cost, travel time reliability, service flexibility and probability of shipment damage.
- C4 – focuses on cross-mode trade-offs between roadway and railway based on transit time, cost, travel time reliability

5.1.3.1 Introductory Note and Qualification questions for SP experiment types

Similar to the previous part, this section started with an introductory note, describing the probable reasons of enhanced or deteriorated shipment related attributes, such as time, cost and reliability, and the likely benefits/impacts for them from the changes of these attributes. This was followed by a set of qualification questions, based on which the respondents were assigned to the most appropriate choice experiments.

At this stage, the survey mainly collected information on whether the respondents shipped goods during peak hours and if they had any alternative mode available to them for the shipment, and if so, whether they were willing to consider shift to off-peak hours or the other mode.

Figure 5-12 shows the screen capture of the introductory note and qualification questions.



In the following sections, you will be presented with various hypothetical scenarios, each has two or three shipping alternatives, with varying levels of transit time, shipment cost, reliability or departure time period. In the hypothetical scenarios, you will find some alternatives may have higher or lower transit time, cost or travel time reliability compared to other alternatives. You can think of the following reasons behind these:

1. *The increase in transit time, or decrease in transit time reliability may be the result of increased traffic congestion, incidents, or construction etc., whereas the increase in shipment cost could be due to the use of longer route or a toll road.*
2. *The decrease in transit time or the increase in transit time reliability could be due to improvement in the infrastructure, or other strategies to improve level of service.*
3. *Any gain in transit time saving means that you could pay less for operating cost, including fuel cost, driver and staff wage.*
4. *In case of improved reliability in transportation network, you may plan for more services or consolidating multiple deliveries, increasing your productivity. On contrary, decrease in reliability or unexpected delay in transit time may result in product deterioration, financial penalty or insurance claim, reputation, running out of stock, etc.*

Do you typically transport goods during peak hours (7:00 AM to 9:59 AM and 4:00 PM to 6:59 PM) ?

Yes No

Figure 5-12: Sample screen capture: introduction and qualification for experiments

Figure 5-13 shows the screen capture of the questions regarding the willingness to shift departure time and mode.

Would you shift your typical departure time for your shipment in order to avoid peak hour congestion ?

Yes No

Did you have any alternative mode for the recent/typical shipment mentioned above?

Yes No

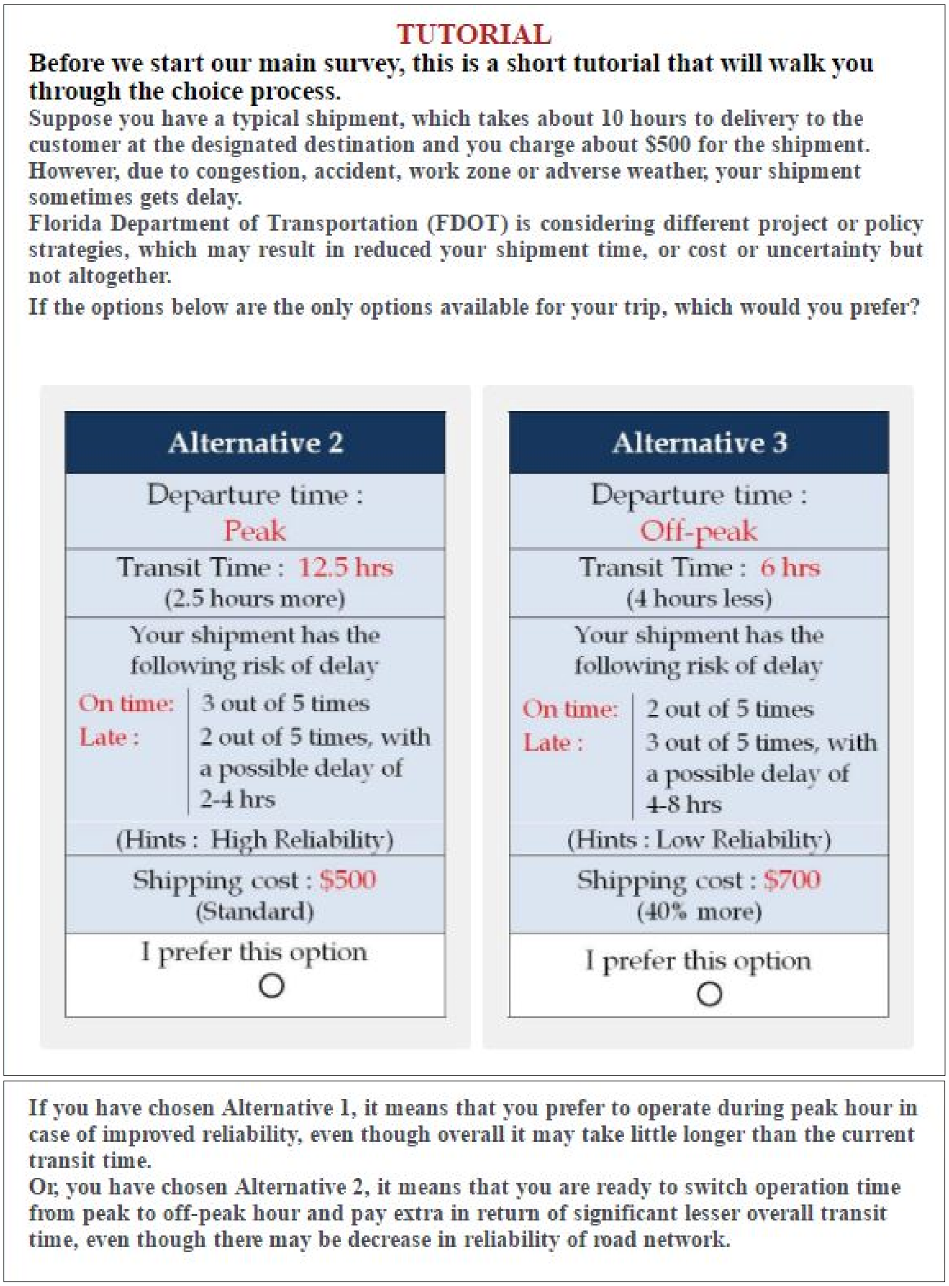
Would you consider changing your mode for this typical /recent shipment in the future, if better service is provided?

Yes No

Figure 5-13: Sample screen capture: willingness to shift departure time and mode

5.1.3.2 Tutorial

This survey employed a short tutorial for the purpose of educating the respondents about different attributes used to define alternatives in the choice questions. In the tutorial, respondents were asked to select one of the two alternatives shown to them, followed by an explanation of the alternatives they had chosen. Figure 5-14 shows the screen capture of the tutorial choice question.



TUTORIAL

Before we start our main survey, this is a short tutorial that will walk you through the choice process.

Suppose you have a typical shipment, which takes about 10 hours to delivery to the customer at the designated destination and you charge about $500 for the shipment. However, due to congestion, accident, work zone or adverse weather, your shipment sometimes gets delay.

Florida Department of Transportation (FDOT) is considering different project or policy strategies, which may result in reduced your shipment time, or cost or uncertainty but not altogether.

If the options below are the only options available for your trip, which would you prefer?

Alternative 2	Alternative 3
Departure time : Peak	Departure time : Off-peak
Transit Time : 12.5 hrs (2.5 hours more)	Transit Time : 6 hrs (4 hours less)
Your shipment has the following risk of delay On time: 3 out of 5 times Late : 2 out of 5 times, with a possible delay of 2-4 hrs	Your shipment has the following risk of delay On time: 2 out of 5 times Late : 3 out of 5 times, with a possible delay of 4-8 hrs
(Hints : High Reliability)	(Hints : Low Reliability)
Shipping cost : $500 (Standard)	Shipping cost : $700 (40% more)
I prefer this option ○	I prefer this option ○

If you have chosen Alternative 1, it means that you prefer to operate during peak hour in case of improved reliability, even though overall it may take little longer than the current transit time.

Or, you have chosen Alternative 2, it means that you are ready to switch operation time from peak to off-peak hour and pay extra in return of significant lesser overall transit time, even though there may be decrease in reliability of road network.

Figure 5-14: Sample screen capture: tutorial question

5.1.3.3 *Attitudinal Questions*

Before starting the main SP survey, this study collected Information regarding the degree of importance users put on different transport-related attributes. This task helped to understand the respondent's attitudinal view towards transport-related attributes and also made the respondents aware of the trading attributes in the main SP survey. Figure 5-15 shows the screen capture of the attitudinal questions presented to the respondents.

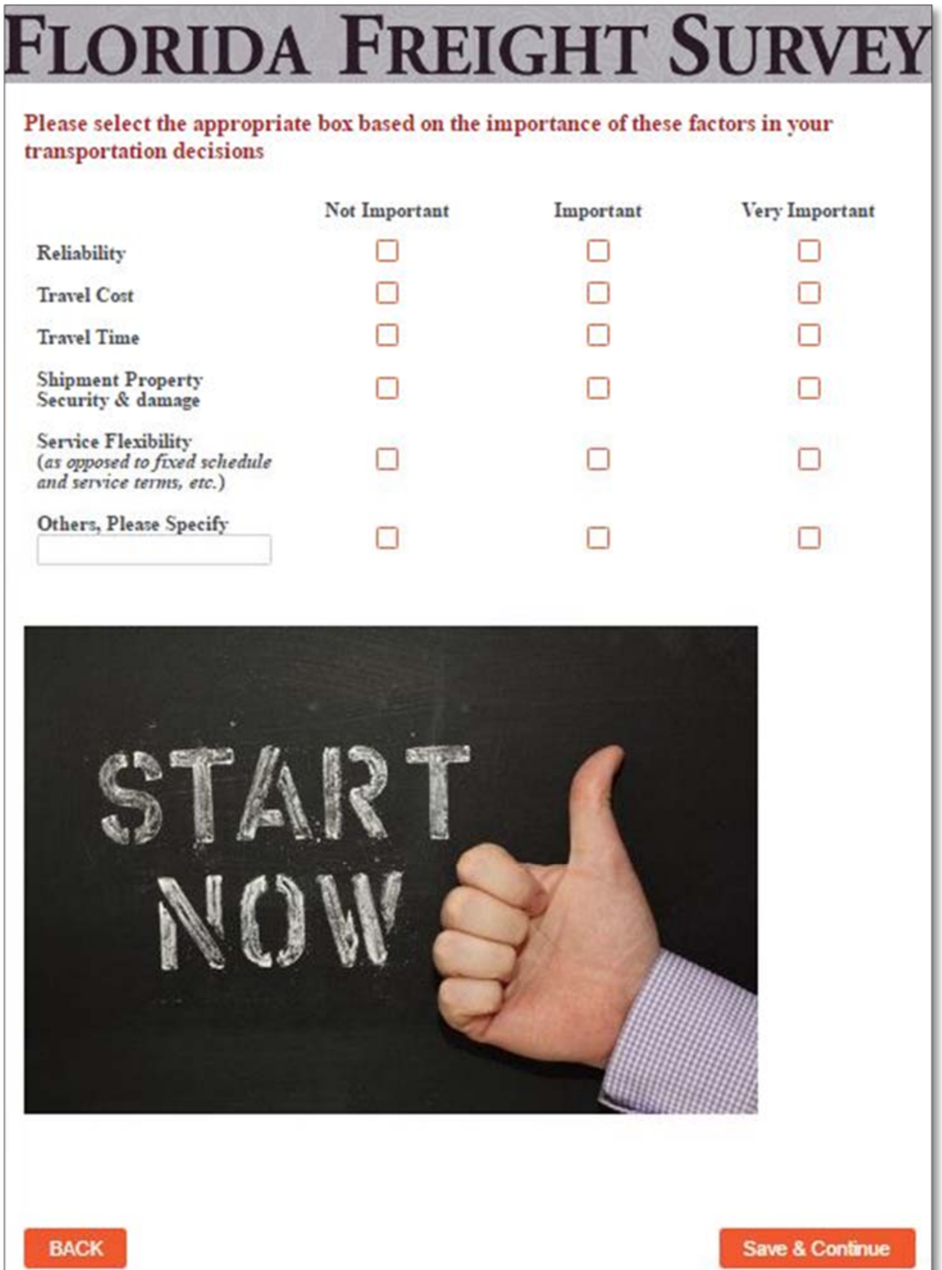


Figure 5-15: Sample screen capture: attitudinal questions

5.1.3.4 Main SP Choice Questions

Based on the information provided by the respondents in "Part 2: Base Shipment information", the respondents were assigned to different experiment types. SP choice questionnaires of these experiments included up to three alternatives, which are characterized by different combinations of attribute values, such as transit time, cost, reliability, service flexibility, and damage and security of the shipment.

Figures 5-16 to 5-19 show the screen captures of examples for the four experiment types. For those who did not show interest in changing, neither departure time nor mode was assigned to C1 (Figure 5-16). Figures 5-17 and 5-18 present the sample choice questions for those who showed interest in changing either time (C2) or mode (C3). Figure 5-19 presents the sample SP choice for those for showed interest in changing both (C4).

For experiments C1 and C2, the choice alternatives were defined by transit time, cost, reliability, and departure time (for C2 only). Experiments C3 and C4 mainly focused on the trade-off between road and rail modes, and additional attributes were introduced in the choice questions, including service flexibility and damage risk.

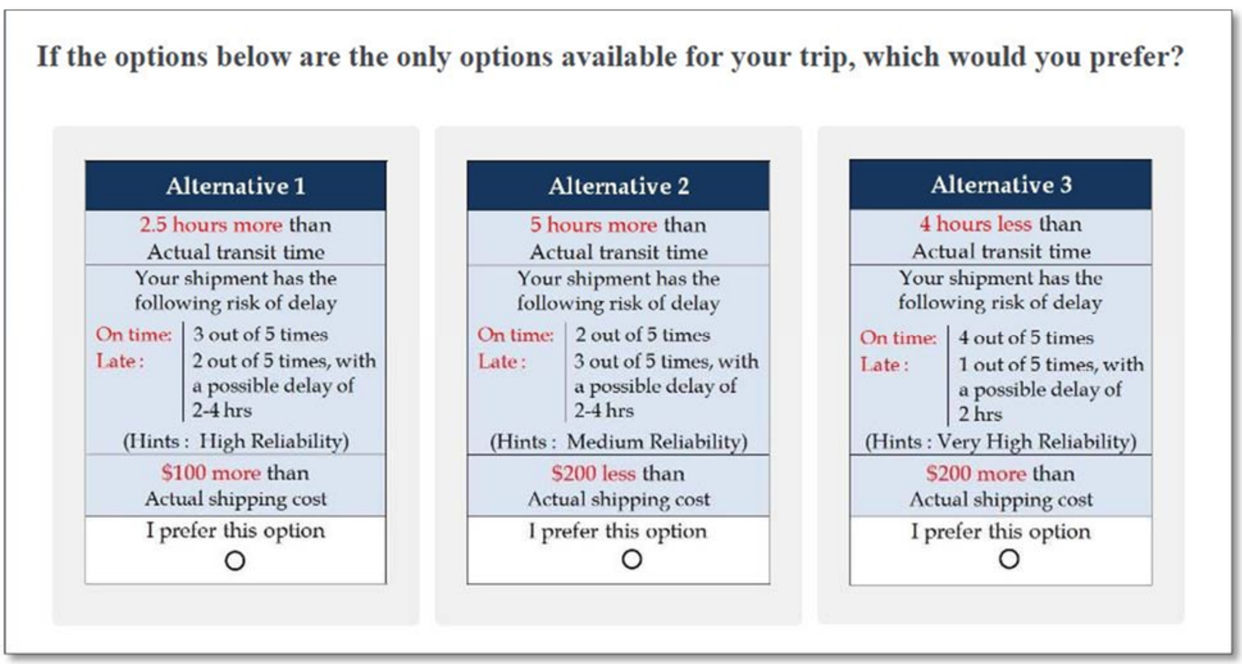


Figure 5-16: Sample screen capture: an example of SP choice question for C1 experiment

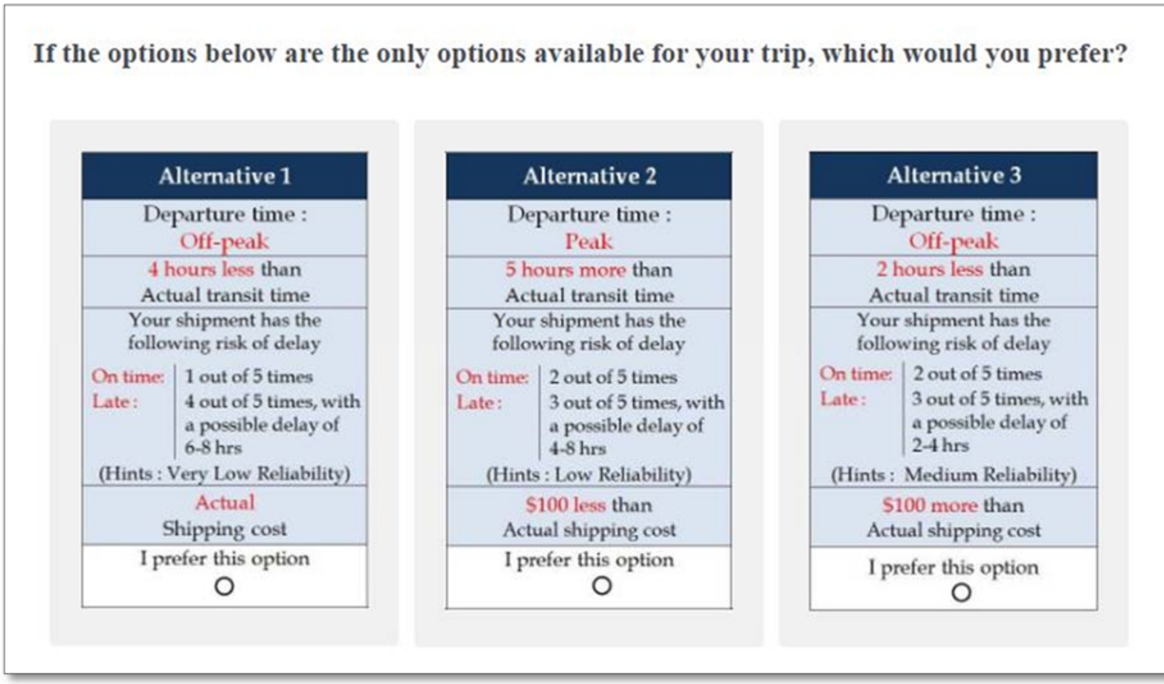


Figure 5-17: Sample screen capture: an example of SP choice question for C2 experiment

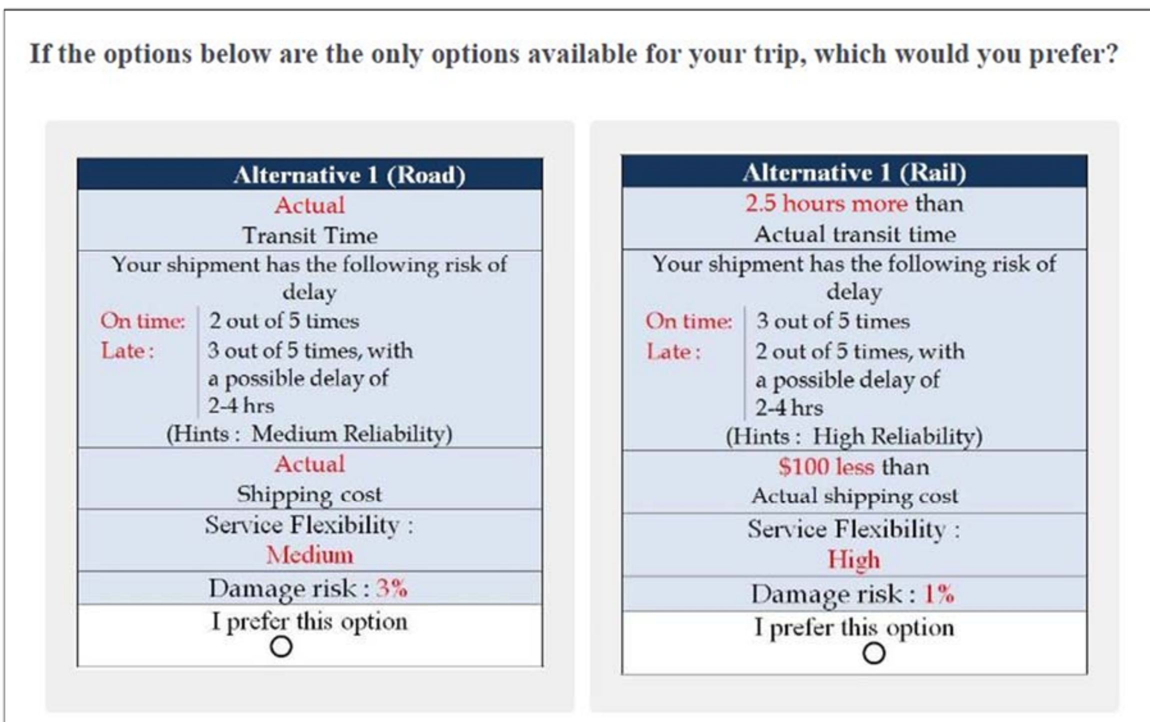


Figure 5-18: Sample screen capture: an example of SP choice question for C3 experiment

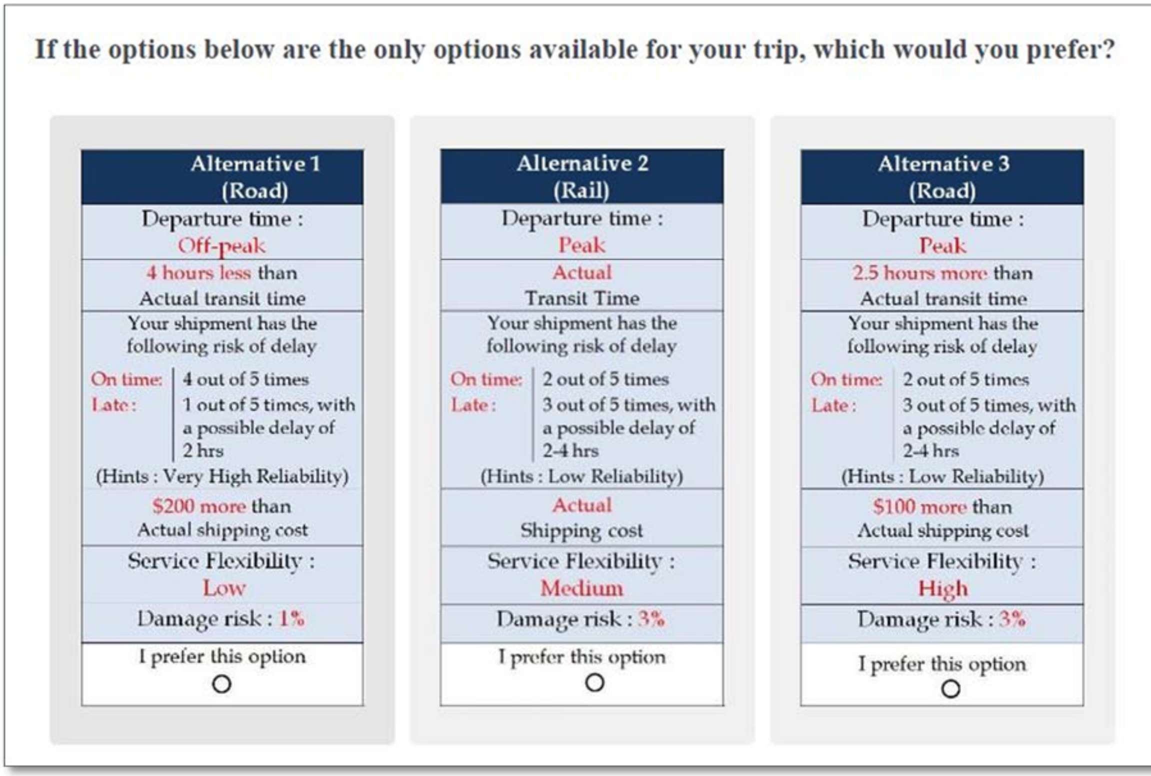


Figure 5-19: Sample screen capture: an example of SP choice question of C4 experiment

As can be seen in the screen capture for the choice questions, the SP design considered the reference shipment information (travel time and travel cost) provided by each participant as the base (actual/current) alternative and adjusted the attribute values around it for the construction of other alternatives.

5.2 Validation Question

After the SP choice questions, the respondents were asked whether they had considered all the attributes or not. These questions can be very useful for validating the responses. Figure 5-20 shows the screen capture of the validation question.

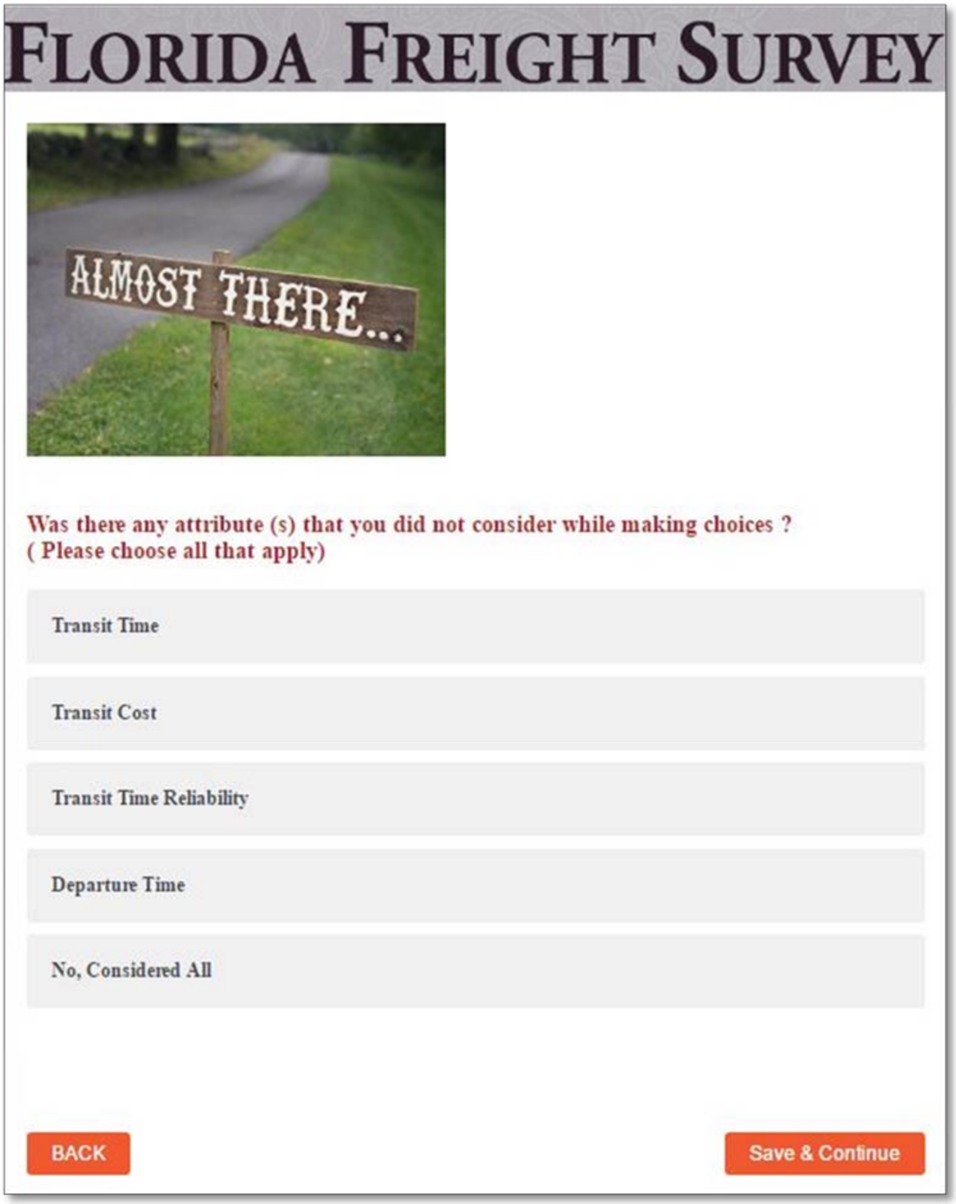


Figure 5-20: Sample screen capture: validation question

5.3 General Questions (Optional)

The final section of the survey was optional for the respondents. This part focused on collecting background information of the firms and the business. The questions include the frequency of late out-bound shipment, followed by number of employees in the firm, and the percentage of shipment under delivery pressure. Figure 5-21 shows the screen capture of the questions in this part of the survey.

Figure 5-21: Sample screen capture: firm background information

Additionally, carriers and 3PLs were asked to indicate who was in charge of route decisions (i.e. whether to take toll road) and whether they would receive toll reimbursement from the client. These questions would help clarify the forces behind the choice behavior.

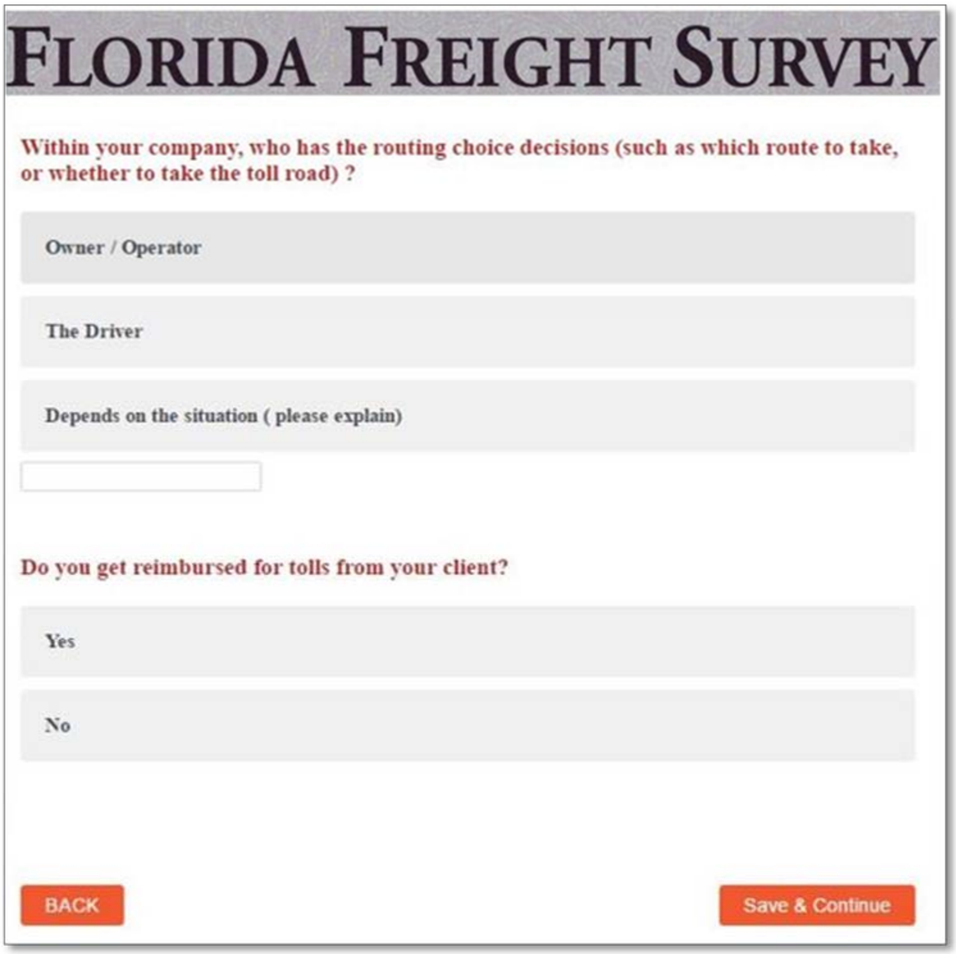


Figure 5-22: Routing and toll related questions (carriers & 3PLs)

6 SURVEY ADMINISTRATION AND RESULTS

This chapter of the report discusses the survey efforts undertaken by the research team and summarizes the sample data. For the data collection, the research team adopted multiple approaches, including researching out freight communities and field visits, to meet the target sample. Additionally, this chapter presents descriptive statistics of the survey data. A complete set of tabulations of survey results by segments is shown in Appendix C.

6.1 Data collection

The survey went live in January through May 2016. Various approaches were taken to promote the survey and recruit participants. Through collaboration with a number of freight associations, including the Florida chamber of brokers & forwarders (FCBF), the Florida Trucking Association (FTA) and the Miami-Dade Metropolitan Planning Organization (MPO), the survey link was sent to their members in the monthly newsletters. A local marketing consultancy firm was also employed to recruit participants. The research team was also attended various conferences and visited offices of establishments for recruitment.

Although the survey was initially designed for web-based approach, paper-based responses were also collected. Table 6-1 shows the completed responses by survey method.

Table 6-1 : Completed responses by survey method

Survey Format	Completed Surveys
Online	74
Paper format	85
Total	159

Table 6-2 displays the summary statistics of road users by the originally proposed market segment. Some cells have zero or very low responses, these groups need to be merged for model estimation to get statistically significant outcomes. More details are provided in the “Model Estimation” Chapter.

Table 6-2 : Number of Survey Participants by Segment (Road Only)

Shippers				Carriers				3PL
Commodity type	Delivery Window Pressure	Ownership of Transport		Shipping Distance (Miles)	Truck Type			
		No	Yes		*Light*	*Medium*	*Heavy*	
Perishable	No	10	6	<50	1	2	2	7
	Yes	2	1	50-300	1	6	12	
Non-perishable	No	13	2					
	Yes	1	0	300+	0	9	75	

Figure 6-1 shows the geographic distribution of the survey respondents. As shown in the figure, the survey sample covered major freight activity centers in Florida.

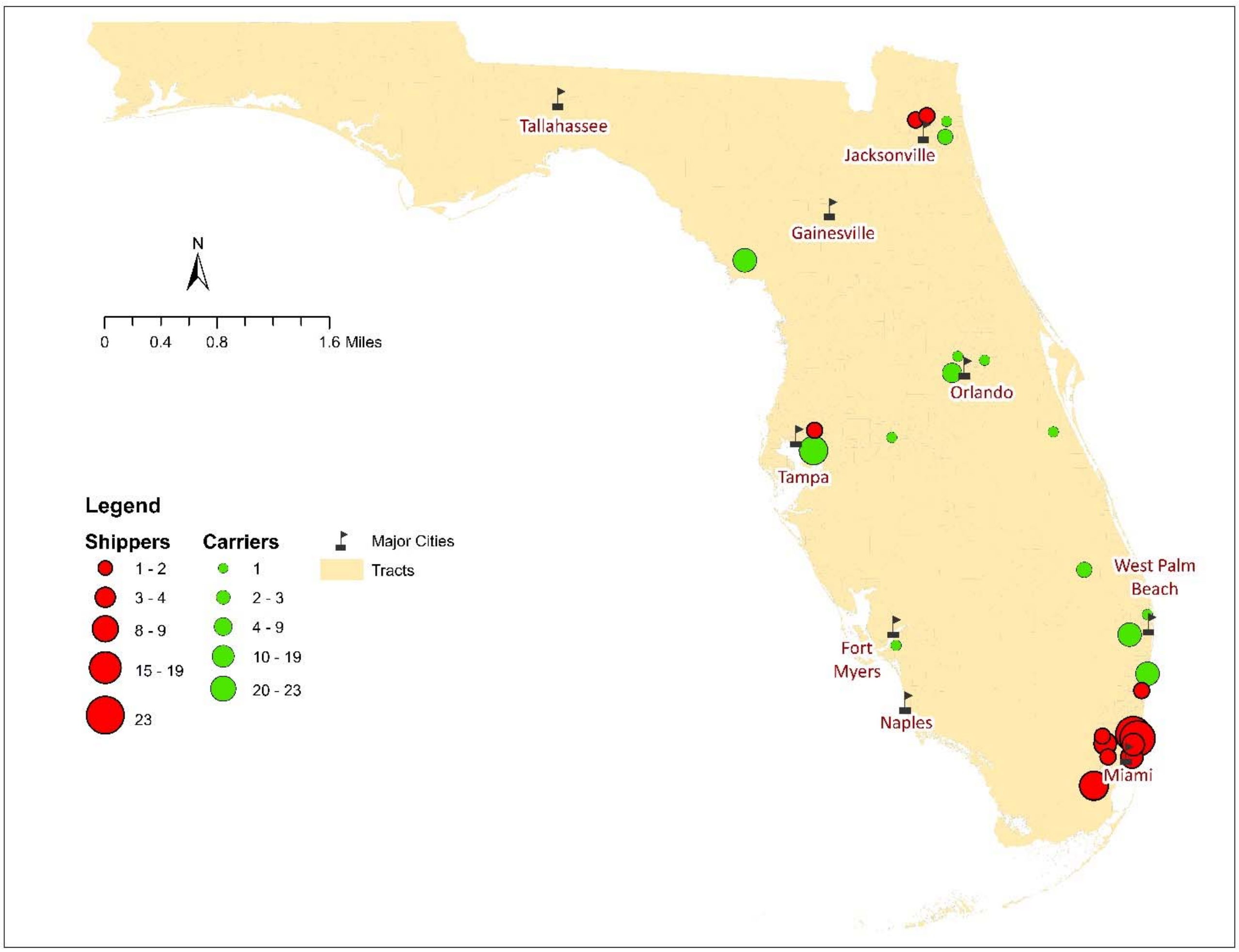


Figure 6-1: Spatial distribution of completed responses by user type

6.2 SURVEY RESULTS

A total of 159 firms completed the survey. This section summarizes the survey results in three sections: base shipment characteristics, stated preference questions and general information.

6.2.1 Base Shipment Characteristics

In this section, the respondents were asked to describe a recent / typical shipment. This included information related to mode, commodity type, shipping distance and duration, shipping cost and other characteristics of the shipment.

6.2.1.1 Mode

Most of the respondents in this sample used road as the primary mode. Only 7 out of 159 respondents used other modes (2 for Air and 5 for Waterways). Table 6-3 shows the summary statistics of responses by user group and mode used. Unfortunately, the survey did not capture any rail users.

Table 6-3 : Number of Survey Participants by User Group and Mode

User Type	Road	Rail	Air	Waterways	Total
Carrier	108	0	0	5	113
Shippers with own transport	9	0	0	0	9
Shippers w/o own transport	26	0	0	0	26
3PL/ Forwarders	7	0	2	2	11
Total	150	0	2	7	159

In the subsequent sections, analyses of responses from road users are first presented, and then outcomes of users from other modes are provided. Additionally, all tabulations and graphs used to summarize the analyses are segmented by user group, which include carriers, shippers with own transport, shippers without own transport and 3PLs.

6.2.1.2 *Commodity Type*

Nearly all road users (149 out of 150) responded to the questions when they were asked about the types of commodity shipped. As shown in Figure 6-2, carriers and shippers without own transport represented almost all industries. For both groups, food products had the highest share. On the other hand, most of the surveyed shippers and 3PL groups came from the agriculture industry, which were 66.7% and 42.9% respectively; followed by food products and miscellaneous products (indicated as "others" in the survey). The data showed that miscellaneous type mainly included auto parts, electronics and heavy machinery equipment.

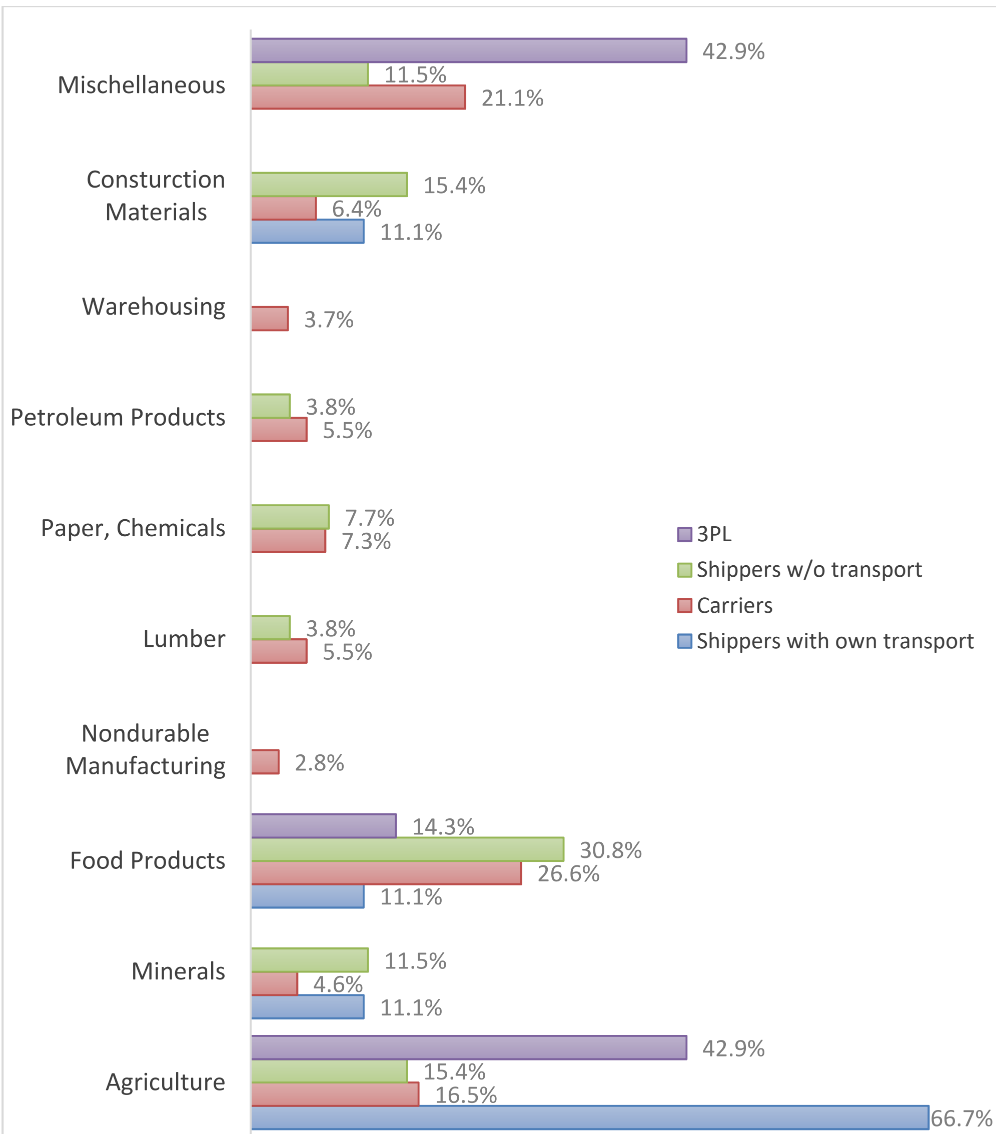


Figure 6-2 : Shipment by commodity type (road only)

Users from waterways and air mode in the sample mainly transported food products, construction materials and miscellaneous types, except two in waterways who transported all types of commodities. Table 6-4 provides the summary of commodity types transported by other mode users.

Table 6-4 : Commodity types transported by users from Waterways and Air

Mode	Commodity Types (number of responses)
Waterways	Food products (3), Construction Materials (2), All types (2)
Air	Miscellaneous : Auto parts , Medical equipment (2)

6.2.2 Shipping Distance and Duration

For all groups except shippers with own transport, the distances of typical (or, recent) shipment were more than 300 miles. As shown in Figure 6-3, the share of long distance (>300 miles) shipment were 77% for carriers, 88% for shippers without transport and 71% for 3PL respectively. On the contrary, more than half (55%) of the shippers with own transport reported a typical/recent shipment between 50 and 300 miles, while 33% of them reported a shipment greater than 300 miles and 11% reported a shipment within 50 miles.

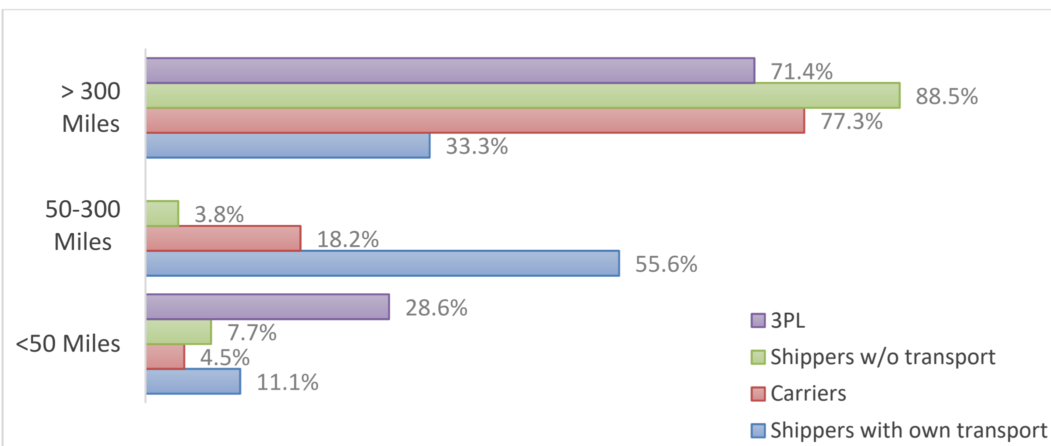


Figure 6-3: Shipment by shipping distance (road only)

For air and waterway modes, users mostly shipped goods outside of Florida; only two users were found who used waterway for shipping goods within Florida.

Figure 6-4 shows the sample distribution of road users by shipping duration. For carriers, most of the shipments were between 12 to 18 hours (42%), followed by 8 to 12 hours (24%), and 1 to 3 days (16%). Similarly, a major share (58%) of the shipment for shippers without own transport fell between 12 to 24 hours, with only 4% between 3 to

5 days and 15% between 1 to 8 hours. It was also seen that the shipments from shippers with own transport were either less than 12 hours or across multiple days, whereas the 3PLs mostly handled shipment of long durations (multi-day shipments).

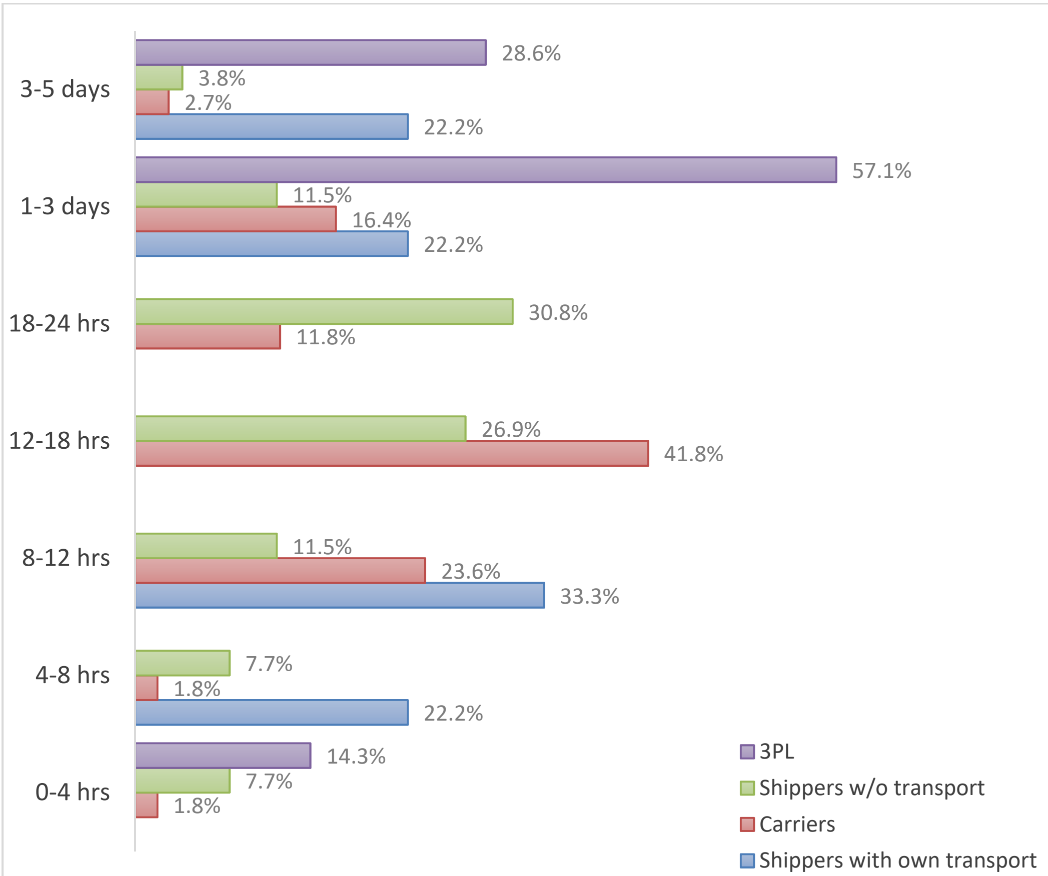


Figure 6-4: Shipment by shipping duration (road only)

For other modes, Table 6-5 shows that, as expected, shipments by waterways ran for multiple days, the shipment duration by air was between 0 to 8 hours.

Table 6-5 : Shipping Duration for Water and Air Modes

Waterways		**Air**	
1-3 days	3+ days	0-4 hrs.	4-8 hrs.
4	2	1	1

6.2.3 Shipping Cost

In the surveyed sample, the shipping costs for carriers and shippers with own transport covered a wide range as shown in Figure 6-5. Interestingly, the shipping costs of all shipments for shippers without own transport were below $400, although more than half of their shipments took 12 to 24 hours. On the contrary, 50% of shipping cost for 3PL was more than $1800, probably related to the long-distance multi-day shipments.

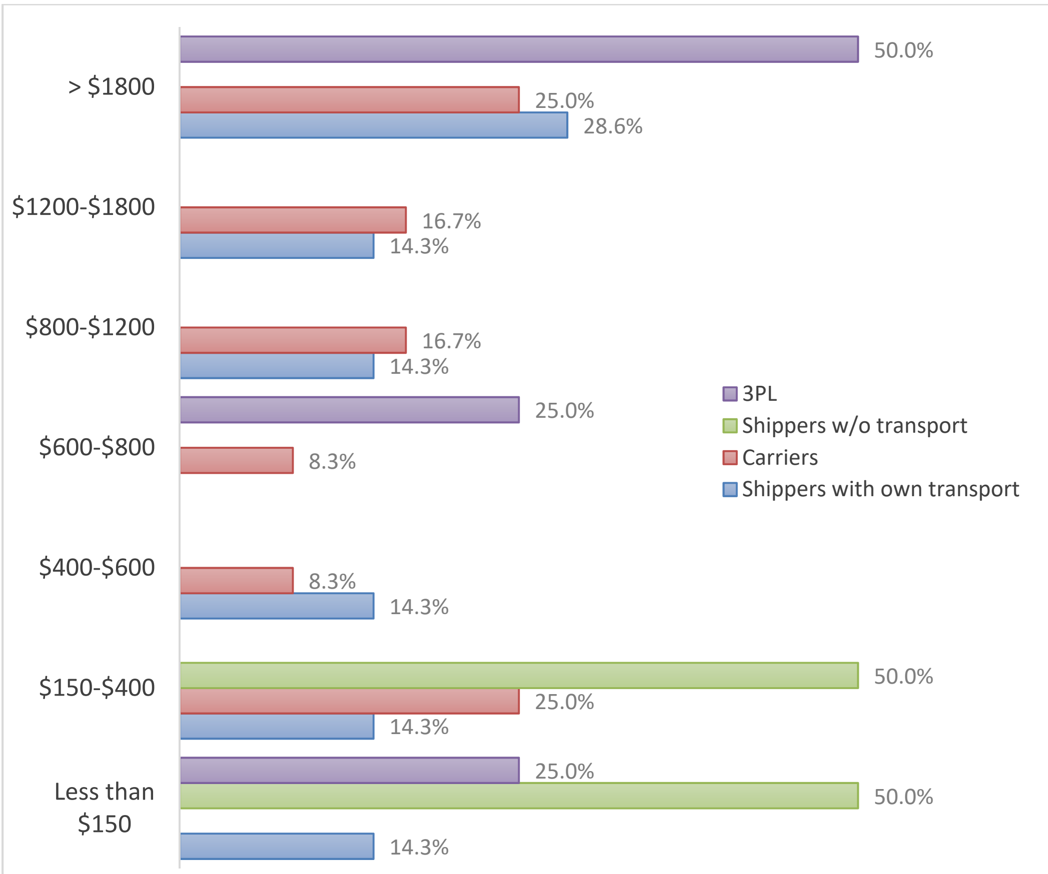


Figure 6-5: Shipment by shipping cost (road only)

Table 6-6 shows the summary of shipping cost for water and air modes. For waterway users, 4 out of 7 shipments cost more than $1,800, one between $800 and $1,200, and one between $150 and $400. One of the two air shipments cost within $800 to $1,200.

Table 6-6 : Shipping cost for Water and Air Modes

Waterways			Air	
$150 - $400	$800 - $1,200	>$1,800	$800 - $1,200	Unknown
1	2	4	1	1

6.2.4 Shipment Size

The sample contains a wide range of shipment size and types. Most respondents (76%) used "pounds" to describe their shipment size, which are summarized in Table 6-7. The mean weight of shipment for all groups except shippers with own transport weighed more than 40,000 lbs. (20 ton) in the sample.

Table 6-7 : Shipping size by groups (lbs. only)

Values	Shippers with Own Transport	Carriers	Shippers w/o Transport	3PL
Min	6000	1000	500	1000
Max	40000	80000	80000	80000
Mean	23000	49291	61395	42500
Total Respondents	2	92	21	4

The sample also contains few shipments of other units, which includes gallon, items, pallet, and skids. A more detail about this can be found in Appendix C.

6.2.5 Trucking and Truck Type

In terms of truck type used, heavy trucks were used for a majority of the shipments among all groups. Figure 6-6 shows that about 80% of the shipments from carriers and 3PLs used heavy trucks. The shippers in this sample showed higher rate of using medium and light trucks than other groups, especially shippers without transport, where 25% of the shipments were carried by medium and light trucks respectively.

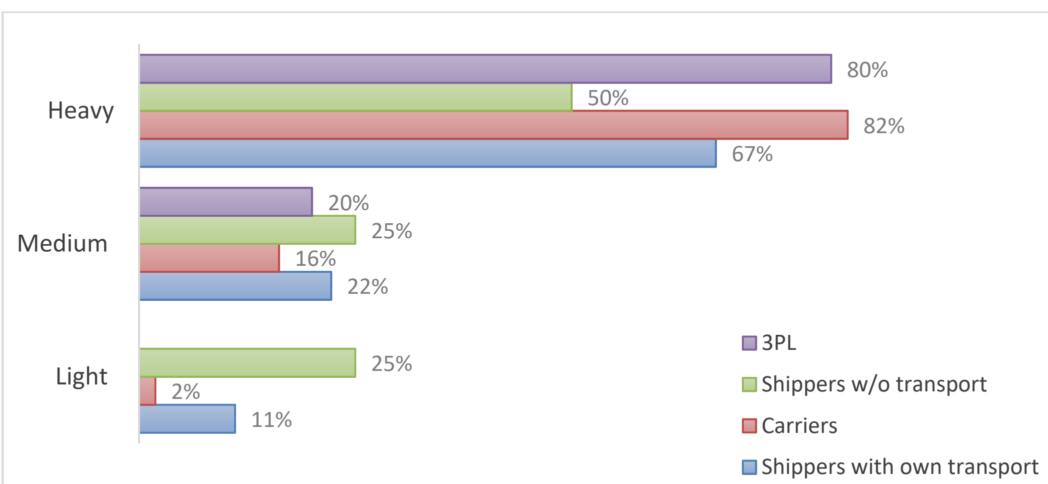


Figure 6-6: Shipment by truck type (road only)

The results showed that trucking type for carriers and both groups of shippers were mostly of full truck load (FTL). Twenty percent of shippers with own transport used less than truck load (LTL) and twenty-five percent of carriers employed refrigerated method. On the other hand, LTL and refrigerated trucking type comprised the major share of shipments for the 3PL. The sample also contains very few shipments of drayage and other special types, as shown in Figure 6-7.

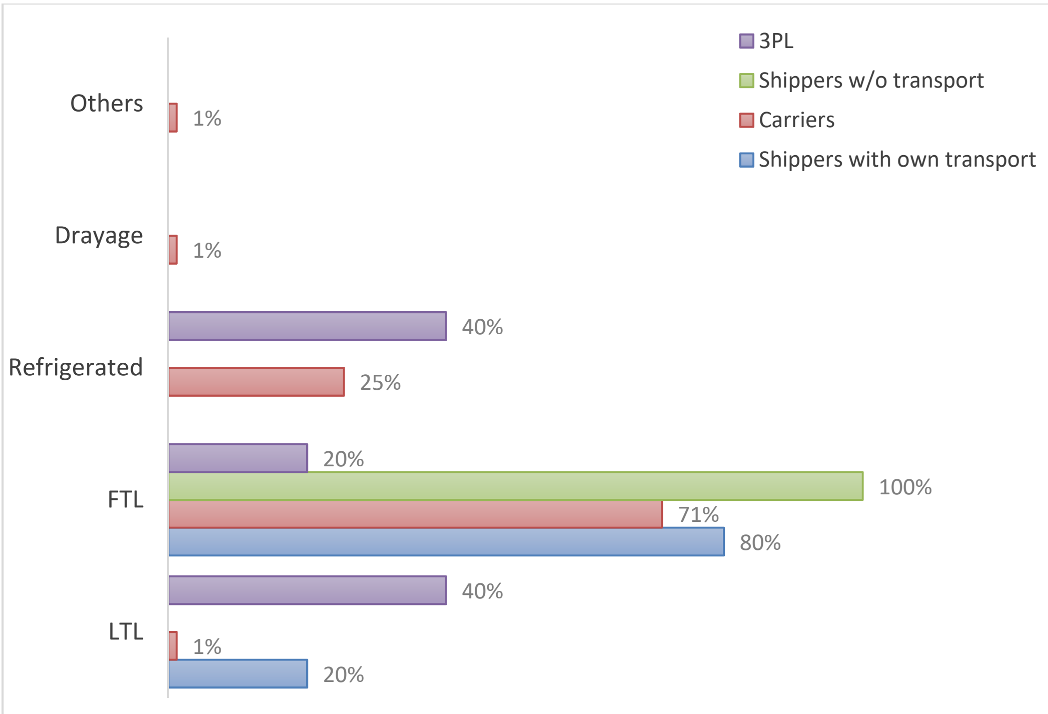


Figure 6-7: Shipment by trucking type (road only)

6.2.6 Delivery Time Specification and Monetary Penalty for Delay

Figure 6-8 presents how delivery time was specified for the shipments, which may also impact the user's choices in view of travel time reliability. Except for 3PL, most of the shipments were required to be delivered within certain hours. For 3PL, the time window for 57% of the shipments was "within certain days", followed by "within certain hours" (28%), and "within certain weeks".

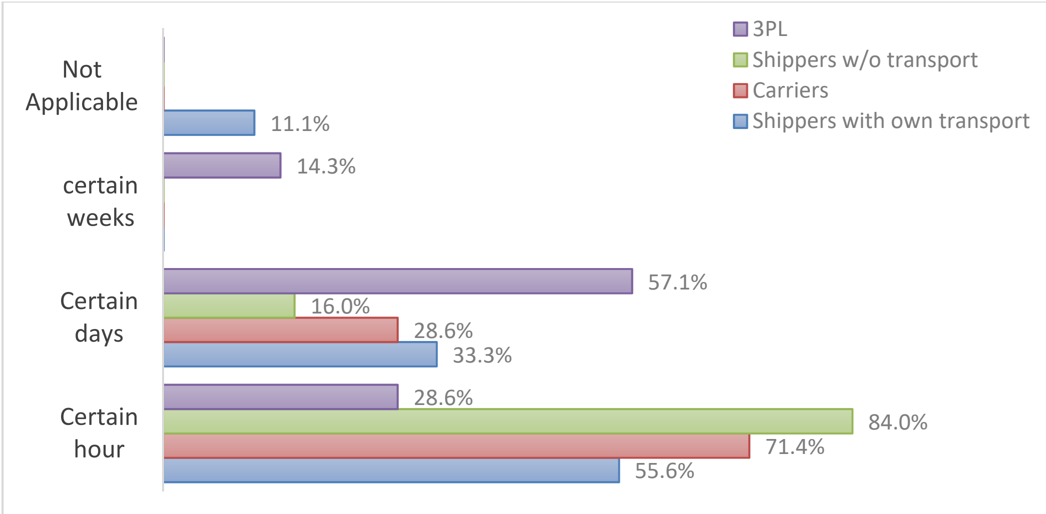


Figure 6-8: Shipment by delivery time specified in contract

In terms of whether monetary penalty were imposed for the shipments, Figure 6-9 shows that a majority of the carriers and shippers (both groups) reported no provision for late delivery, while only 11% of the shipments were bounded by late penalty. On the other hand, more than half of the shipments (57%) for 3PL were subject to monetary penalty.

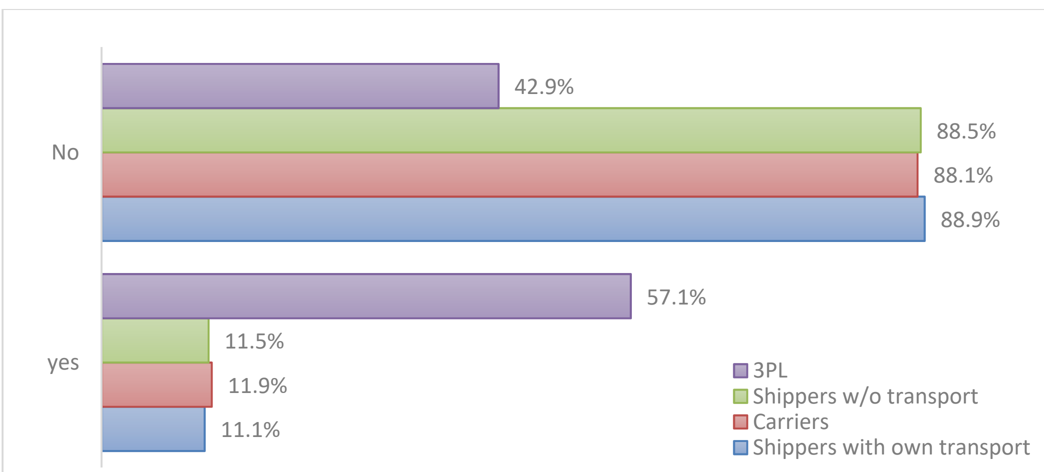


Figure 6-9: Percentage of shipment having monetary penalty

6.3 Stated Preference Choice Questions

6.3.1 Allocation of Choice Experiments

As discussed previously, each respondent was asked to indicate their willingness to shift departure time and mode, and was assigned to one of the four different choice experiments. Additionally, two sets of attribute values were adopted to make the choices more realistic, based on the shipping distance they provided previously. Table 6-8 shows the survey responses collected by experiment type.

Table 6-8: Summary Statistics of Responses by Experiment Types

Questionnaires Type	Experiment Type			
	Within Mode		Across Mode	
	C1	C2 (time shift)	C3 (mode shift)	C4 (time & mode shift)
Set – 1 (0-300 miles)	116	6	0	0
Set - 2 (300+ miles)	34	2	1	0
Total	150	8	1	0

6.3.2 Attitudinal Questions

Figures 6-10 to 6-14 summarize the general attitudes toward various transport-related attributes, including shipping time, cost, reliability, security and damage, and flexibility. Forty-two percent of the respondents expressed their preferences toward shipping time, which is summarized in Figure 6-10. Among the respondents, only 7% of carriers and 20% of shippers with own transport stated that shipping time was not important to them.

Thirty percent of the respondents expressed their opinion on shipping cost, which is shown in Figure 6-11. The figure shows that about 80% of shippers with own transport viewed shipping cost as the most important, followed by carriers (69%), 3PLs (50%), and shippers without transport (26%). About 6% of carriers and 11% of shippers without transport stated that shipping cost was important to them.

Thirty-one percent of the respondents expressed their opinions on travel time reliability. Most of them (more than 80%) viewed reliability as the most important, especially for carriers as shown in Figure 6-12.

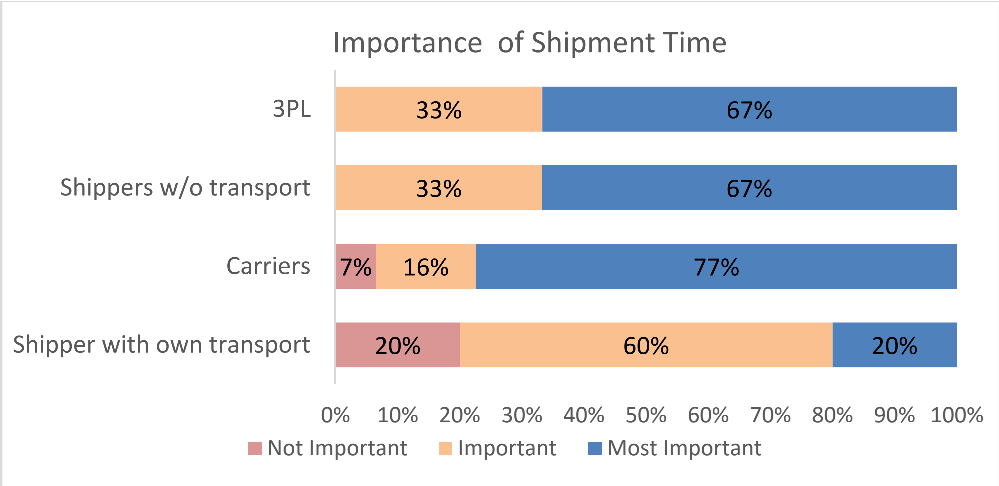


Figure 6-10: Importance of shipping time

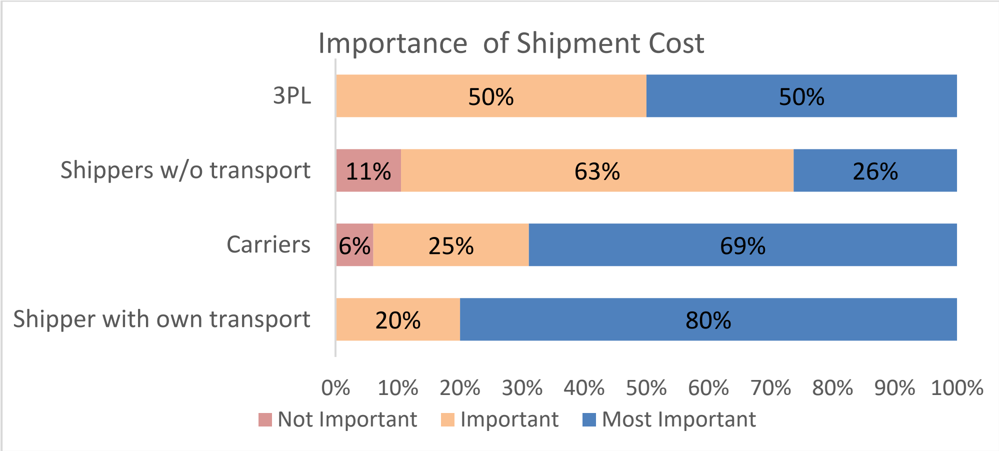


Figure 6-11: Importance of shipping cost

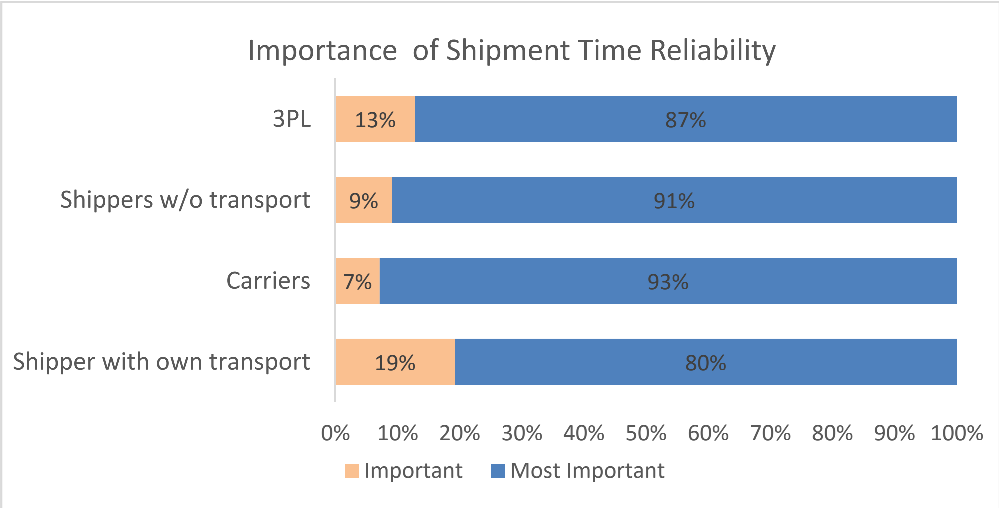


Figure 6-12: Importance of shipping time reliability

The survey also showed that shipment security was important for most of the respondents. As shown in Figure 6-13, shippers without transport and carriers put relatively higher importance towards security compared to other groups.

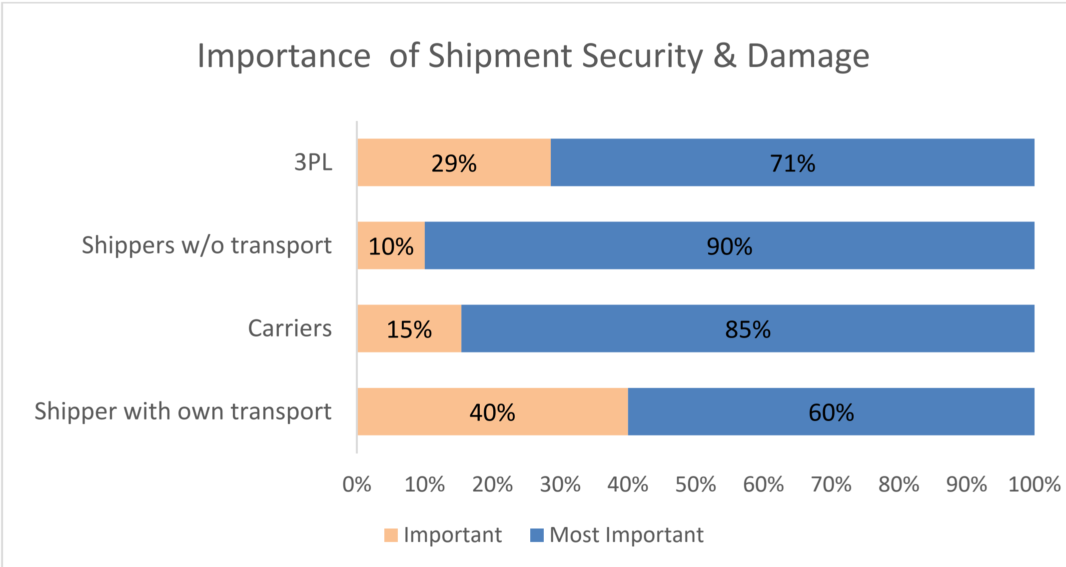


Figure 6-13: Importance of security and damage

Figure 6-14 presents the level of importance on service flexibility for the 23% of the respondents who stated their opinion towards service flexibility. The result showed that 80% of shippers with own transport viewed service flexibility as the most important, a much higher shared compared to other groups.

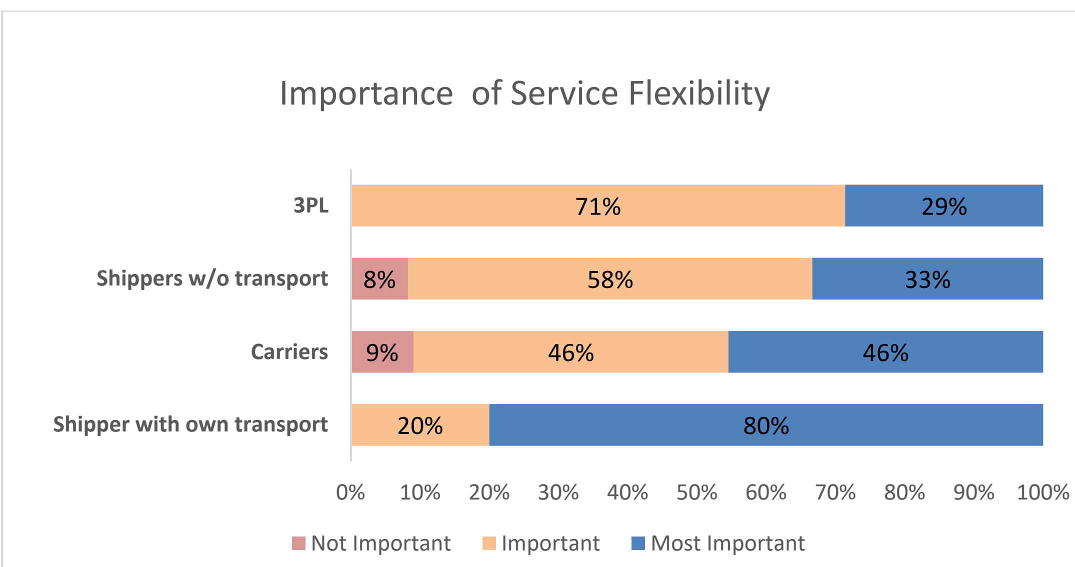


Figure 6-14: Importance of service flexibility

6.3.3 SP Choice questions

In SP surveys, it is important that respondents trade-off the attributes in their decision-making. In this regard, result shows that only 14 respondents (out of 150 road users) always chose the fastest option. Additionally, the survey responses were checked for respondents who always chose the left option, and found only 2 such instances. Table 6-9 shows the summary of the analyses on trading behavior However, due to the limitation of the small sample size, these responses are kept for model estimation.

Table 6-9: Trading Behavior

Scenarios	Number (Percentage)
Always choose the cheapest option	0 (0%)
Always choose the fastest option	14 (9%)

6.3.4 Validation Questions

When asked about the attributes they considered in SP choice making, 140 (88%) of respondents answered to this question. 133 (84%) reported that they considered all the attributes, which includes shipping time, cost, reliability and (or) departure time. Only few respondents (4%) considered cost, time or reliability while making choice.

6.4 General Information (Optional Part)

This part of the survey was made optional to reduce respondent burden and make the survey more appealing to the respondents. Most of the questions of this part are related to the background information of the firms and their business.

6.4.1 Frequency of Outbound Shipment Delay

Sixteen percent of the respondents reported frequency of shipment delay. Figure 6-15 shows that delays are regularly experienced by all groups, more than eighty percent of all respondents indicated delay at least 1 to 7 times out of 10 times. Twenty percent of carriers and fourteen percent of shippers with own transport reported frequent delays (7 out of 10 times).

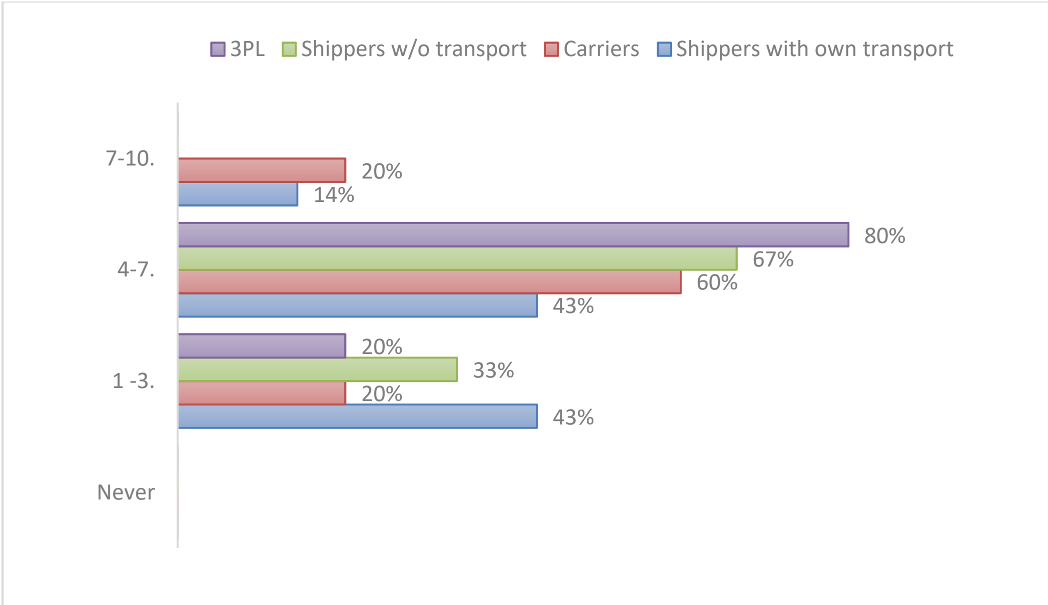


Figure 6-15: Frequency of outbound shipment delay (out of 10 times)

6.4.2 Number of Employees

Thirty percent of the respondents described their firm size. Figure 6-16 shows that most of them had more than 20 employees.

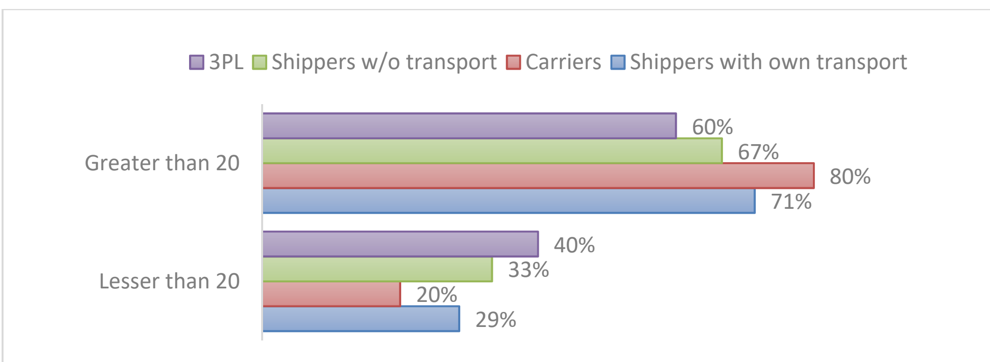


Figure 6-16: Firm size

6.4.3 Shipment under Delivery Pressure

Twenty-eight percent of respondents provided information regarding the percentage of shipment under delivery pressure. Figure 6-17 shows that 3PLs and shippers were likely to be under delivery pressure than carriers, as 80% of 3PL and 67% of shippers (both groups) reported that more than 50% of their shipments were under delivery pressure, that share was 36% for carriers.

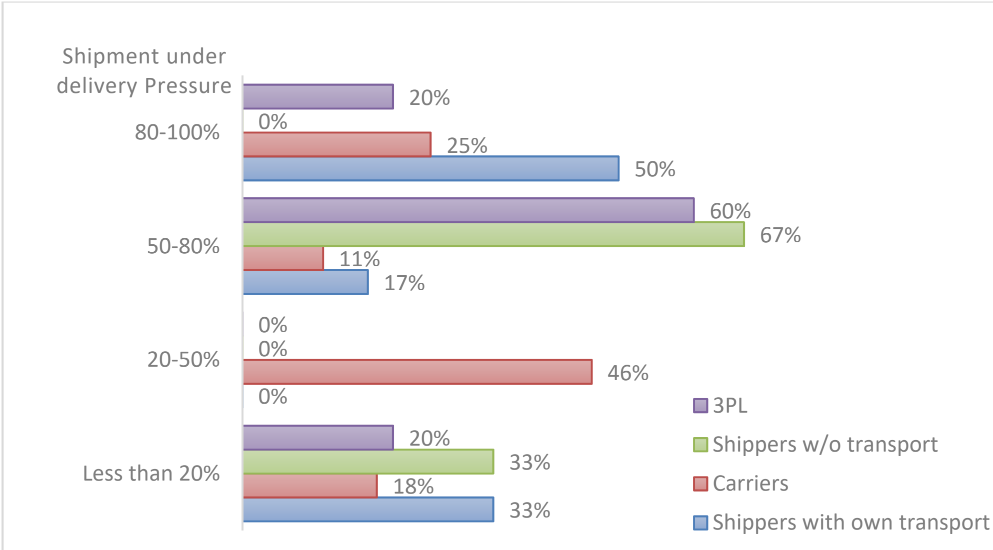


Figure 6-17: Shipment under delivery pressure

6.4.4 Percentage of Shipment by Mode

This question intends to understand whether the shippers and 3PLs use multiple modes for shipment. Only 17 of them responded to this question. 7 firms reported using road and 4 firms using waterways for 80-100% of their shipments. Table 6-10 shows the summary statistics of the percentage of shipment transported by different modes.

Table 6-10: Shipments Transported By Mode

Range / Mode	80-100 %	50-79 %	20-49 %	0-19 %
Road	7	1	1	2
Rail	0	0	1	0
Air	0	0	1	0
Waterways	4	0	0	0
Total	11	1	3	2

6.4.5 Routing Decisions and Reimbursement of Tolls

The questions regarding routing decisions and reimbursement of tolls were only asked to carriers and shippers with own transport. Around 28 responses in routing decision and 30 responses in reimbursement for tolls were collected, where 82% of them reported that they did not get any reimbursement for tolls from the clients (Figure 6-18) and 70% of the drivers made the routing decisions (Figure 6-19). Similarly, among 6 shippers with own transport, 83% of them reported no reimbursement from the client and owner, operator and drivers were found to take routing decisions equally.

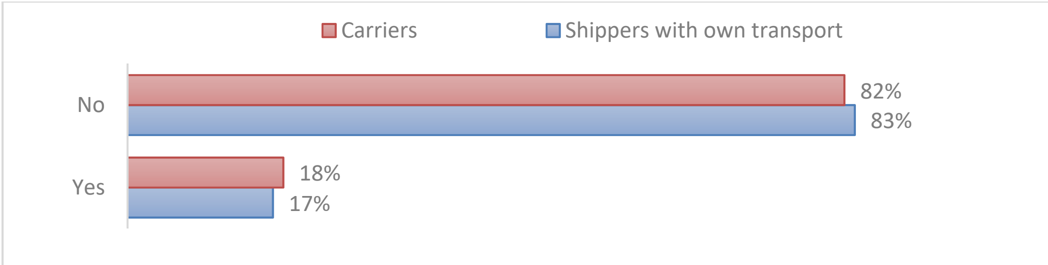


Figure 6-18: Reimbursement for tolls

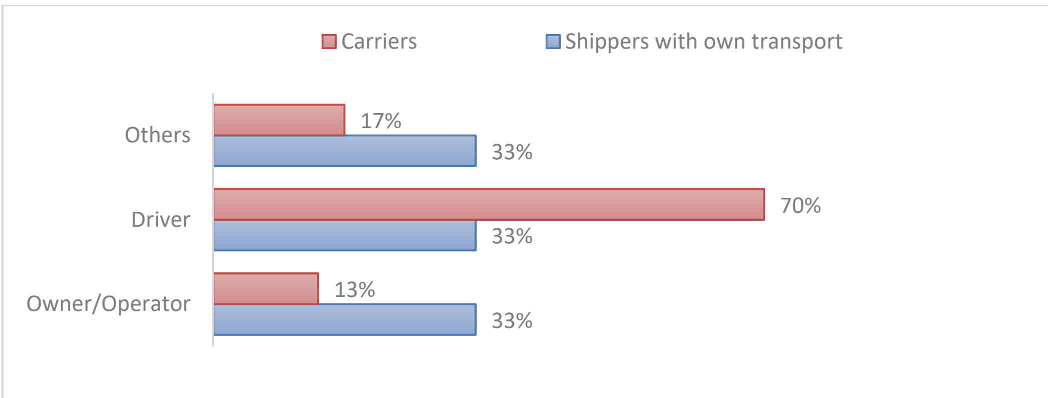


Figure 6-19: Routing decisions

7 MODEL ESTIMATION

Before model estimation, the data collected from the survey were checked against two aspects to ensure that the respondents were trading-off the attributes and the responses were valid.

1) Did the respondent always choose the cheapest, fastest options or the ones with the highest reliability?
2) Did the respondent always choose the alternative in the same position (i.e. left, middle, or right)?

A total of 250 responses from 39 respondents (32 carriers, 6 shippers without transportation, and 1 3PL) were identified and removed from the model estimation dataset. Additionally, a likelihood based diagnostic test was performed to identify outliers that contributed abnormally low to the utility. Removing these data improved the model fits and solved the issue with positive signs for cost and travel time that was found in the initial model estimation. Future work will further investigate these data for potential endogeneity (correlation between the error term and the explanatory variables) in the next stage.

7.1 Model Structure

Various forms of logit structures including binomial logit, multinomial logit (MNL), mixed logit (ML), conditional logit, nested logit, heteroscedastic extreme value (HEV) model etc., have been employed in the literature to estimate VOT and VOR values. Among them, MNL and ML are the two most widely used model structures. A brief discussion for both structures is provided below.

MNL and ML models were developed for the purpose of this analysis. Particularly, both model structures were used to analyze the whole dataset, while only MNL model was possible for the user specific models mainly due to sample limitation for some of the market segments. The main motive for exploring different model structures was to determine the best specification that can better fit and therefore explain the sample.

Specifically, two types of MNL specifications were employed in this study, additive and multiplicative, as shown in equation (24) and equation (25), respectively.

Additive specification:

$$U = \beta_c C + \beta_T T + \beta_R \sigma \ + \ \varepsilon \tag{24}$$

where β_T, β_c, and β_R is the coefficients for the travel time, cost, and travel time reliability variable respectively; T, C, and σ is the travel time, cost, and measure of travel time reliability (standard deviation of travel time) respectively; ε is the random error term.

Multiplicative specification with WTP Space:

$$U = \lambda \ * \ log(C + VOT * \ T + VOR * \sigma) + \ \epsilon \tag{25}$$

where λ is the scale parameter associated with the error term; VOT and VOR is the coefficients for the value of travel time and travel time reliability respectively.

ML model, an extension of MNL model, provides more flexibility by allowing for random taste variation across respondents. Instead of assuming a fixed (mean value) for coefficients, ML model considers an underlying distribution. Equation (26) shows the ML specification used in this paper. The utility for an individual, n (n = 1, …, N) faced with alternative i in t choice scenario is expressed as:

$$U_{itn} = \beta_n' X_{itn} + [\eta_{in} + \varepsilon_{itn}] \tag{26}$$

where X_{itn} represents the vector of explanatory variables, which include travel time, cost, and reliability; β_n'represents the vector of coefficients that needs to be estimated; η_{in} is the error term that is normally distributed over individuals and alternatives; ε_{itn} is the extreme value-distributed error term that is independently and identically distributed over individuals or alternatives.

Since there is no closed analytical form for the likelihood functions of ML models, the coefficients are estimated integrating the traditional logit model over all values of η_{in}, where ϕ are the fixed variables) as shown in equation (27):

$$P_{in} = \int_{\eta_{in}} L_{in}(\beta_n|\phi) f(\beta_n|\phi) \eta_{in} \tag{27}$$

where P_{in} is the probability that individual n chooses alternative i.

To account for multiple observations from the same respondents, both MNL and ML models were estimated with individual-specific (panel specification) in Biogeme. Travel time and travel time reliability were treated as random parameters with a normal distribution. 1000 Halton draws were applied for model estimation.

In addition to developing separate models for different freight users (i.e. carrier, shippers and 3PL) and commodity types, the interaction terms for several shipment characteristics were introduced in the models to identify probable sources of heterogeneity in users' sensitivity towards travel time and travel time reliability.

7.2 Initial Model Tests / Base Models

Table 7-1 shows the results for the MNL and ML models developed for the whole dataset without consideration of user heterogeneity. All the coefficients showed the expected signs and were statistically significant. While the MNL specification for both additive and log WTP multiplicative space models showed similar goodness-of-fit measures, the ML model showed better performance with higher R-square value.

Similarly, the two MNL models showed close values for VOT and VOR, while the ML model suggested lower values, especially for VOT. From the statistical point of view, it is evident that the sample gained a little benefit from the use of multiplicative WTP space structure. The standard deviation estimate for both random variables (travel time and travel time reliability) in the ML model showed significant coefficients, indicating the presence of user heterogeneity.

Table 7-1: MNL and ML Models Based on the Whole Dataset

Coefficients	MNL Model (additive)	MNL Model (Log WTP multiplicative space)	ML Model
Constant Specific - Alt 2	-0.20 (-1.43)	52.0 (0.86)	-0.026 (-0.57)
Constant Specific - Alt 3	0.187 (1.40)	-54.3 (-0.88)	0.023 (0.48)
Travel Time	-0.061 (-4.33)	-	-0.026 (-3.19)
Travel time Reliability	-0.0773 (-3.76)	-	-0.039 (-2.80)
Travel Cost	-0.0013 (-2.84)	-	-0.0007 (-4.55)
Coeff_VOT	-	46.5 (4.64)	-
Coeff_VOR	-	73.0 (4.07)	-
scale	-	3.96 (5.58)	-
STD. of Travel Time	-	-	0.0481 (4.67)
STD. of Travel Time Reliability	-	-	-0.0467 (-2.60)
Initial Log likelihood	-425.16	-425.16	-425.16
Final Log likelihood	-397.60	-386.49	-331.10
Adjusted R-Square	0.05	0.08	0.25
Number of Observations		387	
Number of Individuals		97	
Value of Time (per shipment)	46.9	46.5	37.0
Value of Reliability (per shipment)	59.46	73.0	55.0

Note: t-stats are shown in the parentheses; "-" represents not applicable; "*" denotes statistically significant for robust-t test at 95% confidence interval.

7.3 User-Specific Models

Table 7-2 shows the model results for the user specific models. MNL models were developed for carriers, shippers with transportation, shippers without transportation, and 3PLs separately. The table shows that 3PLs had an insignificant coefficient for travel time, as a result a VOT value could not be derived for 3PLs.

As shown in the table, some variables were insignificant based on t-test but significant for robust t-test at 95% confidence interval. Probably because t-test performs well when the sample is normally distributed with equal variance, which probably is not true for this sample as freight shipments tend to vary largely in terms of size, shipping cost, and duration etc. Relying on the t-test would be too stringent in this case. Therefore those coefficients were kept in the model.

Among all models, the shippers sample showed better model performance, especially shippers without transportation, while the carrier sample showed the poorest model performance. In terms of willingness to pay, shippers without transportation showed the highest VOT, whereas shippers with transportation showed the highest VOR values.

Table 7-2: User-Specific MNL Model Results

Coefficients		Carriers	Shippers with Transportation	Shippers without Transportation	3PL
Constant Specific	**Alt2**	-0.214 (-1.02)	0.117 (0.23)	-0.025 (-0.03)	-0.294 (-0.53)
	Alt3	0.078 (0.203)	-0.418 (-0.67)	1.27 (1.50)	-1.17 (-1.98)
Travel Time		-0.044 (-2.91)	-0.178 (-1.3)*	-0.416 (-2.85)	-0.033 (-0.24)
Travel Reliability		-0.106 (-3.94)	-1.43 (-3.86)	-0.113 (-1.72)*	-0.460 (-2.32)
Travel Cost		-0.0037 (-5.19)	-0.0081 (-2.15)	-0.0015 (-1.39)*	-0.009 (2.43)
Initial Log likelihood		-213.13	-47.24	-131.83	-32.95
Final Log likelihood		-177.67	-24.20	-15.96	-20.40
Adjusted R-Square		0.10	0.31	0.83	0.08
No. of Observations		194	43	120	30
No. of Individuals		71	7	15	4
Value of Time (per shipment)		12	22	277	-
Value of Reliability (per shipment)		29	177	75.0	51.0

Note: t-stat are shown in the parentheses; "-" represents not applicable; "*" denotes statistically significant for robust-t test at 95% confidence interval.

7.4 User-Specific Models with Interaction Effects

Table 7-3 presents the results for the user specific models with interaction effects. It shows that the models performed better when interaction effects were taken into consideration, as indicated by higher R-square values compared to the models shown in Table. The model for the 3PLs did not show any improvement, thus was not presented in Table 7-3.

The results on the interaction effects suggest that shipping weight was a possible source of heterogeneity for all user groups. Specifically, shipping weight contributed to the heterogeneity towards travel time reliability for carriers and shippers with transportation, while shippers without transportation showed heterogeneity towards travel time by shipping weight.

For shippers with transportation, a positive sign for the interaction effect between shipment weight of less than 10 tons and reliability suggest that they had less concern on reliability for light shipments compared to heavy shipments. This finding is consistent with Masiero and Hensher (2012), who focused on shippers and found higher VOR values as shipping weight increases. Interestingly, the opposite effect was observed for carriers – a positive sign for the interaction variable between shipment weight of more than 20 tons and reliability suggests that carriers valued reliability less for heavy shipments.

The sample for shippers without transportation did not show significant interaction effects for travel time reliability, but showed positive interaction effects between travel time and shipping weight of less than 10 tons. It indicates that shippers without transportation were less concerned about travel time savings for shipments of light volumes than heavy shipments.

In addition to shipping weight and shipping distance, trucking type and truck size also showed significant contributions towards sensitivity to travel time reliability for carriers. A positive value for the interaction effect between shipment distance of 300 miles or more and reliability indicates that, all else being equal, carriers showed less VOR for long distance (greater than 300 miles) shipments. It is logical as the window of delivery for longer distance shipment is relatively wider, and tolerance for variability or delay would be higher. This finding is consistent with the literature (Wigan et al.,2000; Beuthe and Bouffioux, 2008; Masiero and Hensher, 2012), where higher VOR values were found for shorter distances compared to longer distances.

Table 7-3: User-Specific MNL Model Results (With Interaction Effects)

Coefficients		Carriers	Shippers with Transportation	Shippers without Transportation
Constant Specific	Alt2	-0.268 (-1.08)	-0.58 (-0.10)	-0.078 (-0.10)
	Alt3	0.04 (0.17)	-1.65 (-1.04)	1.21 (1.46)
Transport Related Attributes				
Transit Time		-0.068 (-3.53)	-0.15 (-1.08)*	-1.26 (-0.04)*
Transit Time Reliability		-0.476 (-2.89)	-2.974 (-2.44)	-0.106 (-1.64)
Shipment Cost		-0.006 (-5.73)	-0.0089 (-2.14)	-0.0014 (-1.33)*
Interaction effect with Transit Time Reliability				
Distance (miles)	300+	0.407 (2.59)		
Shipping weight (ton)	<10		2.25 (1.93)	
	20-30	0.144 (2.12)		
	30+	0.154 (1.32)*		
Trucking Type	FTL	-0.133 (-1.39)*		
Truck Size	Light & Medium	-0.102 (-1.32)*		
Interaction effect with Transit Time				
Shipping weight (ton)	< 10			0.87 (0.03)*
Statistics of Model Fitness				
Initial Log likelihood		-169.17	-47.24	-123.04
Final Log likelihood		-130.06	-23.45	-14.46
Adjusted R-Square		0.17	0.35	0.83
No. of Observations		154	43	112
No. of Individuals		61	7	14

Note: t-stat are shown in the parentheses; "-" represents not applicable; "*" denotes statistically significant for robust-t test at 95% confidence interval.

On the other hand, a negative sign for the interaction variable between full truck load (FTL) and reliability indicates that carriers showed higher value towards reliability for this kind of service. Similarly, carriers showed higher VOR for shipments transported by small and medium trucks compared to heavy trucks. This is reasonable given that small and medium trucks most likely serve urban multi-drop or short distance (within a day) shipments that demand greater certainty.

7.5 Commodity Models

Table 7-4 shows the ML model results for different commodities. As shown in the table, agriculture and food products were merged to get statistically significant result. Models developed for other commodity types such as mining, construction materials did not show statistically significant results, therefore not presented. In addition, two models were estimated for perishable and non-perusable commodities separately. Given the significance of shipment weight as indicated in the previous section, the mean shipment weight for each group was also shown in the table.

Table 7-4: ML Model Results by Commodity Group and Product Type

Coefficients		Agriculture & Food Products	Heavy Manufacturing, Auto Parts, Electronics	Paper, Chemicals & Non-durable Manufacturing	Petroleum Products & Minerals	Perishable	Non-Perishable
Constant Specific	Alt2	-0.301 (-1.13)	0.064 (0.18)	-0.915 (-1.87)	-0.73 (-1.12)	-0.315 (-1.20)	-0.16 (-0.59)
	Alt3	-0.531 (-1.61)	0.333 (0.96)	-0.462 (-1.01)	-1.21 (-1.52)	-0.493(-1.52)	0.116 (0.42)
Travel Time_Mean		-0.110 (-1.39)*	-0.149 (-1.74)	-0.242 (-1.45)	-0.14 (-2.03)	-0.142 (-2.04)	-0.115 (-2.23)
Travel Reliability_Mean		-0.368 (-3.77)	-0.126 (-2.31)	-0.099 (-1.36)*	-0.167 (-1.27)*	-0.396 (-3.09)	-0.279 (-3.12)
Transit Cost		-0.005 (-3.52)	-0.005 (-3.41)	-0.006 (-2.69)	-0.007 (-2.05)	-0.005 (-3.70)	-0.005 (-4.17)
STD. of Travel Time		-0.487 (-3.77)	0.262 (2.44)	0.426 (1.97)	0.80 (1.46)	-0.48 (-4.10)	-0.47 (-3.86)
STD. of Travel Time Reliability		0.442 (3.19)	-0.038 (-0.28)	0.003 (0.04)	1.27 (1.60)	-0.42 (-3.15)	0.37 (3.61)
Initial Log likelihood		-199.95	-92.28	-61.52	-46.14	-209.83	-214.22
Final Log likelihood		-155.22	-77.87	-45.58	-33.54	-161.48	-161.79
Adjusted R-Square		0.19	0.05	0.15	0.12	0.20	0.21
No. of Observations		182	84	56	42	191	195
No. of Individuals		45	19	15	9	47	49
Mean Shipment Weight (in tons)		26.16	27.24	25.46	24.23	26.10	24.49
Value of Time (per shipment)		22.0	29.80	40.3	20.57	28.40	23.0
Value of Reliability (per shipment)		74.0	25.20	16.5	23.86	79.20	55.80

Note: t-stat are shown in the parentheses; "-" represents not applicable; "*" denotes statistically significant for robust–t test at 95% confidence interval.

It shows that the models had reasonable and comparable model goodness-of-fit, except for the heavy manufacturing group. In terms of willingness to pay, perishable shipments showed much higher VOR value than non-perishable shipments. Among the groups, agriculture and food products showed the highest VOR values and paper, chemical and non-durable manufacturing for the highest VOT values.

7.6 WTP Estimation

This section discusses the WTP values derived from this study for comparison purpose. The models and values derived presented in the previous sections are shipment based, as most studies in the literature. This study also estimated ton-hour based values as shown in Table 7-5; the estimation models showed the same general pattern as the models presented in the previous sections and are not presented in the paper to save space. The reliability ration (RR) was also derived based on both shipment-hour and ton-hour values.

Table 8-5 presents a summary of all the VOT and VOR values derived for various groups in this study. In general across all groups in the sample, a value of $37.00 per shipment-hour ($1.53 per ton-hour) for travel time savings and $55.0 per shipment-hour ($3.81 per ton-hour) for improvements of reliability were found. In general, the freight users valued reliability approximately twice as much as the travel time. These observations are within the range indicated in the literature.

Among the user groups, the VOT values ranged from $12.00 to $277.00 per shipment-hour, and $0.50 to $23.00 per ton-hour, while the VOR values ranged from $28.00 to $177.00 per shipment-hour, and $3.00 to $22.00 per ton-hour. Carriers showed the lowest WTP, probably because they directly bear these additional costs. On contrary, WTP values were much higher for shippers, with the highest VOT values shown by shippers without transportation and the highest VOR values shown by shippers with transport. Still, these highest values for shippers were in the range indicated in the literature, but probably deserve further investigation. As expected, shippers with transportation showed the greater RR values, but followed by carriers, indicating that shippers without transportation value reliability much less than time savings compared to other groups.

As expected, perishable products showed higher VOT and VOR values than non-perishable products, as both time savings and reliability are important in shipping perishable items. Also, higher RR values for perishable products indicated that reliability was relatively more important than time savings compared with no-perishable products. Similarly, agriculture and food products reflected the highest VOT and VOR values, and RR values among the commodity groups.

Table 7-5: Summary of WTP Estimation by User Group and Commodity Type

Type	Sub-groups	Value of Time		Value of Reliability		RR (based on shipment)	RR (based on tonnage)
		Per Shipment-Hour	Per Ton-Hour	Per Shipment-Hour	Per Ton-Hour		
All		37.0	1.53	55.0	3.81	1.5	2.5
User Group	Carriers	12.0	0.50	29.0	3.0	2.41	6.0
	Shippers with Transportation	22.0	1.0	177.0	22.0	8.0	22.0
	Shippers without Transportation	277.0	23.0	75.0	5.13	0.3	0.22
	3PL	-		51.0		-	-
Commodity Group	Agriculture and Food	22.0	1.50	74.0	4.38	3.4	2.9
	Heavy Manufacturing	30.0	1.75	25.0	2.25	0.8	1.3
	Paper, Chemicals & Non-durable manufacturing	40	2.75	17.0	1.38	0.4	0.50
	Petroleum & Minerals	21	4.3	24.0	10.2	1.1	2.4
Product Type	Perishable	28	0.63	79	4.38	2.8	7.0
	Non-Perishable	23.0	1.43	56	3.14	2.4	2.20

Besides user group, commodity group and product type, the impacts of other shipment characteristics on WTP are presented in Table 7-6 and Figure 7-1. Table 7-6 presents the changes in VOT and VOR estimates when the interaction effects were taken into account. Both absolute and relative differences are provided. Figure 7-1 presents the absolute impacts on VOR values. As shown in Table 7-6 and Figure 7-1, when these shipment characteristics were considered, it revealed significant differences in the estimated WTP values.

Particularly, when shippers were hiring transportation for light shipments (less than 10 tons), they were less interested to pay for travel time savings, about $279.00 per shipment-hour (or 69%) less than average. Similarly, shippers with own transportation were also less concerned on reliability for light shipments, with a VOR value 76% lower than average. These findings suggest that WTP for shippers increases with the shipment volume.

Table 7-6: Summary of WTP Estimation by Shipping Characteristics

Groups	Sources of Heterogeneity	Absolute Differences (in $ per shipment-hour)		Relative Differences (in % per shipment-hour)	
		ΔVOT	ΔVOR	% ΔVOT	% ΔVOR
Carriers	Long distance (300+ miles)		-68		86% ↓
	Shipping weight: 20-30 t		-24		30% ↓
	Shipping weight : 30+ t		-26		32% ↓
	Trucking Type: FTL		+22		28% ↑
	Truck Size: Light & Medium		+17		21% ↑
Shippers with Transportation	Shipping weight : <10 t	-279			69% ↓
Shippers without Transportation	Shipping weight : <10 t	-250		76% ↓	

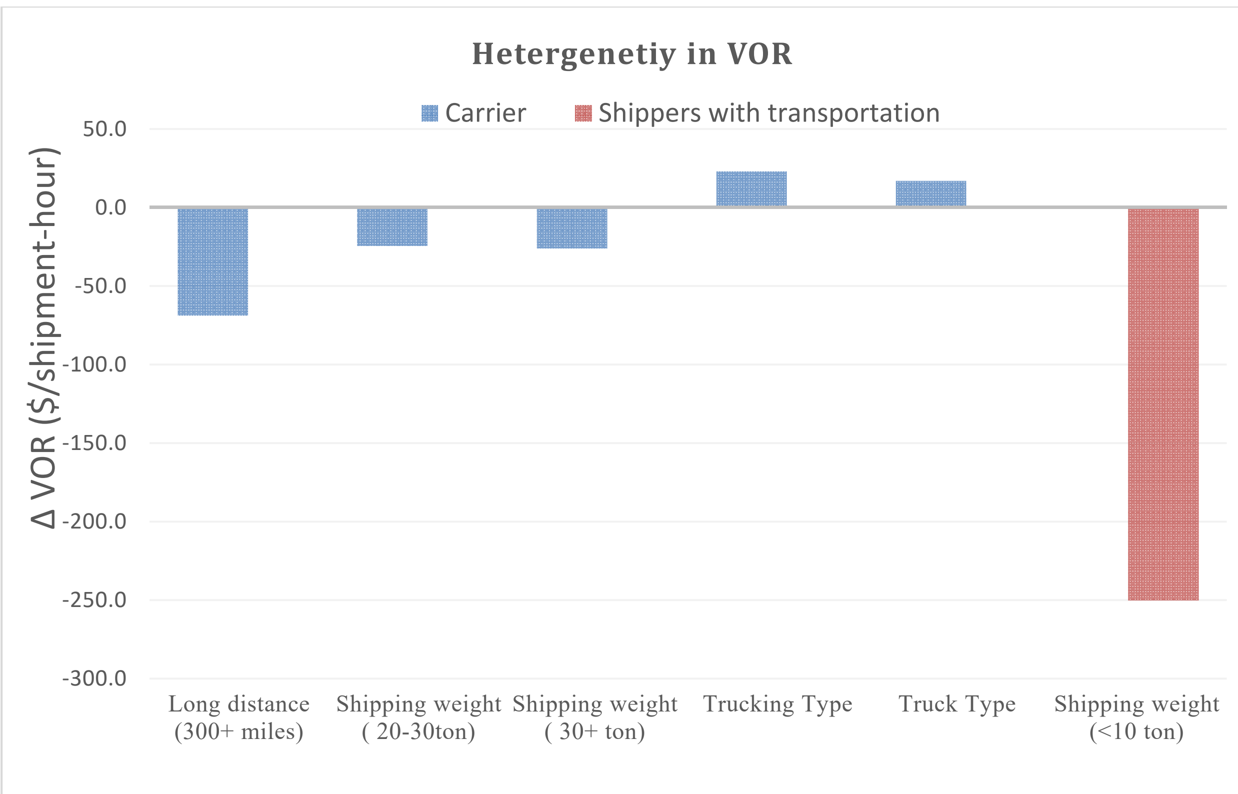


Figure 7-1: Summary of VOR value changes by shipping characteristics

For carriers, depending on the shipping distance and shipping weight, their WTP to improve reliability may change from $68 per shipment-hour less to $26 per shipment-hour more than the average WTP. In this regard, long-distance (300 miles or longer) shipments had the largest negative impacts, while FTL showed the highest positive impacts on VOR.

In comparison with past studies, the literature suggested that VOT values varied from $13.00 to $276.00 per shipment-hour or $0.63 to $10.72 ton-hour (Halse et al., 2010; De Jong et al., 2014; Wigan et al,2010; Bolis and Maggi, 2003; Small et al; 1999), whereas values from this study ranged from $12.00 to $277.00 per shipment-hour or $0.5 to $23.0 per ton-hour. Similarly, as shown in Table 8.5 and discussed in the literature review section, past studies suggested VOR values from $28.00 to $497.00 per shipment-hour or $0.02 to $5.50 per ton-hour, whereas this study showed relatively comparable VOR values from $17 to $177 per shipment-hour, and $1.38 to $10.20 per ton-hour.

Besides, the RR values derived from this study as shown in Table 7-5 suggested a range of 0.30 to 9.00, which confirmed the findings in the literature – 2.00 to 8.00 suggested by McMullen et al. (2015) and 1.20 recommended by De Jong et al. (2009).

8 RECOMMENDATIONS

This chapter discusses probable ways to incorporate the findings of this study into freight planning and project evaluation. Two major studies, the National Cooperative Highway Research Program (NCHRP) 594 and 570, investigated current practices of freight planning at state and regional levels. The reports indicated the needs to provide more guidance for state and metropolitan planning agencies on how to better incorporate freight issues into the planning and project selection processes. NCHRP 594 identified seven key elements of freight planning and programming integration (Cambridge Systematics et al., 2007). NCHRP 570 provided a comprehensive framework of design, assessment and management of freight policy, planning, and programming at different resource levels for small and medium-sized Metropolitan Planning Originations (MPOs) (Cambridge Systematics et al., 2007).

Both reports highlighted the lack of data and tools to understand and analyze freight behavior and operations. In this regard, the findings of this study can contribute in two major aspects: incorporating value of reliability (VOR) in the benefit-cost analysis (BCA) for project evaluation and accommodating the effect of unreliability into demand models. The two aspects are related as travel demand models often serve as the primary source to generate transportation performance data that are needed for the BCA.

8.1 Benefit-Cost Analysis

Benefit-cost analysis (BCA) is a tool widely used by planners, engineers and practitioners to evaluate the economic advantages (benefits) and disadvantages (costs) of a set of investment alternatives. The main objective of a BCA is to translate all flows of benefits and costs of an investment over time into monetary terms and provide a common basis (i.e. net present value) to determine whether it is a sound investment or to compare with alternative investments for prioritization.

This section briefly describes the BCA procedure recommended by the American Association of State Highway and Transportation Officials (AASHTO) (AASHTO, 2010), followed by a discussion of the value of time (VOT) and VOR values to be used in the analysis.

AASHTO's report: User and Non-User Benefit Analysis for Highways (AASHTO, 2010) provided a framework of project evaluation for state and local transportation planning authorities. The manual included theories and methods on the estimation of the benefits and costs of highway projects.

The report identified three types of project benefits, which are 1) savings in travel time, 2) savings in out-of-pocket and other operating expenses, and 3) reduction in accidents. On the other hand, the "total cost" of the project comprised of a variety of incurring costs, which include capital, operation and maintenance, financial and project delay costs.

The process involves the identification of user groups (e.g. income class, vehicle types, and trip purposes, etc.) and link(s)/corridor(s) that would likely be affected by the project. The changes in operation performance (e.g. volume, speed, and travel time, etc.) of the link(s)/corridor(s) due to alternative projects are then quantified in required unit for further use using the formulas provided in the manual. Figure 8-1 provides a sketch of cost linkages, showing how the cost components are related to network and user characteristics.

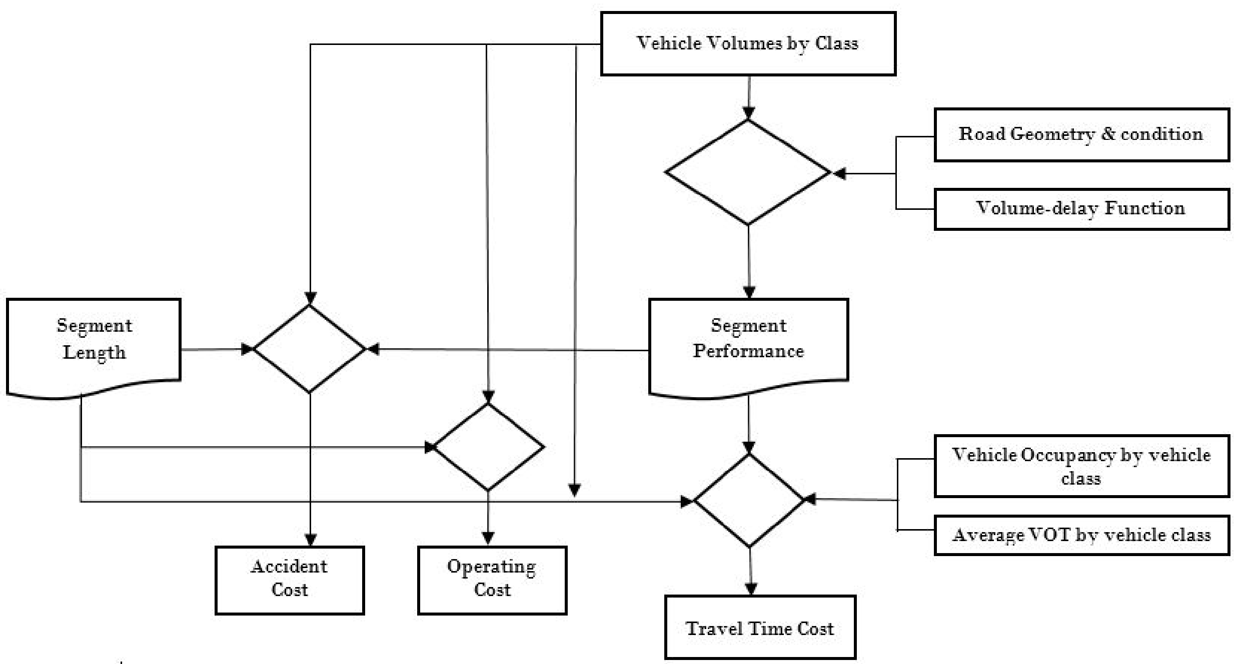


Figure 8-1: Stylized representation of the user cost linkages (Source: AASHTO, 2010)

The manual also provided detailed unit costs by user class, to convert project benefits into monetary values. In this regard, the report recommended a VOT value of $20.23 for freight transportation, which was 20% greater than average driver wage (AASHTO, 2010).

While the manual provides a comprehensive framework to estimate the user benefits and costs of highway projects, it has several limitations to address project impacts on freight transportation. Compared to passenger travel, the determination of appropriate values of transportation network improvements for freight is much more complicated. A typical freight movement involves both shippers and carriers. Our study results described in previous deliverables indicate that the valuation of travel time savings and reliability improvement vary substantially among user groups, commodity types, and different shipment characteristics (weight, shipping distance, etc.). From this perspective, the limitations of the manual include (Sage, et al., 2013):

- The value of travel time savings based on drivers' wage may underestimate the true value placed by carriers, which may include handling costs at shipment origin and destination and other supporting costs.
- Other components in the supply-chain costs that influence shipper decisions are not considered, which include inventory management costs, reliability buffer costs, freight loss and damage claim processing costs, and depreciation of commodity value, etc.
- The benefits of travel time reliability improvement are not explicitly considered in the process.

The findings from this study can be incorporated into the existing BCA process through: 1) adding a component to address the benefits of reliability improvement on freight, and 2) updating the VOT values by various groups. Table 8-1 presents the recommended VOT and VOR values based on the study results of the Florida Freight Survey.

Table 8-1: Estimated VOT and VOR Values by Group-Based on Florida Survey

Components	VOT ($/hr)	VOR ($/hr)
	User Specific	
All	$37	$55
Transportation service Related	$12	$29
Cargo/Goods Related	$22 – $277	$75 - $177
	Industry Specific	
Agriculture and Food	$22	$74
Heavy Manufacturing	$30	$25
Paper, Chemicals & Non-durable manufacturing	$40	$17
Petroleum & Minerals	$21	$24
	Goods Specific	
Perishable	$28	$79
Non-Perishable	$23	$56

8.2 Travel Demand Modeling

Travel demand models are the primary sources to provide the necessary inputs for BCA in terms of network performance data (volume, speed, travel time, and reliability etc.). To be able to incorporate travel time reliability into demand modeling process or BCA, there is a need to establish a process to derive reliability measures and predict future values in light of transportation improvement projects.

Two approaches have been discussed in practice to incorporate reliability:

1. The SHRP 2 project L04 recommended a method to predict the standard deviation of travel time (as a measure of reliability) based on travel time and travel distance;
2. The Puget Sound Regional Council (PSRC) derived speed variances in relation to average speeds as a representation of unreliability, and employed a modified version of Volume Delay Function (VDF) to incorporate reliability in network assignment (PSRC, 2009).

The SHRP2 Project L04 developed a model that relates travel time and standard deviation (as a measure of unreliability) at route level, as shown below (Mahmassani et al., 2013):

$$\sigma = a + b\,({}^{T}/_{D}) \tag{28}$$

where a and b are coefficients that need to be estimated using local network data;
T is the route travel time and D is the travel distance.

This approach can be applied without the need to modify the existing travel demand models. The OD matrix produced by demand models can be used to derive reliability measures based on the above equation; the improvement in reliability will then be converted into monetary value using the recommended VOR values. Figure 8-2 shows the flowchart of this process. Feedback loops can also be added to the modeling process, to account for the choice behavior in response to reliability changes as shown in the figure. The outcome of the unreliability model will be incorporated in network assignment as an additional cost to the generalized cost function for the users. Further feedback iterations can be employed to accommodate the impacts of unreliability on mode choice and other choices.

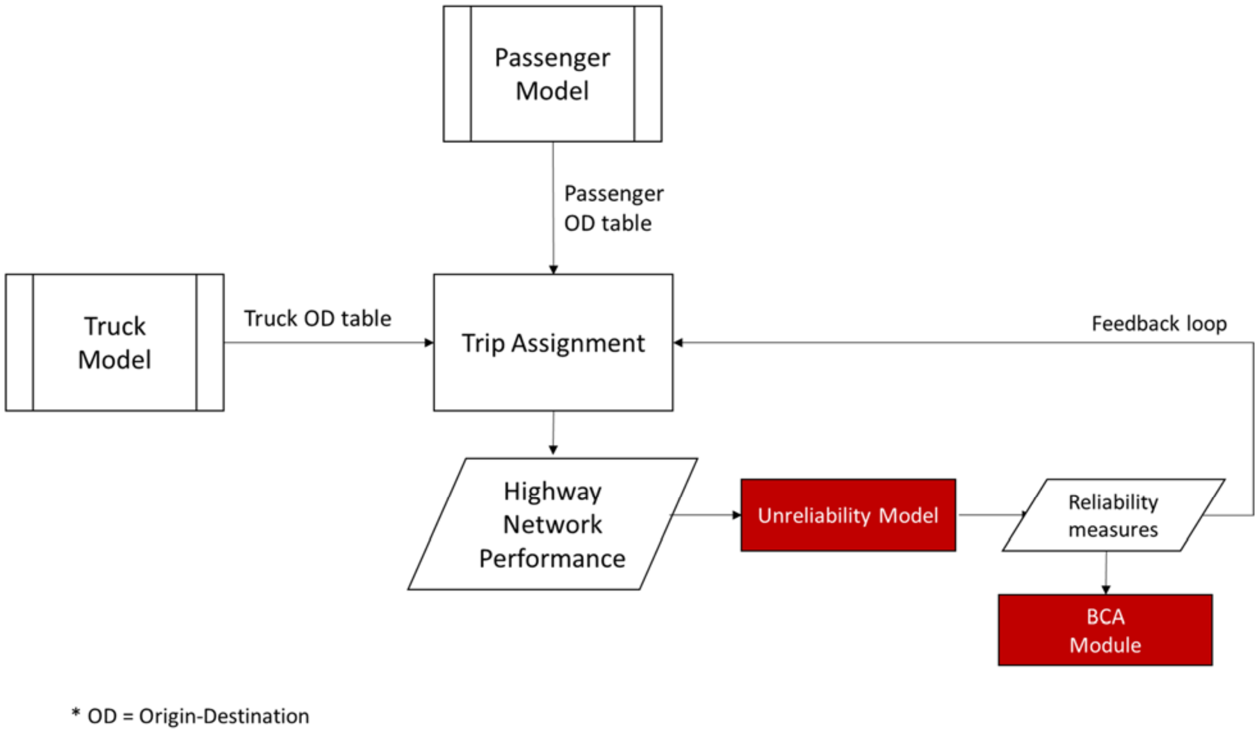


Figure 8-2: Incorporation of reliability into the travel demand modeling process

The PSRC employed the concept of "certainty equivalent" to simulate the value of unreliability (represented as the variation in speeds from the mean or typical condition). The concept was drawn from stock trading, where a buyer is willing to pay extra for an expected (guaranteed) price at a future time. This extra amount would represent the value of certainty. In the context of travel decisions, a traveler is willing to accept a lower average speed with absolute certainty in equivalency to traveling at a higher speed with a risk of experiencing much lower speed. This certainty equivalent, representing the willingness to pay to reduce variation in speed, was measured in time increments, which were then converted into dollar values based on VOTs by user class.

This "equivalent certainty" was incorporated into the PSRC travel demand model in the form of time penalty through the VDF. A modified VDF was developed which contains an additional delay component in consideration of unreliability. Equations 2 and 3 show the VDF formulas, with and without the consideration of reliability used in the PSRC model

$$VDF\ delay, t_i = t_o + t_o\, a\, ({}^{V}/_{C})^{\mathrm{b}} \qquad (29)$$

where t_i and t_o is the coefficients of delay and free flow time (in minutes per mile); V is coefficient of total link volume in passenger car equivalent (PCE); C is total link capacity in PCE; a and b are coefficient of the BPR VDF function :

$$VDF\ delay, t_i = t_o + t_o a \left(V/_C \right)^b + U(t_i) \quad (30)$$

where $U(t_i)$ is certainty- equivalent delay penalty form unreliability at t_i, which can be expressed as: $c + et_i + f t_i^2 + gt_i^3 + ht_i^4$ and c, e, f, g and h are coefficients that are estimated using real world traffic data for the segments.

This approach differs from the SHRP2 L04 approach, as the value placed on reliability is realized through time increments, and only VOT values are needed. The reliability measures used are also different between the two approaches.

Further investigations of these approaches are needed regarding data needs, model calibration and validation for implementation in the Florida Statewide model.

9 CONCLUSIONS

This report presents a study in investigating freight users' preference towards transportation related attributes, particularly the role of travel time reliability in their transportation decisions. The report provided a comprehensive review of existing studies in measuring VOR for freight users, and discussed critical issues in this area, including the reliability measures adopted by various studies, the theoretical and mathematical foundation of modeling the valuation of reliability, and potential factors that contribute to the variations in the estimated VOR values. Particularly, the report discussed various SP survey design components, which may also influence the study focus and modeling approaches. The review showed the complexity and challenges in studying VOR for freight users, which relies on carefully designed survey implementation and well thought study approach. Insufficient data has been a major obstacle to the advancement of understanding how the freight industry values travel time reliability. The large variations in the VOR values derived from existing studies indicate the necessity for further research efforts in this area.

To fill the knowledge gap in understanding the choice behavior of freight users, this study proposed a framework for SP survey design that covers all user groups (i.e. shippers with and without transportation, carriers, and forwarders) and four different modes (road, rail, air and waterways), along with various other market segments. This framework also provides the flexibility that allows the allocation of the respondents to one of the four choice experiments based on their indications of whether they are willing to switch mode or time of day (peak and off-peak hours). This approach helps to ensure that the scenarios are reasonable and applicable to the respondents, and to avoid lexicographic (biased to one alternative) responses. Additionally, this survey also provides unique opportunity to investigate the freight users' choice behavior towards mode shift and changes in departure time.

Given the challenges in collecting information from the freight industry, various strategies were employed to reach out to the freight community and recruit potential participants. Freight user conferences, professional associations, and social events were also targeted as opportunities to recruit participants and obtain feedback regarding the survey instrument. The lessons learned from the pilot survey and the feedback received from the industry provided valuable inputs for enhancing the survey questionnaire and design. Particularly, our observations and experiences indicated that:

- There was a general concern in understanding the "typical shipment" definition, which is not surprising as there can be numerous possibilities of shipment in real scenarios i.e. single or multiple drops, usual or emergency situations, special or normal arrangement, etc.

- The interest in participating in the survey was generally low without attractive incentives.
- The setting and presentation of the choice questions/scenarios need to be as simple and straight forward as possible; when participants find them too complicated, it eventually will discourage survey participation.
- The technical terms used to describe the choices/scenarios, such as transit time and cost, need to be clearly defined, since every contract varies depending on the merit of client and situations.
- It is critical to involve freight stakeholders and organizations early in the project and especially survey design stage. Recruitment through these organizations and agencies were found much more effective than direct contact with the users.

The proposed framework and experiences through the survey design and implementation help shed light on the strategies and methods in developing SP surveys targeting the freight industry, which may provide some useful information for researchers and practitioners interested in conducting similar studies.

The survey collected 1,226 responses from 159 firms in Florida between January and May 2016 via both online and paper methods. Although the proposed survey framework and design cover all freight modes, this study was only able collect enough sample for truck mode. Still, these data provided valuable information for the investigation of how roadway freight users value travel time reliability in their choices.

Using the SP survey data, various modeling approaches were explored to identify the presence and impacts of user heterogeneity on WTP. Particularly market segmentation and interaction modeling techniques were employed to investigate preference variations among users groups, commodity groups, product type, and various other shipment characteristics.

Separate VOT and VOR values were estimated for carriers, shippers with and without transportation, and forwarders. Results indicate that carriers showed the lowest WTP value compared to other groups. When heterogeneity were taken into account, the results showed significant differences in WTP values. The results from this study confirmed findings from past studies and highlighted the importance of user heterogeneity in studying WTP for freight users. Furthermore, when investigating the effects of shipment characteristics on the user’s preference in WTP, the results found that shipping distance and weight were the two most significant attributes.

The findings of the study contribute to the research by providing empirical evidence in quantifying VOR values for freight transportation and the impacts of user heterogeneity. In regards to the integration of the study results into freight planning and project evaluation, the benefit-cost analysis process recommended by AASHTO was summarized, and the limitations of existing practices in addressing the impacts of reliability on freight transportation was highlighted. The report recommended VOT and VOR values by cost components that could be considered for future benefit cost analysis. However, this study is subject to the sample size and geographic (within Florida) limitations. Therefore, these values should be used with caution. The report also discussed practical approaches to incorporate travel time reliability into the travel demand modeling process. Through the incorporation of reliability into benefit-cost analysis and the demand modeling process, it is expected to provide more accurate assessment of project benefits to freight transportation, therefore lead to better policy and investment decisions with freight considerations.

Future work can expand the geographic scope of the study and explore other model techniques to further examine the taste variations in freight transportation decisions. Given the complexity and diversity in freight transportation, it would be necessary to develop guidelines for analyzing VOR within the freight context. These guidelines should pay special attention to the measures and representation of reliability, market segments, survey design, and analytical techniques. This would certainly lower the barriers to a better understanding of how the freight industry values travel time reliability and lead to better practices in freight planning and investment decisions.

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APPENDIX

Appendix A: Survey Questionnaire

INSTRUCTIONS FOR REVIEWERS

Text in [ ] square brackets appearing before a question indicates a question that will not be seen by all respondents and the logic for the respondents who will see that question. For example: “[If a truck user] What kind of trucks did you use for the shipment?”

Text in [ ] square brackets appearing after a question denotes the variables attributed to the question on the page.

INSTRUCTION AND QUALIFICATION QUESTIONS

1.1. Dear Freight Stakeholders:

Welcome to Florida Freight Survey!

In an effort to support the investment and policy decisions that reflect the needs of freight stakeholders in Florida, the Lehman Center for Transportation Research (LCTR) at the Florida International University (FIU) is working with the Florida Department of Transportation (FDOT) in conducting a stated preference survey to better understand how the freight industry values transportation system performance in travel time reliability.

The purpose of this survey is to help us understand the underlying factors in freight transportation decisions in terms of system performance attributes, and the user's willingness to pay to improve travel time reliability. Your response to this survey is crucial in achieving the goal of this study to provide the insights to support freight transportation planning and decision-making.

Participation in the survey is simple:

1. Complete the questionnaire about your firm and typical shipment, which takes about 10 minutes.
2. You will be presented with 6-7 hypothetical choice questions to choose the best option among these. It takes about 15 minutes to complete.

Your participation in the survey is completely voluntary and we take your privacy seriously. All records of this study will be kept confidential and protected. Analysis will be performed to the aggregated data only. Under no circumstances, will your name or other identification information be revealed.

If you have any questions regarding the survey or the methodology, please feel free to contact the Principal Investigator Dr. Xia Jin at xjin1@fiu.edu or 305-348-2825.

Thank you in advance for participating in the survey!

By agreeing with the participation, you will give your consent and confirm your participation in the survey

1.2. Please select the appropriate category

- o Shippers
- o Carriers
- o Forwarders or third party logistics
- o None of the Above

1.3. [If respondent has selected the "None of the above"]

Thank you for taking time to provide this information. Unfortunately, this survey will not be benefited from your responses, as it is designed for only shippers, carriers and forwarding/3PL parties. We really appreciate your sincere efforts.

If you have any questions regarding the survey or the methodology, please feel free to contact the Principal Investigator Dr. Xia Jin at xjin1@fiu.edu, or Kollol Shams at ksham004@fiu.edu.

1.4. [If respondent has selected the "Shippers"]
How do you transport your shipments?

- Own fleet
- For hire
- Third-party logistics
- Others, please specify ____

BASE SHIPMENT CHARACTERISTICS QUESTIONS

This section asks about one of your recent shipments, which will only be used to generate possible scenarios for your shipment in later part. You are advised to give approximate values, in case you find this information sensitive

To avoid any kind of ambiguity, please read the following instructions before you fill up the questions:

1) *Your typical shipment may consists of many types of commodity, such as agricultural, minerals, food products, heavy construction materials, etc., but please select any one of these commodities.*
2) *If you use more than one mode for that shipment, please select the primary mode, which carries the majority of the shipment duration. For example, trucks are often used to transport goods to and from rail stations, but "Rail" is considered as the primary mode.*
3) *Your shipment consists of a one-way distance (or duration), traveled (or spent) from your departure location (typically includes your distribution center or your client's pick up location) to the designated arrival location (client's specified, customer's location). It includes all the intermediary times or distance spent between these points.*
4) *You may have multiple drops for a single shipment. In that case, please select first drop as your typical shipment (in case you are not sure about the first drop, please take your best guess!).*
5) *Shipment cost amounts to the price paid for the transportation services, including transshipments (for shippers, 3PL or forwarding companies) or transportation operating costs (which may include fuel, driver, administration, insurance, etc.) and possible transshipment costs (excluding initial loading and final unloading).*

We understand that it is hard to give a single shipment information (in particular, freight rate, transit time, etc.) since every contract varies depending on the merit of client and situations. Please provide a typical one with no case of special arrangement or emergency situation, which will only be used to ask your further questions.

2.1. Please select the primary mode for your recent or typical shipment

- o Truck
- o Rail
- o Air
- o Waterways

2.2. What was the commodity type for the shipment?

- o Agricultural
- o Minerals
- o Lumber
- o Paper, Chemicals
- o Petroleum Products

- Warehousing
- Non-municipal Waste
- Construction Materials (Concrete, Glass, Clay, Stone)
- Others, Please Specify
- Food Products
- Nondurable Manufacturing

2.3. [If Truck is selected]
What was the shipping distance?

- Less than 50 miles
- 50-300 miles
- Greater than 300 miles

2.4. [If Rail is selected]
What was the shipping distance?

- Less than 300 miles
- 300-1000 miles
- Greater than 1000 miles

2.5. [If Air or Water mode is selected]
What was the shipping distance?

- Within Florida
- Outside Florida
- Please specify distances (in miles)

2.6. [If Air or Water mode & Outside Florida is selected]
Please specify your

- Origin (State, City)
- Destination (State, City)

2.7. What was the shipping duration?

____ day(s) _____ hour(s), OR

- o 0-4 hrs
- o 4- 8 hrs
- o 8-12 hrs
- o 12-18 hrs
- o 18-24 hrs/ 1 day
- o 1 -3 day
- o 3-5 day
- o Others ____

2.8. [If Shippers without transport or 3PL is selected]

What was the shipping cost? (the price paid for the transportation services, including transshipments)

$____________, OR

- o Less than $150
- o $150-$400
- o $400-$600
- o $600-$800
- o $800-$1200
- o $1200-$1800
- o Others ___

2.9. [If Shippers with transport or carriers is selected]

What was the shipping cost? (transportation operating costs (which may include fuel, driver, administration, insurance, etc. and possible transshipment costs - excluding initial loading and final unloading)

$____________, OR

- o Less than $150
- o $150-$400
- o $400-$600
- o $600-$800
- o $800-$1200
- o $1200-$1800
- o Others ___

2.10. What was the shipping size?

_______ tons/ items/ft^3/ other _(select any unit)

2.11. How is the delivery time defined by clients, or contract?

Within

- o certain hour (s) of day
- o certain day (s)
- o certain week (s)
- o Not applicable

2.12. Was there monetary penalty for late delivery?

- o Yes
- o No

2.13. [If Truck mode is selected]

What kind of truck did you use for the shipment?

- o Light : Pick-ups and Vans
- o Medium: Two-Axle, Six-Tire Single-Unit Trucks
- o Heavy: Three or more single unit/trailer/multi-trailer trucks

2.14. [If Trucking type is selected]

What kind of trucking did you use for the shipment?

- o Less than Truckload (LTL)
- o Full Truck Load (FTL)
- o Refrigerated
- o Drayage
- o Others ____________________

STATED PREFERENCE QUESTIONS

In the following sections, you will be presented with various hypothetical scenarios; each has two or three shipping alternatives, with varying levels of transit time, shipment cost, reliability or departure time period. In the hypothetical scenarios, you will find some alternatives may have higher or lower transit time, cost or travel time reliability compared to other alternatives. You can think of the following reasons behind these:

- *The increase in transit time, or decrease in transit time reliability may be the result of increased traffic congestion, incidents, or construction etc., whereas the increase in shipment cost could be due to the use of longer route or a toll road.*
- *The decrease in transit time or the increase in transit time reliability could be due to improvement in the infrastructure, or other strategies to improve level of service.*
- *Finally, any gain in transit time saving means that you could pay less for operating cost, including fuel cost, driver and staff wage.*
- *Similarly, in case of improved reliability in transportation network, you may plan for more services or consolidating multiple deliveries, increasing your productivity. On contrary, decrease in reliability or unexpected delay in transit time may result in product deterioration, financial penalty or insurance claim, reputation, running out of stock, etc.*

Please click "Next" to continue

3.1. Do you typically transport goods during peak hours (7:00 Am to 9:59 AM and 4:00 PM to 6:59 PM?
  - o Yes
  - o No

3.2. [If respondent has selected "Yes"]

Would you shift your typical departure time for your shipment in order to avoid peak hour congestion?
  - o Yes
  - o No

3.3. Did you have any alternative mode for the recent/typical shipment mentioned above?
  - o Yes
  - o No

3.4. [If respondent has selected "Yes"]
Would you consider changing your mode for this typical / recent shipment in future, if better service is provided?

- o Yes
- o No

3.5. Before we start our main survey, this is a short tutorial that will walk you through the choice process.

Suppose you have a typical shipment, which takes about **10 hours** to delivery to the customer at the designated destination and you charge about **$500** for the shipment. However, due to congestion, accident, work zone or adverse weather, your shipment sometimes gets delay. Florida Department of Transportation (FDOT) is considering different project or policy strategies, which may result in reduced your shipment time, or cost or uncertainty but not altogether. Now, if you have to choose from the following two options, which one would you prefer?

Alternative 1	**Alternative 2**
Transit time : XX	Transit time : XX
Your shipment has the following risk of delay On time: 4 out of 5 times Late : 1 out of 5 times, with a possible delay of 30 min	Your shipment has the following risk of delay On time: 2 out of 5 times Late : 3 out of 5 times, with a possible delay of 1-2 hrs
Shipping cost	Shipping cost :
I prefer this option ○	I prefer this option ○

3.6. Tips for tutorial

If you have chosen Alternative 1, it means that you prefer to pay more than the current cost for improved reliability. Or, if you have chosen Alternative 2, it means that you ready to accept longer transit time than the regular one in return of lower operation cost.

3.7. Please select the appropriate box based on the importance of these factors in your transportation decisions

Attribute	Not important	Important	Most important
Reliability	O	O	O
Travel Cost	O	O	O
Travel Time	O	O	O
Security & Damage	O	O	O
Service Flexibility (can provide service without prior notification)	O	O	O
Others, Please specify ____	O	O	O

3.8. Image : Start Now

3.9. Experiment, C1

[If respondent is not willing to ship goods during peak hour - *"No" on Question 16, or (s)he has selected "Yes" on Question 16 and "No" on Question 17* - AND (s)he is not interested in shifting to other modes – *"No" on Question 18, or (s)he has selected "Yes" on Question 18 and "No" on Question 19*]

You are re-evaluating your options for your shipments this month. Below are <3> different options for your shipment. These options vary by Transit time, Cost, Travel time reliability.
If the options below are the only options available for your trip, which would you prefer?

[For all the questions] Highlighted information may have changed.

Alternative 1	Alternative 2	Alternative 3
Actual Transit Time	X hrs more than Actual transit time	X hrs more than Actual transit time
Your shipment has the following risk of delay On time: Y out of 5 times Late : Y out of 5 times, with a possible delay of Z hrs (Hints : XX Reliability)	Your shipment has the following risk of delay On time: Y out of 5 times Late : Y out of 5 times, with a possible delay of Z hrs (Hints : XX Reliability)	Your shipment has the following risk of delay On time: Y out of 5 times Late : Y out of 5 times, with a possible delay of Z hrs (Hints : XX Reliability)
X more than Actual shipping cost	X less than Actual shipping cost	X less than Actual shipping cost
I prefer this option ○	I prefer this option ○	I prefer this option ○

3.10. Experiment C2

[If respondent is willing to ship goods during peak hour - *"Yes" on Question 16*, or (s) he has selected "No" on Question 16 and "Yes" on Question 17 AND (s) he is not interested in shifting to other modes – *"No" on Question 18, or (s) he has selected "Yes" on Question 18 and "No" on Question 19*]

You are re-evaluating your options for your shipments this month. Below are <3> different options for your shipment. These options vary by Transit time, Cost, Travel time reliability, <Departure time >.

If the options below are the only options available for your trip, which would you prefer?

[For all the questions] Highlighted information may have changed.

[For all the questions] Highlighted information may have changed.

Alternative 1	Alternative 2	Alternative 3
Departure time : Off-Peak	Departure time : Peak	Departure time : Off-Peak
Actual Transit Time	X hrs more than Actual transit time	X hrs less than Actual transit time
Your shipment has the following risk of delay On time: Y out of 5 times Late : Y out of 5 times, with a possible delay of Z hrs (Hints : XX Reliability)	Your shipment has the following risk of delay On time: Y out of 5 times Late : Y out of 5 times, with a possible delay of Z hrs (Hints : XX Reliability)	Your shipment has the following risk of delay On time: Y out of 5 times Late : Y out of 5 times, with a possible delay of Z hrs (Hints : XX Reliability)
X more than Actual shipping cost	X less than Actual shipping cost	X less than Actual shipping cost
I prefer this option ○	I prefer this option ○	I prefer this option ○

3.11. Experiment C3

[If respondent is not willing to ship goods during peak hour - *"No" on Question 16,* or (s) he has selected "*Yes*" on Question 16 and *"No*" on Question 17 AND (s) he is interested in shifting to other modes – *"Yes" on Question 18 and "Yes" on Question 19*]

You are re-evaluating your options for your shipments this month. Below are <2> different options for your shipment. These options vary by Transit time, Cost, Travel time reliability, <Service flexibility, Damage risk >.

If the options below are the only options available for your trip, which would you prefer?

[For all the questions] Highlighted information may have changed.

[For all the questions] Highlighted information may have changed.

Alternative 1 (Road)	**Alternative 1 (Rail)**
Actual Transit Time	X hrs more than Actual transit time
Your shipment has the following risk of delay On time: X out of 5 times Late : X out of 5 times, with a possible delay of X hrs (Hints : XX Reliability)	Your shipment has the following risk of delay On time: X out of 5 times Late : X out of 5 times, with a possible delay of 2-4 hrs (Hints : XX Reliability)
X more than Actual shipping cost	X less than Actual shipping cost
Service Flexibility : X	Service Flexibility : X
Damage risk : X%	Damage risk : X%
I prefer this option ○	I prefer this option ○

3.12. Experiment C4

[If respondent is willing to ship goods during peak hour - *"Yes" on Question 16*, or (s)he has selected *"No"* on Question 16 and *"Yes"* on Question 17 AND (s)he is interested in shifting to other modes – *"Yes" on Question 18 and "Yes" on Question 19*]

You are re-evaluating your options for your shipments this month. Below are <3> different options for your shipment. These options vary by Transit time, Cost, Travel time reliability, <Departure time, Service flexibility, Damage risk >.

If the options below are the only options available for your trip, which would you prefer?

[For all the questions] Highlighted information may have changed.

[For all the questions] Highlighted information may have changed.

Alternative 1 (Rail)	**Alternative 2 (Road)**	**Alternative 3 (Rail)**
Departure time : Peak	Departure time : Peak	Departure time : Off-peak
X hrs more than Actual transit time	Actual Transit Time	X hrs less than Actual transit time
Your shipment has the following risk of delay On time: 4 out of 5 times Late : 1 out of 5 times, with a possible delay of ½ day (Hints : Very High Reliability)	Your shipment has the following risk of delay On time: 2 out of 5 times Late : 3 out of 5 times, with a possible delay of 2 days (Hints : Low Reliability)	Your shipment has the following risk of delay On time: 2 out of 5 times Late : 3 out of 5 times, with a possible delay of 2 days (Hints : Low Reliability)
X more than Actual shipping cost	Actual Shipping cost	X more than Actual shipping cost
Service Flexibility : XX	Service Flexibility: XX	Service Flexibility : XX
Damage risk : X%	Damage risk : X%	Damage risk : X%
I prefer this option ○	I prefer this option ○	I prefer this option ○

VALIDATION QUESTIONS

4.1. Image [Almost There]

4.2. Was there any attribute (s) that you did not consider while making choices (Please select all that apply)?

Transit Time	☐
Transit Cost	☐
Transit Time Reliability	☐
No, considered all	☐

4.3. This is an optional selection, which will ask you about a series of questions regarding your attitudes towards freight transportation. Do you want to continue?

- o Yes
- o No

4.4. [If respondent selects "No"]

Contact Information (optional):

If you want to consider yourself for the $10 gift card, please provide at least your name and e-mail address.

Your name:

Your e-mail address (mandatory):

Name of your company:

Position (mandatory):

Your contact information:

Thank you for taking the time to provide this information. We really appreciate your sincere efforts.

If you have any questions regarding the survey or the methodology, please feel free to contact the Principal Investigator Dr. Xia Jin at xjin1@fiu.edu or 305-348-2825, or Kollol Shams at ksham004@fiu.edu or 786-308-5942.

[If respondent selects "Yes", continue to 5.1]

GENERAL QUESTIONS (OPTIONAL)

5.1. How often are your out-bound shipments late (out of 10 times)?

- o Never
- o 1-3
- o 4-7
- o 7-10

5.2. How many employees does your firm have?

- o Less than 20
- o Greater than 20

5.3. What percentages of your shipments are on delivery pressure?

- o <20%
- o 20-50%
- o 50-80%
- o 80-100%

5.4. [For Shippers, 3PL only]
What percentages of your shipments are on delivery pressure?

- o Road transport ________ %
- o Rail ________ %
- o Air _________%
- o Waterways _________%
- o Others _________%

5.5. [For Carriers & Shippers with own transport]
Within your company, who makes the routing choice decisions (such as which route to take, or whether to take the toll road)?

- o Owner/Operator
- o Driver
- o Depends on the situation (please explain) ________________________

5.6. [For Carriers & Shippers with own transport]
Do you get reimbursed for tolls from your client?

- o Yes
- o No

5.7. Contact Information (optional):

If you want to consider yourself for the $10 gift card, please provide at least your name and e-mail address.

Your name:
Your e-mail address (mandatory):
Name of your company:
Position (mandatory):
Your contact information:
Thank you for taking the time to provide this information. We really appreciate your sincere efforts.

If you have any questions regarding the survey or the methodology, please feel free to contact the Principal Investigator Dr. Xia Jin at xjin1@fiu.edu or 305-348-2825, or Kollol Shams at ksham004@fiu.edu or 786-308-5942.

Appendix B: Survey Screen Capture

1. Introduction and Qualification Questions

1.1. Introduction

(This survey is approved by the Institutional Review Board: FIU IRB-15-0163)

Dear Freight Stakeholders :

Welcome to Florida Freight Survey !

In an effort to support the investment and policy decisions that reflect the needs of freight stakeholders in Florida, the Lehman Center for Transportation Research (LCTR) at the Florida International University (FIU) is working with the Florida Department of Transportation (FDOT) in conducting a stated preference survey to better understand how the freight industry values transportation system performance in travel time reliability.

The purpose of this survey is to help us understand the underlying factors in freight transportation decisions in terms of system performance attributes, and the users willingness to pay to improve travel time reliability.**Your response to this survey is crucial in achieving the goal of this study** to provide the insights to support freight transportation planning and decision-making.

Participation in the survey is simple:

1. Complete the on-line questionnaire about your firm and typical shipment, which takes about 5 minutes.
2. You will be presented with 6-7 hypothetical scenarios to choose the best options among these. It takes about 10 minutes to complete.

Your participation in the survey is completely voluntary and we take your privacy seriously. **All records of this study will be kept confidential and protected.** Analysis will be performed to the aggregated data only. Under no circumstances, will your name or other identification information be revealed.

If you have any questions regarding the survey or the methodology, please feel free to contact the Principal Investigator Dr. Xia Jin at xjin1@fiu.edu or 305-348-2825.

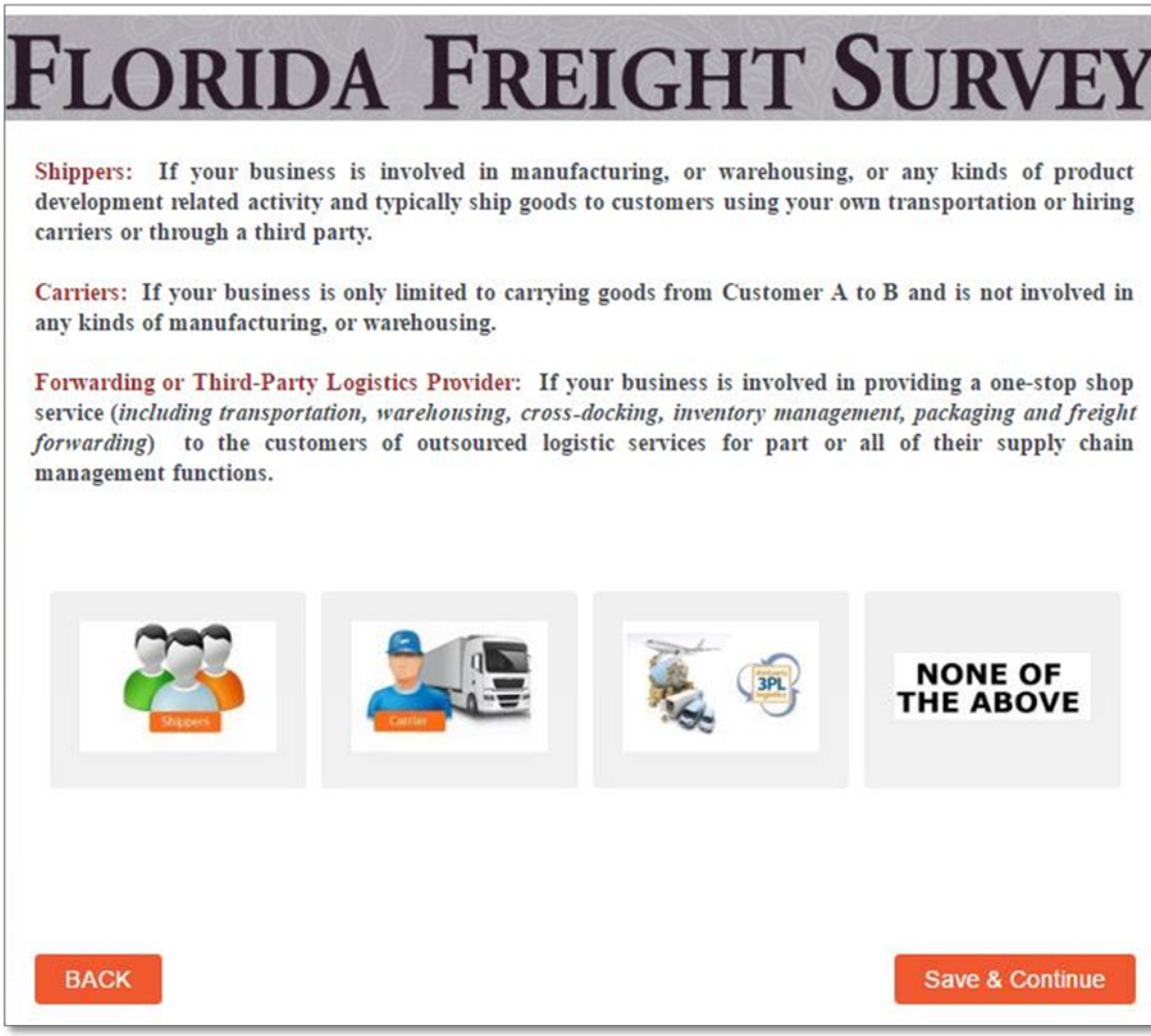
Thank you in advance for participating in the survey!

Sincerely,
Kollol Shams
Ph.D. Candidate
Dept. of Civil & Environmental Engineering
Florida International University
Phone: (786) 308 5942
Email: ksham004@fiu.edu

By clicking "Continue" below, you will give your consent and confirm your participation in the survey.

Continue (Click Here)

1.2. Qualification question for the survey



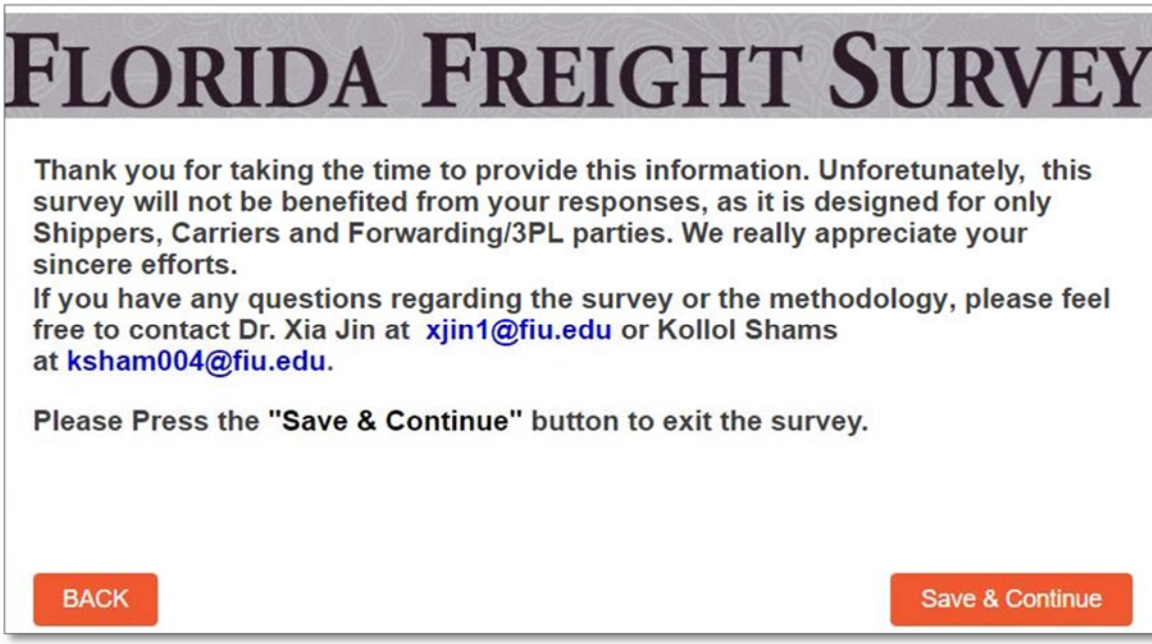
FLORIDA FREIGHT SURVEY

Shippers: If your business is involved in manufacturing, or warehousing, or any kinds of product development related activity and typically ship goods to customers using your own transportation or hiring carriers or through a third party.

Carriers: If your business is only limited to carrying goods from Customer A to B and is not involved in any kinds of manufacturing, or warehousing.

Forwarding or Third-Party Logistics Provider: If your business is involved in providing a one-stop shop service (*including transportation, warehousing, cross-docking, inventory management, packaging and freight forwarding*) to the customers of outsourced logistic services for part or all of their supply chain management functions.

1.3. Qualification question for the survey (if selected “None of the Above”)


FLORIDA FREIGHT SURVEY

Thank you for taking the time to provide this information. Unforetunately, this survey will not be benefited from your responses, as it is designed for only Shippers, Carriers and Forwarding/3PL parties. We really appreciate your sincere efforts.
If you have any questions regarding the survey or the methodology, please feel free to contact Dr. Xia Jin at xjin1@fiu.edu or Kollol Shams at ksham004@fiu.edu.

Please Press the **"Save & Continue"** button to exit the survey.

BACK

Save & Continue

1.4. Ownership of transport (Shippers only)


FLORIDA FREIGHT SURVEY

How do you transport your shipments (please choose all that apply)?

Own fleet

Third-party logistics

For hire

Others, Please Specify

2. Base Shipment Questions

2.1. Pre-survey Instructions

FLORIDA FREIGHT SURVEY

This section asks about one of your recent shipments, which will only be used to generate possible scenarios for your shipment in later part. You are advised to give approximate values, in case you find this information sensitive. To avoid any kind of ambiguity, please read the following instructions before you fill up the questions:

1. Your typical shipment may consists of many types of commodity, such as agricultural, minerals, food products, heavy construction materials, etc., but please select any one of these commodities.

2. If you use more than one mode for that shipment, please select the primary mode, which carries the majority of the shipment duration. For example, trucks are often used to transport goods to and from rail stations, but "Rail" is considered as the primary mode.

3. Your shipment consists of a one-way distance (or duration), traveled (or spent) from your departure location (typically includes your distribution center or your client's pick up location) to the designated arrival location (client's specified, customer's location). It includes all the intermediary times or distance spent between these points.

Figure : One way Shipment

4. You may have multiple drops for a single shipment. In that case, please select first drop as your typical shipment (in case you are not sure about the first drop, please take your best guess!).

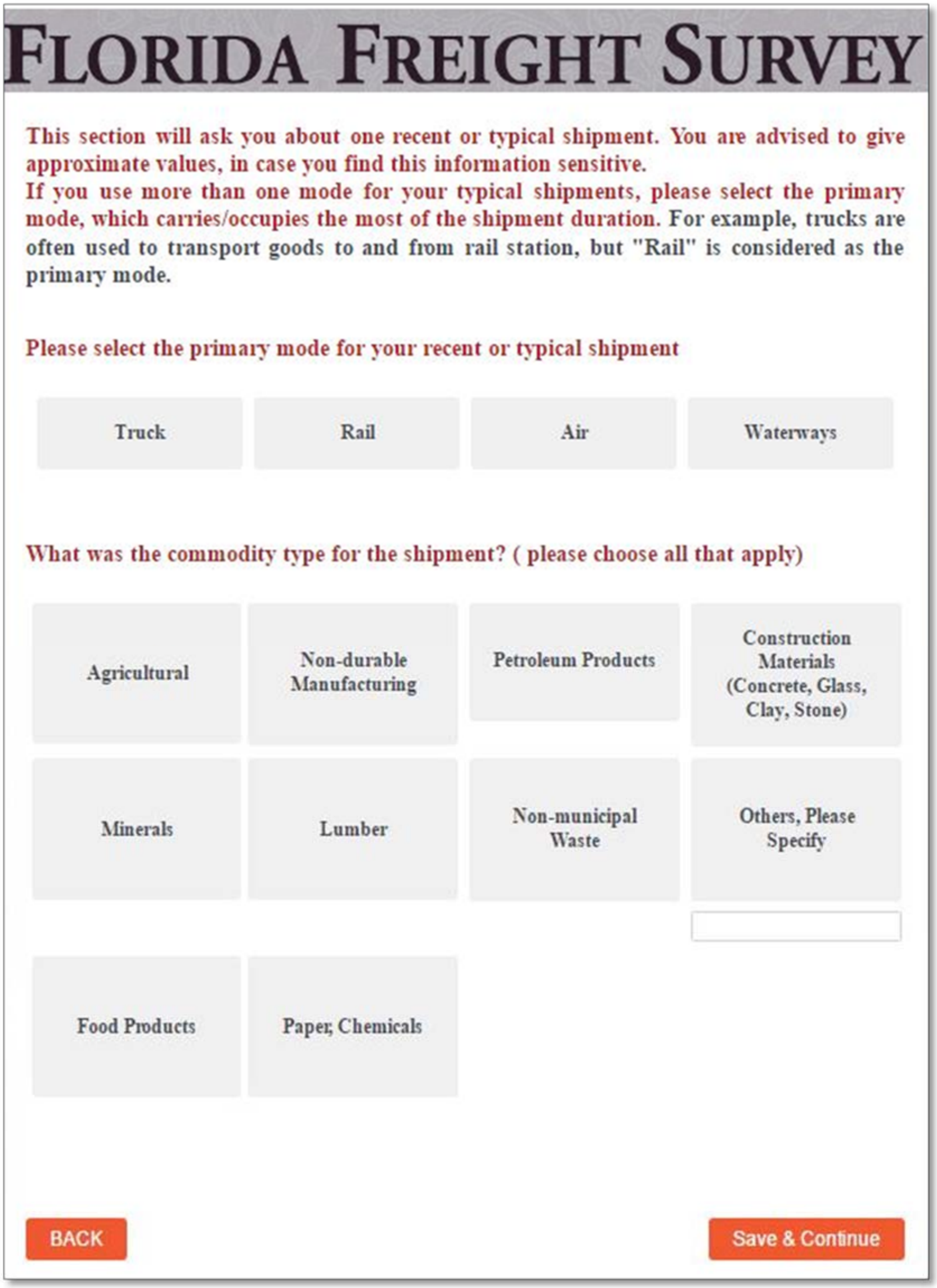
Figure : One way Shipment (Multi drops)

5. Shipment cost amounts to the price paid for the transportation services, including transshipment (for shippers, 3PL or forwarding companies) or transportation operating costs (which may include fuel, driver, administration, insurance, etc.) and possible transshipment costs (excluding initial loading and final unloading).

We understand that it is hard to give a single shipment information (in particular, freight rate, transit time, etc.) since every contract varies depending on the merit of client and situations. Please provide a typical one with no case of special arrangement or emergency situation, which will only be used to generate scenarios.

Save & Continue

2.2. Base Shipment Characteristics Questions



FLORIDA FREIGHT SURVEY

This section will ask you about one recent or typical shipment. You are advised to give approximate values, in case you find this information sensitive.
If you use more than one mode for your typical shipments, please select the primary mode, which carries/occupies the most of the shipment duration. For example, trucks are often used to transport goods to and from rail station, but "Rail" is considered as the primary mode.

Please select the primary mode for your recent or typical shipment

Truck | Rail | Air | Waterways

What was the commodity type for the shipment? (please choose all that apply)

Agricultural | Non-durable Manufacturing | Petroleum Products | Construction Materials (Concrete, Glass, Clay, Stone)

Minerals | Lumber | Non-municipal Waste | Others, Please Specify

Food Products | Paper, Chemicals

BACK

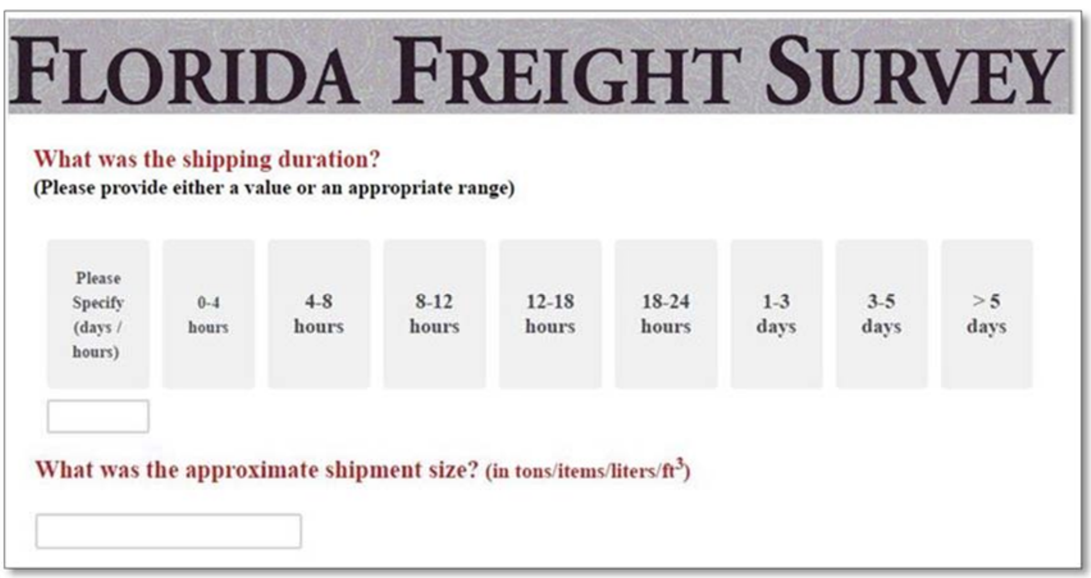
Save & Continue

2.4 Base Shipment Characteristics Questions (Road only)

2.5 Base Shipment Characteristics Questions (Rail only)

2.6 Base Shipment Characteristics Questions (Waterways and Air Only)

2.7 Base Shipment Characteristics Questions



2.8 Base Shipment Characteristics Questions
(3PL & Shippers without own transport only)

FLORIDA FREIGHT SURVEY

What was the approximate cost of shipping?

It amounts to the price paid for the transport services, including transshipment

(Please provide either a value or an appropriate range)

Please Specify ($)	<$150	$150-$400	$400-$600	$600-$800	$800-$1200	$1200-$1800	>$1800

2.9 Base Shipment Characteristics Questions
(Carriers & Shippers with own transport only)

FLORIDA FREIGHT SURVEY

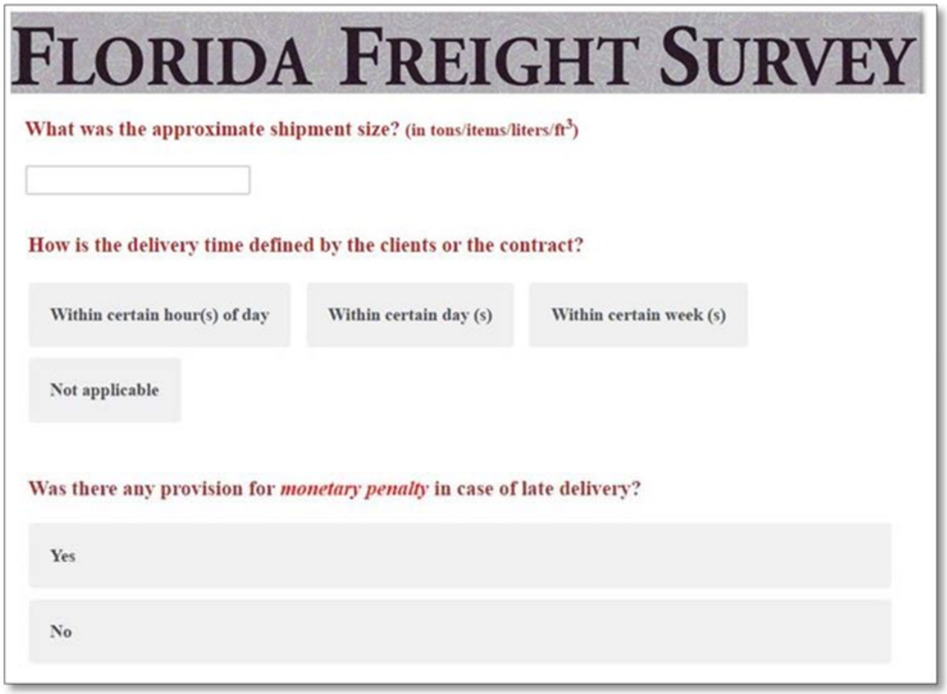
What was the approximate cost of shipping?

It includes transportation operating costs (which may include fuel, driver, administration, insurance, etc.) and possible transshipment costs (excluding initial loading and final unloading)

(Please provide either a value or an appropriate range)

Please Specify ($)	<$150	$150-$400	$400-$600	$600-$800	$800-$1200	$1200-$1800	>$1800

2.10-2.12 Base Shipment Characteristics Questions



FLORIDA FREIGHT SURVEY

What was the approximate shipment size? (in tons/items/liters/ft^3)

How is the delivery time defined by the clients or the contract?

- Within certain hour(s) of day
- Within certain day (s)
- Within certain week (s)
- Not applicable

Was there any provision for *monetary penalty* in case of late delivery?

- Yes
- No

2.13 & -2.14 Base Shipment Characteristics Questions (Truck mode only)

FLORIDA FREIGHT SURVEY

What type of trucking do you perform?

- Less than Truck Load (LTL)
- Drayage
- Full Truck Load (FTL)
- Others
- Refrigerated

What kind of truck did you use for the shipment?

- **Light :** Pick Up, Vans
- **Medium :** Two-Axle Six-Tire Single Unit Trucks
- **Heavy :** Three or more axle Single/Multi - Unit/Trailer Trucks

Stated Preference Questions

3.1 Introductory Note and Qualification for SP experiment types

FLORIDA FREIGHT SURVEY

In the following sections, you will be presented with various hypothetical scenarios, each has two or three shipping alternatives, with varying levels of transit time, shipment cost, reliability or departure time period. In the hypothetical scenarios, you will find some alternatives may have higher or lower transit time, cost or travel time reliability compared to other alternatives. You can think of the following reasons behind these:

1. *The increase in transit time, or decrease in transit time reliability may be the result of increased traffic congestion, incidents, or construction etc., whereas the increase in shipment cost could be due to the use of longer route or a toll road.*
2. *The decrease in transit time or the increase in transit time reliability could be due to improvement in the infrastructure, or other strategies to improve level of service.*
3. *Any gain in transit time saving means that you could pay less for operating cost, including fuel cost, driver and staff wage.*
4. *In case of improved reliability in transportation network, you may plan for more services or consolidating multiple deliveries, increasing your productivity. On contrary, decrease in reliability or unexpected delay in transit time may result in product deterioration, financial penalty or insurance claim, reputation, running out of stock, etc.*

Do you typically transport goods during peak hours (7:00 AM to 9:59 AM and 4:00 PM to 6:59 PM) ?

Yes

No

BACK

Save & Continue

3.2-3.3 Qualification for SP experiment types

3.4 Qualification for SP experiment types

3.5 Tutorial Question & Tips

FLORIDA FREIGHT SURVEY

TUTORIAL

Before we start our main survey, this is a short tutorial that will walk you through the choice process.

Suppose you have a typical shipment, which takes about 10 hours to delivery to the customer at the designated destination and you charge about $500 for the shipment. However, due to congestion, accident, work zone or adverse weather, your shipment sometimes gets delay.

Florida Department of Transportation (FDOT) is considering different project or policy strategies, which may result in reduced your shipment time, or cost or uncertainty but not altogether.

If the options below are the only options available for your trip, which would you prefer?

Alternative 2	Alternative 3
Departure time : Peak	Departure time : Off-peak
Transit Time : 12.5 hrs (2.5 hours more)	Transit Time : 6 hrs (4 hours less)
Your shipment has the following risk of delay	Your shipment has the following risk of delay
On time: 3 out of 5 times	On time: 2 out of 5 times
Late : 2 out of 5 times, with a possible delay of 2-4 hrs	Late : 3 out of 5 times, with a possible delay of 4-8 hrs
(Hints : High Reliability)	(Hints : Low Reliability)
Shipping cost : $500 (Standard)	Shipping cost : $700 (40% more)
I prefer this option ○	I prefer this option ○

BACK | Save & Continue

If you have chosen Alternative 1, it means that you prefer to operate during peak hour in case of improved reliability, even though overall it may take little longer than the current transit time.

Or, you have chosen Alternative 2, it means that you are ready to switch operation time from peak to off-peak hour and pay extra in return of significant lesser overall transit time, even though there may be decrease in reliability of road network.

3.6 Importance of Transportation related factors

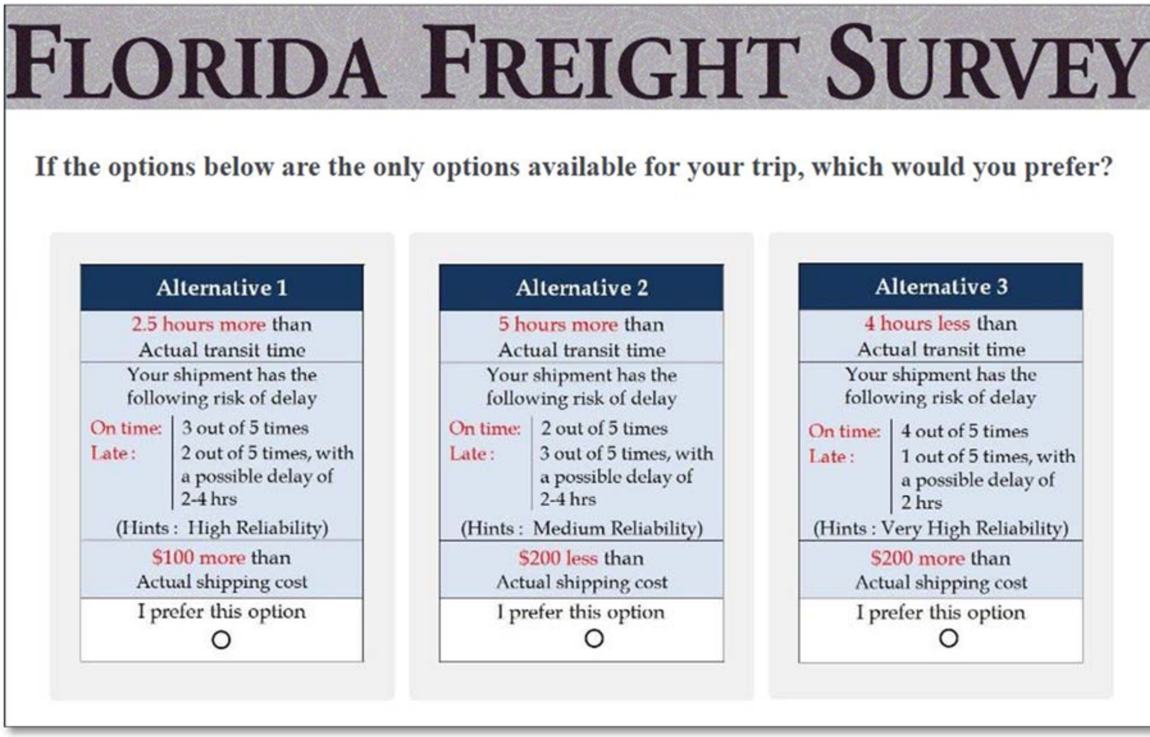
FLORIDA FREIGHT SURVEY

Please select the appropriate box based on the importance of these factors in your transportation decisions

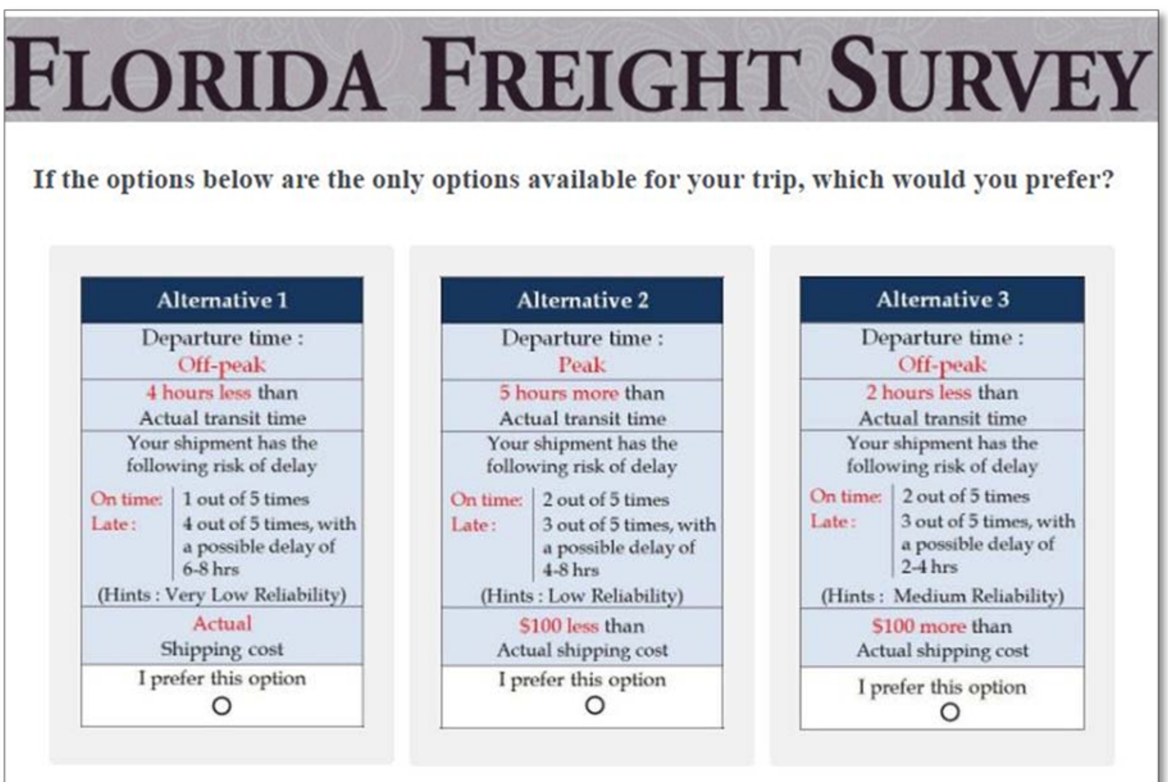
	Not Important	Important	Very Important
Reliability	☐	☐	☐
Travel Cost	☐	☐	☐
Travel Time	☐	☐	☐
Shipment Property Security & damage	☐	☐	☐
Service Flexibility *(as opposed to fixed schedule and service terms, etc.)*	☐	☐	☐
Others, Please Specify ______	☐	☐	☐

BACK   Save & Continue

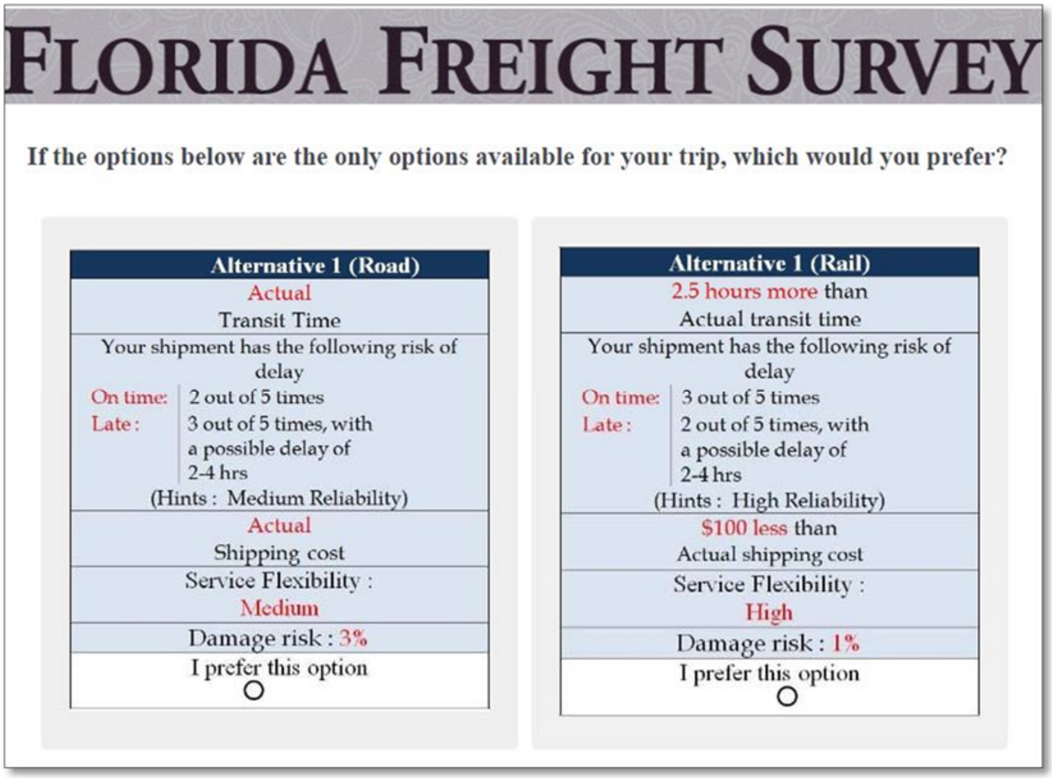
3.7 An example of SP choice question of C1 experiment



3.8 An example of SP choice question of C2 experiment



3.9 An example of SP choice question of C3 experiment

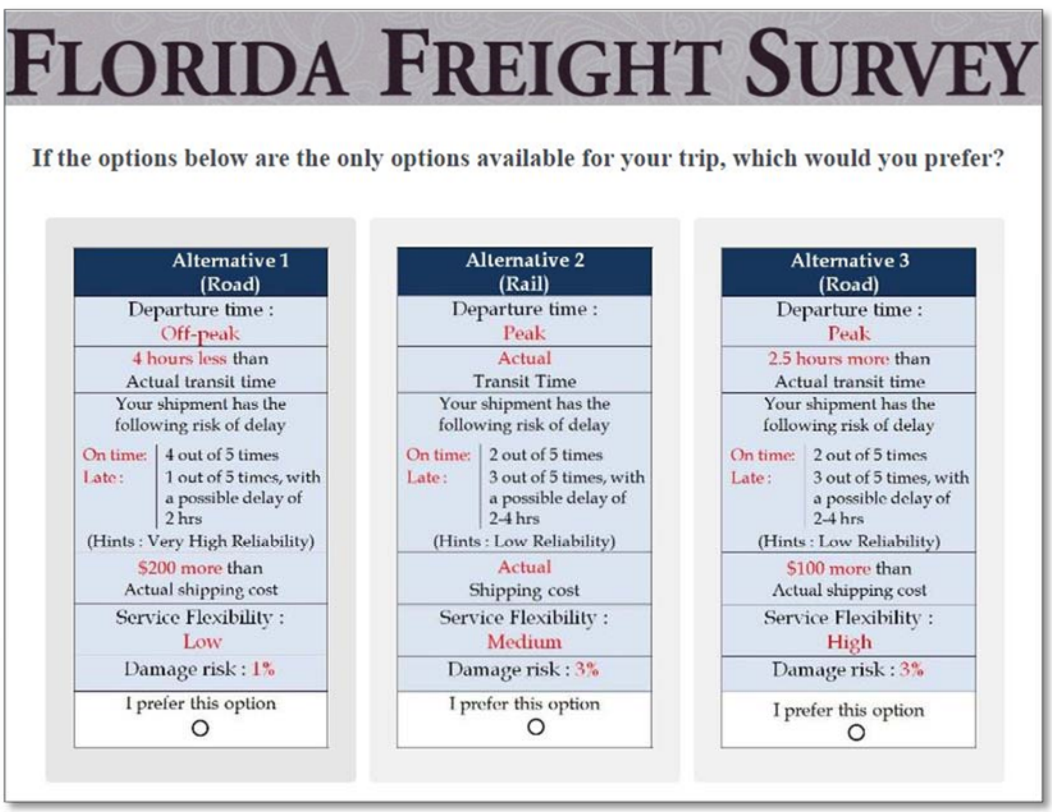


FLORIDA FREIGHT SURVEY

If the options below are the only options available for your trip, which would you prefer?

Alternative 1 (Road)	Alternative 1 (Rail)
Actual Transit Time	2.5 hours more than Actual transit time
Your shipment has the following risk of delay On time: 2 out of 5 times Late: 3 out of 5 times, with a possible delay of 2-4 hrs (Hints : Medium Reliability)	Your shipment has the following risk of delay On time: 3 out of 5 times Late: 2 out of 5 times, with a possible delay of 2-4 hrs (Hints : High Reliability)
Actual Shipping cost	$100 less than Actual shipping cost
Service Flexibility : Medium	Service Flexibility : High
Damage risk : 3%	Damage risk : 1%
I prefer this option ○	I prefer this option ○

3.10 An example of SP choice question of C4 experiment



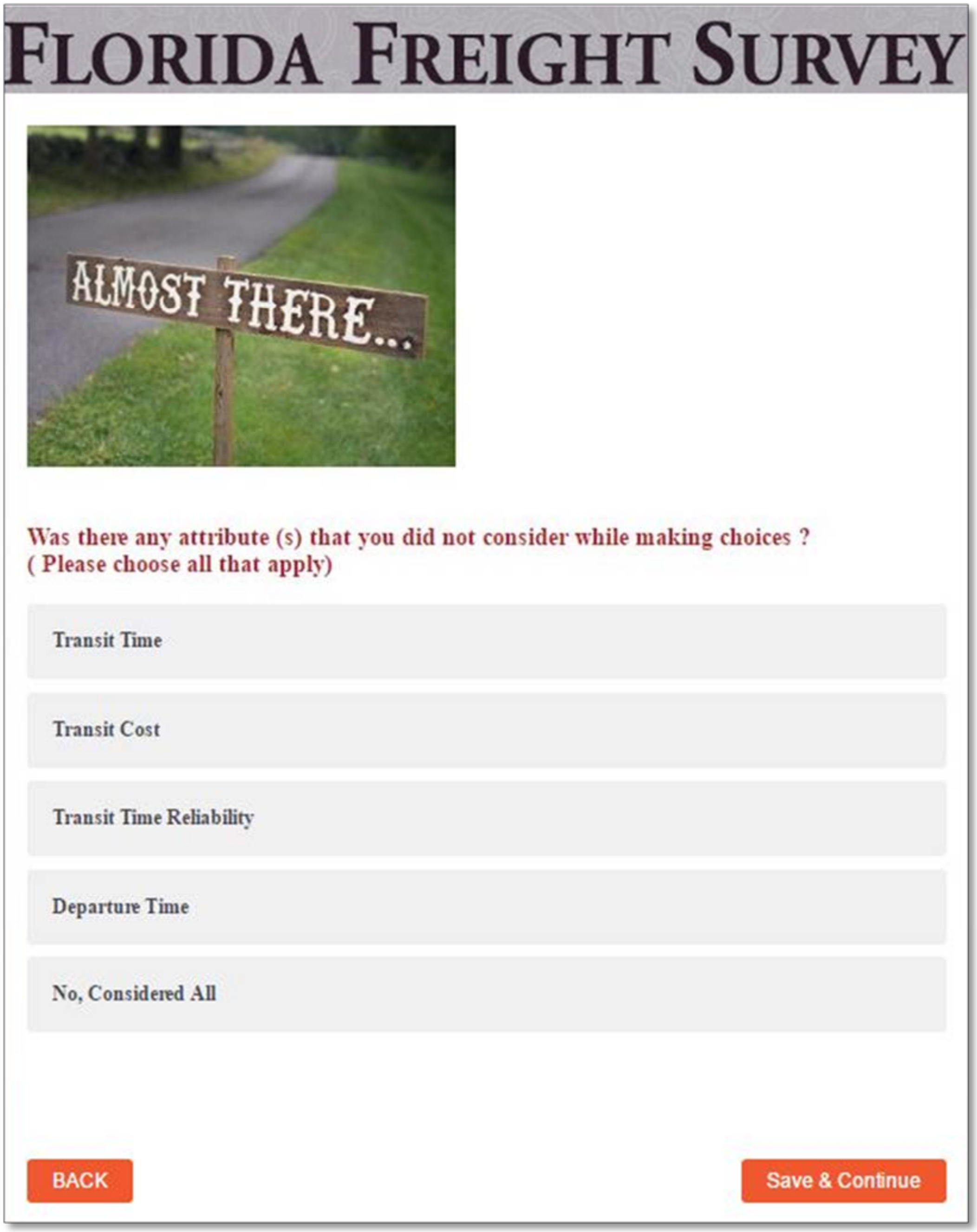
FLORIDA FREIGHT SURVEY

If the options below are the only options available for your trip, which would you prefer?

Alternative 1 (Road)	Alternative 2 (Rail)	Alternative 3 (Road)
Departure time : Off-peak	Departure time : Peak	Departure time : Peak
4 hours less than Actual transit time	Actual Transit Time	2.5 hours more than Actual transit time
Your shipment has the following risk of delay On time: 4 out of 5 times Late: 1 out of 5 times, with a possible delay of 2 hrs (Hints : Very High Reliability)	Your shipment has the following risk of delay On time: 2 out of 5 times Late: 3 out of 5 times, with a possible delay of 2-4 hrs (Hints : Low Reliability)	Your shipment has the following risk of delay On time: 2 out of 5 times Late: 3 out of 5 times, with a possible delay of 2-4 hrs (Hints : Low Reliability)
$200 more than Actual shipping cost	Actual Shipping cost	$100 more than Actual shipping cost
Service Flexibility : Low	Service Flexibility : Medium	Service Flexibility : High
Damage risk : 1%	Damage risk : 3%	Damage risk : 3%
I prefer this option ○	I prefer this option ○	I prefer this option ○

Validation Question

4.1 Consideration of Attributes in choice making


FLORIDA FREIGHT SURVEY

ALMOST THERE...

Was there any attribute (s) that you did not consider while making choices ?
(Please choose all that apply)

Transit Time

Transit Cost

Transit Time Reliability

Departure Time

No, Considered All

BACK

Save & Continue

4.2 Qualification Question for the "General Questions"

General Questions

5.1 Qualification Question for the "General Questions"

FLORIDA FREIGHT SURVEY

How often are your out-bound shipment late (out of 10 times)?

Never | 1-3 | 4-7 | 7-10

How many employees does your firm have?

Less than 20 | Greater than 20

What percentages of your shipments are on delivery pressure?

- Less than 20%
- 20 to 50%
- 50 to 80%
- 80-100%

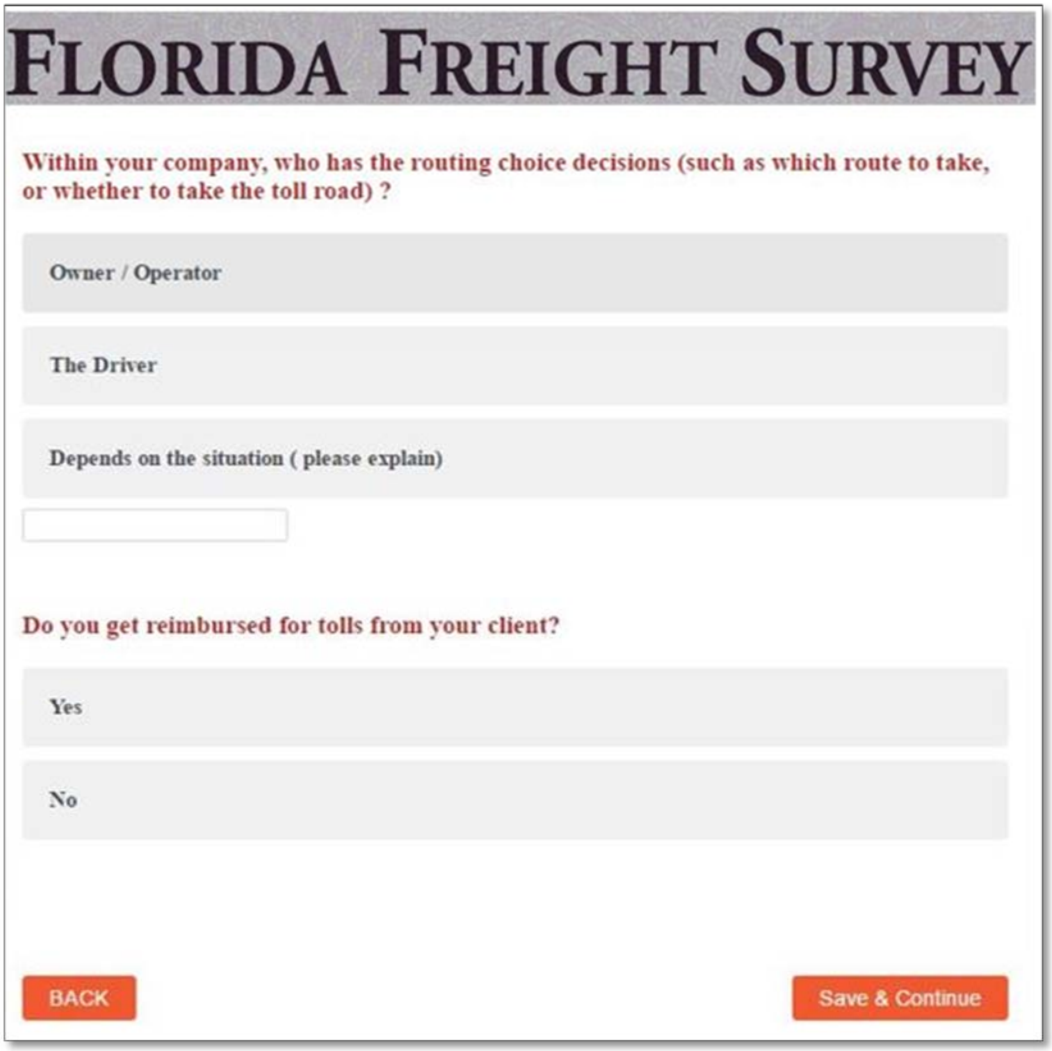
5.2. Qualification Question for the "General Questions" (Shippers & 3PL only)

FLORIDA FREIGHT SURVEY

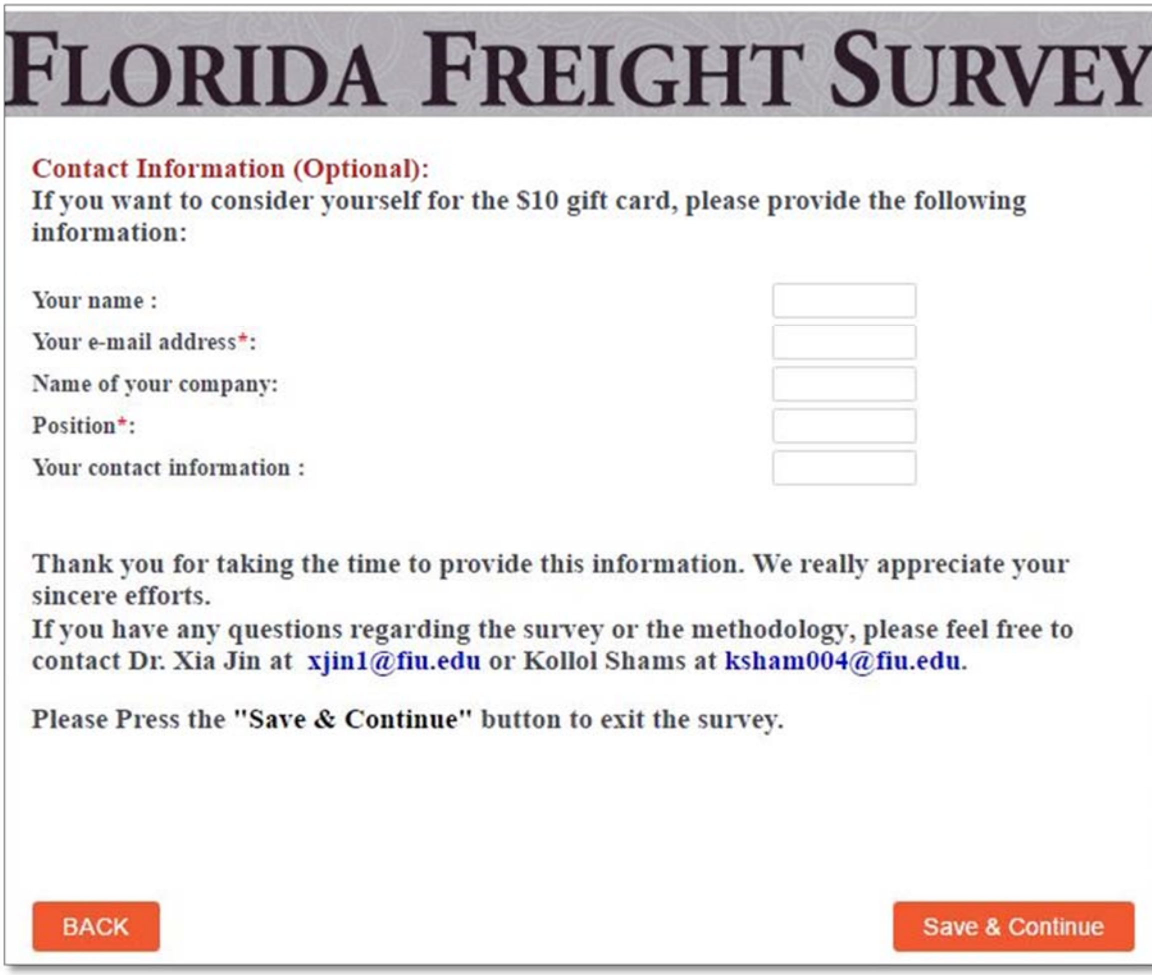
Can you give an indication of percentage of your shipments by your firm ?
[Total = 100%]

Road	0
Rail	0
Air	0
Waterways	0
Others	0
Total	0

5.3. 5.4 Qualification Question for the "General Questions" (Carriers and shippers with own transport)



5.7. Qualification Question for the “General Questions”



FLORIDA FREIGHT SURVEY

Contact Information (Optional):
If you want to consider yourself for the $10 gift card, please provide the following information:

Your name :	
Your e-mail address*:	
Name of your company:	
Position*:	
Your contact information :	

Thank you for taking the time to provide this information. We really appreciate your sincere efforts.
If you have any questions regarding the survey or the methodology, please feel free to contact Dr. Xia Jin at xjin1@fiu.edu or Kollol Shams at ksham004@fiu.edu.

Please Press the **"Save & Continue"** button to exit the survey.

BACK

Save & Continue

Appendix C: Tabulation

Part 1: Base Shipment Information

Number of Survey Participants by Mode And User Group

User Groups	Road	Rail	Air	Waterways	Total
Carrier	108	0	0	5	113
Shippers with own transport	9	0	0	0	9
Shippers w/o own transport	26	0	0	0	26
3PL/ Forwarders	7	0	2	2	11
Total	150	0	2	7	159

Commodity Types by User Group

Commodity Type	Shippers with own transport		Carriers		Shippers w/o transport		3PL	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
Agriculture	6	67%	16	16.5%	4	15%	3	43%
Minerals	1	11%	5	4.6%	3	12%	0	0%
Food Products	1	11%	29	26.6%	8	31%	1	14%
Nondurable Manufacturing	0	0%	3	2.8%	0	0%	0	0%
Lumber	0	0%	6	5.5%	1	4%	0	0%
Paper, Chemicals	0	0%	8	7.3%	2	8%	0	0%
Petroleum Products	0	0%	6	5.5%	1	4%	0	0%
Warehousing	0	0%	4	3.7%	0	0%	0	0%
Construction Materials	1	11%	7	6.4%	4	15%	0	0%
Miscellaneous (i.e. Heavy equipment, auto parts, etc.)	0	0%	23	21.1%	3	12%	3	43%
Total	9	100%	108	100%	26	100%	7	100%

Shipping Distance by User Group

Shipping Distance	Shippers with own transport		Carriers		Shippers w/o transport		3PL	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
0-50 miles	1	11%	5	5%	2	8%	2	29%
50-300 miles	5	56%	20	19%	1	4%	0	0%
>300 miles	3	33%	83	77%	23	88%	5	71%
Total	9	100%	108	100%	26	100%	7	100%

Shipping Duration by User Group

Shipping Duration	Shippers with own transport		Carriers		Shippers w/o transport		3PL	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
0-4 hrs	0	0%	2	2%	2	8%	1	14%
4-8 hrs	2	22%	2	2%	2	8%	0	0%
8-12 hrs	3	33%	26	24%	3	12%	0	0%
12-18 hrs	0	0%	44	41%	7	27%	0	0%
18-24 hrs	0	0%	13	12%	8	31%	0	0%
1-3 day (s)	2	22%	18	17%	3	12%	4	57%
3-5+ days	2	22%	3	3%	1	4%	2	29%
Total	9	100%	108	100%	26	100%	7	100%

Shipping Size by Group (lbs. only)

Values	Shippers with own transport	Carriers	Shippers w/o transport	3PL
Min	3500	1000	500	1000
Max	48000	80000	80000	80000
Mean	19166	49019	61395	42500
Total Respondents	3	93	21	4

Shipping Size by Group (other than lbs.)

Unit	Values	Number of respondents
Gallon	8500	1
Items	4 to 200	3
Pallet	22	1
Skids	1	1

Shipping Cost by User Group

Shipping cost	Shippers with own transport		Carriers		Shippers w/o transport		3PL	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
< $150	1	14%	0	0%	1	50%	1	25%
$150-$400	1	14%	3	25%	1	50%	0	0%
$400-$600	1	14%	1	8%	0	0%	0	0%
$600-$800	0	0%	1	8%	0	0%	1	25%
$800-$1200	1	14%	2	17%	0	0%	0	0%
$1200-$1800	1	14%	2	17%	0	0%	0	0%
1800+	2	29%	3	50%	0	0%	2	50%
Total	7	1	12	0	2	0	4	1

Truck Type by User Group (Truck Mode Only)

Trucking Type	Shippers with own transport		Carriers		Shippers w/o transport		3PL	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
Light	1	11%	2	2%	1	25%	0	0%
Medium	2	22%	17	16%	1	25%	1	20%
Heavy	6	67%	86	82%	2	50%	4	80%
Total	9	100%	105	100%	4	100%	5	100%

Trucking Type by User Group (Truck Mode Only)

Trucking Type	Shippers with own transport		Carriers		Shippers w/o transport		3PL	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
LTL	1	20%	1	1%	0	0%	2	40%
FTL	4	80%	59	71%	1	100%	1	20%
Refrigerated	0	0%	21	25%	0	0%	2	40%
Drayage	0	0%	1	1%	0	0%	0	0%
Others	0	0%	1	1%	0	0%	0	0%
Total	5	100%	83	100%	1	100%	5	100%

Statistics of Monetary Penalty for Late Delivery

Monetary Penalty for late delivery	Shippers with own transport		Carriers		Shippers w/o transport		3PL	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
Yes	1	11%	12	12%	3	12%	4	57%
No	8	89%	89	88%	23	88%	3	43%
Total	9	100%	101	100%	26	100%	7	1

Part 2: Stated Preference Questionnaire

Statistics of Attitudinal Aspects: Shipment Time Reliability

Importance of Shipment Time Reliability								
	Shipper with own transport		Carriers		Shippers w/o transport		3PL	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Not Important	0	0%	1	6%	2	11%	0	0%
Important	1	20%	4	25%	12	63%	3	50%
Most Important	4	80%	11	69%	5	26%	3	50%
Total	5	100%	16	100%	19	100%	6	100%

Statistics of Attitudinal Aspects: Shipment Time

Importance of Shipment Time								
Level	Shipper with own transport		Carriers		Shippers w/o transport		3PL	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Not Important	1	20%	2	7%	0	0%	0	0%
Important	3	60%	5	16%	7	33%	2	33%
Most Important	1	20%	24	77%	14	67%	4	67%
Total	5	100%	31	100%	21	100%	6	100%

Statistics of Attitudinal Aspects: Shipment Security & Damage

Importance of Shipment Security & Damage								
Level	Shipper with own transport		Carriers		Shippers w/o transport		3PL	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Not Important	0	0%	0	0%	0	0%	0	0%
Important	2	40%	2	15%	2	10%	2	29%
Most Important	3	60%	11	85%	18	90%	5	71%
Total	5	100%	13	100%	20	100%	7	100%

Statistics of Attitudinal Aspects: Service Flexibility

Importance of Service Flexibility								
Level	Shipper with own transport		Carriers		Shippers w/o transport		3PL	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Not Important	0	0%	1	9%	1	8%	0	0%
Important	1	20%	5	46%	7	58%	5	71%
Most Important	4	80%	5	46%	4	33%	2	29%
Total	5	100%	11	100%	12	100%	7	100%

Statistics of Attribute Consideration in Choice Making

Attributes		**Shippers with own transport**	**Carriers**	**Shippers without transport**	**3PL**	**Total**
Shipping time only		1	1	0	1	3
Shipping cost only		1	0	0	0	1
Reliability only		3	0	0	0	3
Considered All		4	97	29	3	133

Part 3: General Questions (Optional)

Frequency of Out-Bound Shipment Delay

Out-bound Shipment Delay (out of 10 times)	Shippers with own transport		Carriers		Shippers w/o transport		3PL	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
Never	0	0%	0	0%	0	0%	0	0%
1 -3	3	43%	2	20%	1	33%	1	20%
4-7	3	43%	6	60%	2	67%	4	80%
7-10	1	14%	2	20%	0	0%	0	0%
Total	7	100%	10	100%	3	100%	5	100%

Number of Employees

Out-bound Shipment Delay (out of 10 times)	Shippers with own transport		Carriers		Shippers w/o transport		3PL	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
Lesser than 20	2	29%	6	20%	1	33%	2	40%
Greater than 20	5	71%	24	80%	2	67%	3	60%
Total	7	100%	30	100%	3	100%	5	100%

Percentage of Delivery on Pressure

Percentage of Delivery on Pressure	Shippers with own transport		Carriers		Shippers w/o transport		3PL	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
<20%	2	33%	5	18%	1	33%	1	20%
20-50%	0	0%	13	46%	0	0%	0	0%
50-80%	1	17%	3	11%	2	67%	3	60%
80-100%	3	50%	7	25%	0	0%	1	20%
Total	6	100%	28	100%	3	100%	5	100%

Summary Statistics of Shipment by Modes

	Road	Rail	Air	Waterways
80-100 %	7	0	0	4
50-79%	1	0	0	0
20-49%	1	1	1	0
0-19%	2	0	0	0
Total	11	1	1	4

Statistics of Routing Choice Decisions

Routing Decision	Carrier		Shippers with own transport	
	Count	Percentage	Count	Percentage
Owner/Operator	4	13%	1	33.33%
Driver	21	70%	1	33.33%
Others	5	17%	1	33.33%
Total	30	100%	3	100%

Statistics of Reimbursement for Tolls from Clients (Carriers & Shippers With Own Transport Only)

Reimbursed	Carriers		Shippers with own transport	
	Count	Percentage	Count	Percentage
Yes	5	18%	1	17%
No	23	82%	5	83%
Total	28	100%	6	100%

Appendix D: Glossary

Alternatives	Options containing specified levels of attributes
Attribute Levels	A specific value taken by an attribute; experimental designs require that each attribute takes on two or more levels, which may be quantitative or qualitative
Attributes	Characteristics of an alternative
Blocking	The process of sub-setting the treatment combinations to decision makers
Base table	Containing range of attribute values, within which shipment characteristics are more or less same
Choice set	The set of alternatives over which a respondent makes a choice
D-efficiency	It is a measure related to D-optimal design to calculate the efficiency of design, which is performed by minimizing the determinant of inverse of variance-covariance matrix
Exogenous weighting	The weighting of any data besides choice
Experimental design	The specification of attributes and attribute levels for use in an experiment
Main effect	The direct independent effect of each factor upon a response variable
Interaction effect	An effect upon the response variable obtained by combining two or more attributes which would not have been observed has each of attributes been estimated separately
Labeled Experiment	Alternatives are described conveying information to particular item (e.g. Road, Rail)
Orthogonal design	An orthogonal design in which only the main effects are estimated; all other interactions are assumed to be insignificant
Sampling frame	The sub-set of the population to whom the experiment may be administrated
Treatment combination	Combinations of attributes, each with unique levels
Unlabeled Experiment	Alternatives are described generically conveying no information to particular item (e.g. listed as "Alternative A")