Upper Mississippi and Illinois Transportation Demands for Agricultural Products

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December 2006

Report prepared for the
Institute for Water Resources
U.S. Army Corps of Engineers

This research was conducted for the Navigation and Economic Technologies Program (NETS) of the Army Corps of Engineers directed by Keith Hofseth. The authors gratefully acknowledge both the research support and comments received from Kenneth Casavant and Eric Jessup of Washington State University.

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1. EXECUTIVE SUMMARY AND INTRODUCTION

This report continues the line of research introduced by the Navigation and Economics Technologies (NETS) to examine the structure of transportation demands for use in planning models. Over the past three years, a series of demand studies has been conducted under the NETS program. These studies began with a survey of the existing literature on transportation demand modeling (Clark et al. (2005)). This review along with various National Research Council reports pointed to a need to develop models that reflect the alternatives that individual shippers face and the responsiveness of the choices they make to changes in not only rates but also the time it takes to make shipments and the reliability of the various alternatives. Most previous models of freight demand in the literature are based on aggregate data either in a cross section or in time. However, the Army Corps of Engineers' planning models, which require demand information as a central component, operate at the disaggregate level, describing shipments differentiated by commodity, destination, and origin. There was a general lack of demand studies that fit the needs for Army Corps of Engineer planning models.

Under NETS, this need has been addressed through a series of surveys of individual shippers located in the Upper Mississippi and Illinois Waterway (Train and Wilson (2004)), the Columbia-Snake Waterway (Train and Wilson (2006)), and the Ohio River (2005).[1] In each case, survey methods were used to identify and target shippers that could plausibly use the waterway. To this end, survey methods focused on shippers of commodities that have a historical presence on the waterway and on shippers of varying distance from the waterway to capture the effects of space that are central to the decision to use the waterway. Using these survey data, demand models have been estimated that yield significant evidence that shippers do respond to rates, time in transit and reliability. The responsiveness is two-fold. Shippers' discrete decisions (where and how to ship the product) and continuous decisions (the volume of shipments) are both embedded in most of the studies. In all cases, the analyses reinforce the notion that shippers respond to changes in attributes that can be affected by Army Corps infrastructure decisions.

The present report continues this line of research by examining decisions of agricultural shippers in the Upper Mississippi and Illinois waterway basins. A sample of 480 shippers located in a 10 state area are used to examine shippers' choice of mode and destination (i.e., discrete decisions of where and how to ship) and their decisions regarding the volume of shipments (i.e. the continuous decision of how much to ship.) As in the previous studies, both revealed data and stated preference data are used. Revealed decisions reflect what the shipper actually does, while stated preference data reflect what the shipper says they would do if confronted with a hypothetical situation. Revealed data often exhibit only modest variation in the attributes causing the choice, and the range of responsiveness needed for policy analysis often runs beyond the range of data observed. This short-coming of revealed data can be overcome by the use of stated preference data. Stated preference data, however, are commonly criticized because the

[1] There has also been a host of different studies that have been conducted using these data and are published in a variety of different outlets. The citations enumerated contain the primary reports for each of the surveys conducted.

respondent's stated behavior may not mirror its revealed behavior. As a result, stated preference data may not accurately reveal the parameters of interest (e.g., the parameters of the demand function). Under NETS, Train and Wilson (2005) developed a technique which mitigates both difficulties. The key idea is that the stated preference questions can be based on the shipper's revealed decision. In this way, the criticism that stated preference question constitute hypothetical situations that are not known to respondents is overcome. Further, the nature of stated preference questions is the ability to control the experiment, and, under our approach, to specify the range of the stated preference data. This overcomes the problem of revealed data often not providing enough range in the data. Since, however, the stated preference data are constructed from the revealed decision, an econometric technique had to be developed to recognize that the stated preference data generated are endogenously determined. Finally, as noted later in this report, we also have the ability to gage the consistency of revealed with stated preference data. We find that the use of this technique provides reliable variation in the data and that the revealed and stated preference data are generally consistent.

Two other features are captured in this study. Over the last 25 years or so, ethanol plants have become very prevalent in the Midwest, with the growth accelerating during the last decade. This phenomenon is important since corn is a primary agricultural commodity on the Upper Mississippi and is also a primary input into the production of ethanol. In econometric modeling, the development of ethanol provides more choices for shippers. As growth in the industry occurs, there are more market outlets for corn, and as more plants are located within the waterway catchment area, the potential for traffic diversion becomes more prevalent. To our knowledge, there are few transportation demand studies that have captured the destination choices of agricultural shippers. Rather, most studies focus on mode choices. The research presented below offers a novel approach to examining the choices of shippers. In particular, the model rests on a definition of a shipment as containing both the mode and destination choice. This feature is important since agricultural markets are replete with different market outlets for shippers. We find that the prices of different markets outlets are an important causal variable and that the inclusion of prices in the models allows the presence of different markets outlets to be reflected.

A second feature of the analysis is the use of a mixed logit. In freight market demand studies this is not a common feature. A mixed logit model is based on the same principles as the standard logit model. That is, decision-maker payoff functions (e.g., utility, profit) drive the choice that is made. Traditionally, the payoff functions for different alternatives from which a choice is made has two components, a deterministic equation (with fixed parameters to be estimated using observed explanatory variables) and an unobserved component (the error term). In this specification, the parameters are commonly treated as fixed. That is, it is assumed that shippers share the same set of parameters, and a single set of parameters is estimated. The mixed logit differs in that some or all of the parameters are treated as random, varying over shippers. Instead of estimating fixed parameters, researchers estimate the distribution of the parameters. In transportation markets, there is considerable heterogeneity in shippers, some of which is observed and some of which is not observed. In our previous studies under NETS, we found that there is considerable variation across shippers in the responsiveness of payoffs to observed variables. And, in the current report we have the same result.

The findings of this report can be summarized as follows:

1. The choice models indicate statistically important responses of shippers to changes in rate, time, reliability price, and distance.
2. There are statistically important differences in the responses between truck, rail and barge shipments.
3. Many firms report limited alternatives in their choice of mode and destination, and many report that they would shutdown in the presence of rate increases or if the chosen alternative was taken away. Unlike previous studies conducted under NETS, the effect of a shutdown alternative is reflected in the choices and explicitly captured in the models of switching behavior.
4. Arc elasticities are calculated for each mode and shipment attribute. Demand is found to be inelastic; that is, the arc-elasticities are all less than 1 in magnitude.
5. The rate demand elasticities are all inelastic. Barge elasticities range from -.47 to -.57; Rail elasticities range from -.57 to -.86, and truck elasticities range from -.21 to -.24.
6. The time demand elasticities are all inelastic, and smaller than rate elasticities. Barge time elasticities range from -.026 to -.027; Rail elasticities range from -.051 to -0.54; and Truck elasticities range from -.009 to -.01.
7. The reliability elasticities are all inelastic and rest between those of rate and time elasticities. Barge reliability elasticities range from .20 to .21; rail elasticities range from .27 to .30; and truck elasticities rage from .33 to .47.
8. Annual volume demand elasticities were also estimated for rate, time and reliability. The responses of shippers often pointed to no change in annual volumes from a change in an attribute. A Heckman model was, therefore, used to estimate the model. The results suggest that shippers with large storage capacities and little rail car loading facilities were not likely to adjust volumes in response to rate changes. Given a change does occur, the change is driven largely by the level of the change in the attribute. That is, the elasticities conditioned on a change occurring did not vary with shipper attributes or commodity. But, whether or not a change occurs depends on shipper attributes.
9. The Heckman procedure allows the calculation of two different elasticities. These are a conditional elasticity (given a shippers volume changes) and an unconditional elasticity (where shippers volumes may or may not change). The former is larger in magnitude than the latter for each attribute, by definition. In some cases, annual volumes, given a change in volume, are quite responsive to changes in attributes. However, in most cases, the unconditional elasticities are less than one in magnitude, pointing to relatively inelastic demands.
10. Two different rate elasticities are presented – one where the shipper and its competitors face the same rate change, and one where the shipper but not its

competitors face a rate change. The elasticities calculated from the former are much smaller in magnitude than those calculated from the latter. In both cases, the unconditional elasticities are less than one in magnitude for the median shipper. For some rate change levels, the conditional elasticities are greater than one in magnitude. This suggests that if there is a rate change that induces a volume change, the change is relatively responsive.

11. Both time in transit and reliability elasticities are nonzero; a finding that suggests shippers do adjust annual volumes to these shipment attributes. As with rates, the unconditional elasticities are less than one in magnitude.
12. There is considerable variation across shippers. Over the sample, unconditional rate elasticities (for rate changes applying to both the shipper and its competitors) averaged -.36 with a range of -1.36 to -.02; shipper specific elasticities averaged -.86 with a range from -1.66 to -.37; time elasticities averaged -.31 with a range from -.09 to -.49, and reliability averaged .33 with a range from .16 to .50.

In Section 2, we present the data sources and summary statistics for the analysis. Section 3 documents our analysis of shippers' choice of mode and destination. Section 4 documents our analysis of shippers' annual volume.

2. DATA SOURCES AND DESCRIPTIVE CHARACTERTISTICS

Survey Description

All data used in this analysis were obtained and constructed from a survey of agricultural shippers. The survey was physically conducted by the Social and Economic Sciences Research Center located at Washington State University. The goal of the research was to gather data that pertain to shippers that could conceivable ship down the Upper Mississippi and Illinois waterways. To that end, the mail list was constructed from grain companies, including co-ops in Iowa, Illinois, Indiana, Wisconsin, Kansas, Missouri, Nebraska, North Dakota, South Dakota, Ohio, and Minnesota. The final list of elevators came from three primary sources: 1) a list from Dunn and Bradstreet for companies with relevant 3-digit NAICS commodity listings (111, 115, 311, 493); FarmNet services[2]; and a existing list of warehouses/grain elevator locations compiled by North Dakota State University for elevator firms in the area.[3]

A sample of 2000 potential shippers was drawn from this list and sampled in August, September and October of 2006. The sample was stratified by distance from the waterway. Specifically, a buffer of zip codes with 100 miles of the waterway was identified. Within this buffer there were two strata. A buffer of zip codes within 100 miles of the Mississippi river in which there were approximately 900 locations identified

[2] See http://65.109.0.18/fn/index.html.
[3] The ND Public Service Commission maintains on on-line list of elevators (see http://www.psc.state.nd.us/jurisdiction/grain/location-list-of-nd-elevators.pdf). The resulting list contained duplicate listing, and the list of elevators were inspected to remove duplicates. In addition, a list available from the Farm Service Agency of USDA was also used to supplement and/or verify the list.

and all were sampled. From outside of the 100 mile buffer, 1100 locations were randomly drawn. The total sample size was 2000.

The sample was implemented by first sending a letter introducing the survey. This letter was followed by a survey instrument (Appendix A). A postcard reminder was sent within a week, deleting any responses at that point. If no response was received within the next week or so, a second form was sent. From this methodology there were a total of 480 responses, representing a response rate of 27.4 percent.[4]

The overall goal of the survey is to estimate transportation demand functions by mode. The survey instrument contains a variety of information relating to the attributes of shippers, their last shipment and alternatives to the last shipment, as well as the relationship of annual volumes to transportation service attributes. Each is discussed in turn. We begin with a short description of the spatial locations of shippers and shipments, followed by a summary of shipper attributes. We then describe revealed and stated preference data related to individual shipments and stated preference data related to annual volumes.

Locations of Shippers and Shipments

The locations of shippers and the destinations of shipments are presented in Figures 1 and 2. The locations of the 480 respondents presented in Figure 2 indicate a clustering of shippers along the waterways, although there are shippers located throughout the target states. These locations form the possible origins of shipments. The destinations, as reported by the shippers, are presented in Figure 2. It is noted that these are the destinations reported by the respondent shipper which may or may not reflect the ultimate destination of the product shipped, but does reflect the decision of the initial shipper. The number of destinations reported by shippers reflects a large number of points in the Upper Mississippi basin, but also a number of locations on the West and Gulf coast.

[4] There were 1999 forms mailed. Of these, there were 480 with partial or complete answers returned, 7 refusals, 30 that were ineligible, 23 that were out-of-business, and 188 that were returned to sender. The remaining 1262 are considered non-respondents. This yields a response rate of 480/(1262+7+480)*100 = 27.4%.

Figure 1. Shipper Locations

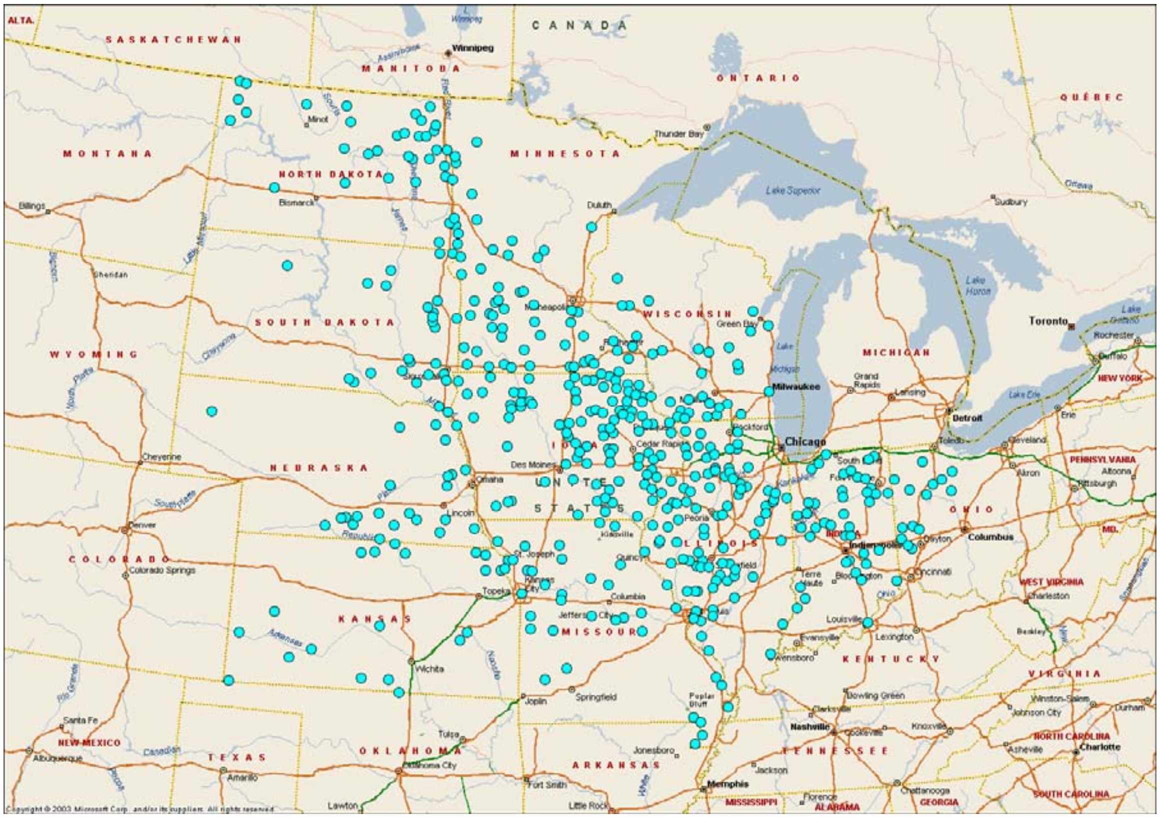

Figure 2. Shipment Destinations

Note: This figure represents the destinations (if available) of shipments that actually occurred. In addition, there are similar mappings can be made for alternative shipments i.e., shipments that were not made under the current set of prices and shipment attributes, but may be made if the current set changed.

Shipper Characteristics

In addition to the geographic locations of shippers and market outlets, there are a number of shipper attributes that affect their transportation decisions. First and foremost among these attributes is the access shippers have to modes. It is well understood in the industry that if a shipper is located on the waterway and has direct access to barge, the shipment will likely occur by barge. In addition, a shipper located a long distance from the waterway, with direct access to rail will more likely ship by rail to market than by a combination of truck-barge. This is especially so if the shipper has substantial rail car loading capacity, and can therefore, access lower rates associated with volume shipments.

The survey included questions related to the access that shippers have to each mode, and, if they didn't have access, the distance to the nearest point Table1. Nearly all shippers have loading capabilities for truck (479/480but far fewer have loading capacity for rail

(201/471) and barge (23/458).[5] Given that a shipper does not have direct access, it could still ship to a rail or barge terminal. When this happens, the average distance is 14 miles to rail access and about 138 miles to barge access. The median values are 20 for rail access and 90 for barge access. This is important in that multimodal options are always a possibility for shippers. That is, they can in most cases ship by truck which is usually a mode with a higher rate relative to rail or barge access points which typically reflect modes with lower rates. As a final point, those shippers that have rail access, tend to have substantial rail car loading capacities (average cars loading capacity is 45 with a median value of 25).

Table 1. Access to modes

Mode	Yes	No	Mean Distance to alternative if No (miles)	Median Distance to alternative if No (miles)	N
Truck	479	1	N.A.	N.A	
Rail	201	270	25	20	248
Barge	23	435	137	90	390

Note: Distance to truck access point was not asked. The N is the number of observations for which the distance data was available.

In addition to mode access, there are a number of other shipper attributes of interest, including its longevity, size, storage capacity, ownership of export facilities, and the number of facilities that are operated by the firm. It appears that the points of origin and location have a long history at those points (Table 2). On average, elevators have been in business about 57 years with a median value of 50 years. Further, fewer than four percent of the locations are newer than 10 years, and only 7.25 percent of the locations are new in the last 20 years, strongly indicating that the location of elevators tends to be relatively fixed.

[5] The numbers in the numerator is the number with access and in the denominator is the total number that responded.

Table 2. Longevity of Facility Locations

Years	Frequency	%	Cumulative %
10	17	3.74	3.74
20	33	7.25	10.99
30	59	12.97	23.96
40	61	13.41	37.36
50	66	14.51	51.87
60	39	8.57	60.44
70	27	5.93	66.37
80	30	6.59	72.97
90	45	9.89	82.86
100	56	12.31	95.16
110	15	3.3	98.46
120	2	0.44	98.9
130	3	0.66	99.56
140	1	0.22	99.78
150	1	0.22	100
Total	455	100	

The sizes of elevators in terms of annual volumes shipped and storage capacity is summarized by Table 3.[6] Very significant differences exist in the size of elevators in the sample. The average and median values of annual volumes shipped are 140,000 and 56,000 tons, respectively. About 70 percent of the sample ships less than 100,000 tons annually, but there several very large shippers with annual quantities in excess of 500,000 tons (Table 3). In terms of storage capacity, the average and median values are 50,645 and 24,000 tons. As with volume, the capacity distribution is also heavily skewed with the sample being dominated by relatively small shippers. Over 30 percent of the sample has storage facilities of less than 15,000 tons, and 70 percent of the sample has storage of less than 50,000 tons. Again, however, there are some very large storage facilities in the data, with, about 12 percent (58 facilities) of the observations reporting storage capacity in excess of 100,000 tons (58 observations).[7]

[6] A number of missing values on total volume shipped initially existed and the range in responses suggests that some miss-recorded values were in the data set. Storage capacity had some of the same issues. However, the use of a number of different web pages and contact with various organizations (state agricultural, Farm Service Agency, Railroad, and company websites) allowed most of the figures that were questionable or missing were either confirmed, replaced or added.

[7] In terms of bushels (using 56 pounds per bushel), a 50,000 ton storage capacity translates into 1.78 million bushels. In the data, there are a number of facilities in excess of 10 million bushels.

Table 3. Elevator Size Distribution

Tons Shipped	N	Percent %	Cum.	Storage Capacity (tons)	N	Percent	Cum. %
0-20000	91	21.16	21.16	0-15000	151	32.06	32.06
20000-50000	112	26.05	47.21	15000-30000	113	23.99	56.05
50000-100000	95	22.09	69.3	30000-50000	68	14.4	70.49
100000-25000	65	15.12	84.42	50000-75000	53	11.25	81.74
250000-500000	41	9.53	93.95	75000-100000	28	5.94	87.69
500000-750000	14	3.26	97.21	100000-200000	42	8.92	96.60
750000-1000000	2	0.47	97.67	200000-300000	6	1.27	97.88
1000000-1250000	5	1.16	98.84	300000-400000	3	0.64	98.51
1250000-1500000	1	0.23	99.07	400000-500000	3	0.64	99.15
Larger	4	0.93	100	Larger	4	0.85	100
Total	430	100		Total	471	100	

Generally, the firms do not typically own export facilities (Table 4). Only 36 of 461 responses (about 8 percent) indicated ownership of export or import facilities. The number of facilities operated by firms averaged 5.7. However, the sample was dominated by relatively small firms, with nearly 50 percent of the sample operating only one facility and almost 85 percent operating five facilities or less. However, larger companies are represented with about 10 percent operating more than 10 facilities and a few in excess of 100 facilities.

Table 4. Number of Facilities owned by each firm

Number	N	%	Cumulative
1	214	49.88	49.88
2-5	147	34.27	84.15
6-10	32	7.46	91.61
11-75	30	6.99	98.6
>75	6	1.4	100
Total	429	100	

Shipment Characteristics

A major purpose of the survey was to develop a database from which choice models can be used. In this regard, the instrument was designed to focus on the last shipment and up to three different alternatives to the shipment choice actually made. A shipment was defined as a mode and a destination choice. Alternative shipments are shipments that could have been made if the chosen shipment was not available. Four hundred seventy one surveyed shippers responded to the initial mode used question (Table 5). Of those, trucks were chosen by over 70 percent of the sample (335 choices). Railroads were chosen by about 23 percent of the sample with the remaining a mix of barge, and multimodal shipments. As in previous studies conducted by these authors, the number of shippers who report they have no alternatives is significant. In particular, 154 of 461 observations (33 percent) report that if the chosen alternative were taken away, they would shutdown. Two hundred ninety four respondents listed at least one alternative, 132 listed two alternatives and 73 listed the maximum of three alternatives. As with the chosen alternative, truck movements dominated with over 80 percent of the responses. Rail represents the second largest frequency in all cases, with barge and multimodal movement making up the rest.

Table 5. Modal Choices and Alternatives

Mode	Chosen	%	Alter. 1	%	Alter. 2	%	Alter. 3	%
B	15	3.18	2	0.68	1	0.76		
R	108	22.93	39	13.27	16	12.12	5	6.85
T	335	71.13	246	83.67	112	84.85	67	91.78
T-B	4	0.85	0	0	0	0	0	0
T-R	9	1.91	6	2.04	2	1.52	1	1.37
T-R-B	0		1	0.34	1	0.76		
Total	471	100	294	100	132	100	73	100

A number of different locations may be available to shippers. The points in Figure 2 represent destinations for the chosen alternative. In addition, Table 6 details the type of destinations, broken into seven different categories. The bulk of chosen alternatives are relatively short-hauled movements to processing (and/or ethanol) plants. For the chosen and for each of the alternative movements, these movements represent the largest category. For the chosen destination, almost one-half of the shipments flow to processing (and/or ethanol) plants. The second largest destination is that of river terminals, followed by rail terminals. There are also a number of movements to export terminals.

Table 6. Destination Alternatives

Destination Type	Chosen	%	Alter. 1	%	Alter. 2	%	Alter. 3	%
River Terminal	101	21.26	75	25.42	40	30.53	29	37.66
Another Terminal	43	9.05	43	14.58	11	8.4	3	3.9
Railroad Terminal	58	12.21	29	9.83	19	14.5	8	10.39
Processing/Ethanol Plant	211	44.42	130	44.07	51	38.93	31	40.26
Other	2	0.42	4	1.36	1	0.76	1	1.3
Export Terminal	34	7.16	5	1.69	3	2.29	3	3.9
Feed lot	26	5.47	9	3.05	6	4.58	2	2.6
Total	475	100	295	100	131	100	77	100

One of the reasons for the dominance of processing/ethanol is that the primary commodity shipped in the data is corn. Specifically, firms were asked to report both the primary commodity handled by their facility and the commodity for which the shipments pertain. In Table 7, the number of shipments in grouped categories is provided along with the average price per ton received. Corn shipments dominate the sample with over 60 percent of all shipments (295/480). Corn, of course, is a primary ingredient of ethanol, and there has been tremendous growth in this industry, particularly over the last 10 years or so. In addition to corn shipments, there are a number of shipments of soybeans and beans recorded (49/480 and 33/480, respectively). This was an "open-ended" question, and the term "beans" groups different types together. On inspection of the data, some of the beans shipped are not soybeans. That is, in the open-ended responses, beans were described by pinto, extruded, edible and kidney. Generally, the prices observed for these later tended to be considerably higher than those of "beans" (not designated). In addition to corn and beans, there are also a number of wheat shipments (69/480). The final category "other" has 34/480 shipments and represents variety of different commodities that include barley (2), canola (1), cotton (1), feed (3), fertilizer (2), flour (1), lentils (1), grain (6), oats (2), sorghum (5), soymeal (4), sunflower (2) and otherwise unspecified (4). Generally, inspection of table 7 suggests that the higher valued commodities are beans and soybeans, wheat, and other, while corn receives an average price per ton of about $80.

Table 7. Commodity Shipped and Prices per ton Received by Commodity

Commodity	Number	Price/ton	Std Dev
Corn	295	$79.9 (242)	$11
Soybeans	49	181.9 (43)	16.5
Beans	33	215 (28)	104.1
Wheat	69	148.6 (55)	21.5
Other	34	161.1 (18)	67
Total	480	114.6 (386)	58.4

Note: The numbers in () reflect the number of observations for which price is available. If specialty beans are excluded from the "beans" category, the average is $174 per ton. Specialty beans receive much higher prices with an average of $401.

Each of the choices made by shippers has different attributes attached to it. These data are presented by mode first, and then by chosen and next best alternative. Table 8 presents prices received at the destination, rates, transit times, reliability and distances by mode. By and large, most of these statistics are within the realm of prior expectations in experience and in the literature. On average, commodities shipped receive a price per ton of about $110 per ton (more detailed statistics by commodities are discussed below). The price received for products shipped by rail is somewhat higher than for the other modes. This arises because shipments of commodities exist are higher in value than the prevalent commodity (corn), including soybeans, other beans (pinto, extruded, kidney), and soybean meal which pull the average up.

Table 8. Shipment Attributes-Descriptive Statistics by Mode

Variable\Mode	Barge Average	Std. Dev.	Rail Average	Std. Dev.	Truck Average	Std. Dev	Overall Average	Std. Dev
Price/Ton	109.0 (10)	33.6	130.1 (121)	67.2	106.9 (591)	52.1	111.5 (737)	56.0
Rate/Ton	26.5 (17)	7.1	20.0 (127)	12.5	7.2 (727)	5.9	9.62 (886)	9.6
Time (hours)	256.9 (17)	126.1	219.3 (148)	212.3	59.0 (699)	258.6	93.2 (881)	257.6
Reliability (%)	86.2 (17)	12.2	60.2 (149)	27.8	87.4 (693)	16.5	82.5 (876)	21.6
Distance (miles)	1032.4 (17)	441.9	678.2 (159)	624.3	75.9 (738)	106.5	210.9 (934)	405.9
Rate/tonmile	3.4 (17)	2.8	5.7 (127)	5.2	15.6 (726)	20.21	13.8 (885)	18.8
Miles per hour	5.19 (17)	5.24	5.36 (145)	7.14	17.7 (697)	15.45	15.3 (873)	15.07

Note: There were 18 barge observations, 165 rail observations, and 751 truck observations. The number in () under each average value is the number of respondents providing enough information to specify the variable.

Barge movements tend to be of longer hauls than rail and truck (1032 versus 624 versus 106 for barge, rail, and truck) and tend to cost less per mile (3.4 5.7 and 13.8 cents per tonmile, respectively). Barge movements also tend to travel slower than rail and truck, with miles per hour of 5.19, 5.36 and 17.7. Time in transit for this questionnaire included not only the travel time but also the time to schedule and wait for equipment. Finally, shippers report that barge and truck shipments are more reliable than rail service with over 85 percent of shipments considered arriving on time, while rail reliability is lower with about 60 percent of shipments arriving on time.

Table 9 compares the shippers' chosen alternative with the alternative that they identify as their next-best alternative. The chosen alternative dominates the next best alternative in terms of price received with a difference of about \$3.4 per ton. Rates, however, are also higher for the chosen alternative. Specifically, the rates are about \$2.3 per ton higher. The difference in the margin (Price-rate) is \$2.75 per ton and is statistically different from zero and is of a sizable economic difference. The primary driver of the difference in rates is that the distances traveled for the chosen alternative tends to be markedly higher than for the alternative shipments. Indeed, the average distance for the chosen alternative is 340 miles, while for the alternative is only about 135. This suggests a tradeoff from relatively distant high value market to relatively local markets with lower returns. Once controlling for distance both in rates and transit times (rate per tonmile and miles per hour), the rate (cents per tonmile) and miles per hour each suggest that the chosen alternative has better attributes i.e., costs less and gets to the destination at a higher rate of speed: though, the differences are not statistically important.

Table 9. Shipment Attributes-Average values by Chosen and Next Best Alternative

Variable	Chosen	Next Best	Difference	Paired t-test	N
Price (dollars per ton)	115	110.6	4.4	3.4	213
Rate dollars per ton	11.4	9.1	2.3	3.13	248
Time in hours	88.3	95	-6.7	-0.49	246
Reliabilty (%)	80.8	81.3	-0.5	-0.26	253
Rate/Tonmile	14	16	-2	-0.97	247
Mph	14.2	14	0.19	0.2	241
Distance (Miles)	340	135	205	6.1	276

Stated Preference Responses to Shipment Attributes

Revealed data reflect actual decisions made by shippers and form the basis for many studies. However, it is commonly recognized that a problem with revealed data is that often the attributes do not have a large enough range of data to identify the parameters of interest. Indeed, in Table 9, rates per unit mile, times-in-transit, and reliability each have statistically insignificant differences between the chosen and next-best alternative. Because of the limited variation in such statistics, there is a growing literature on stated preference modeling. A stated preference survey confronts survey respondents with a set of hypothetical states, and solicits a preference. This approach considerably simplifies analysis and the difficulty of collecting survey responses to confidential information. However, it is criticized in being based on hypothetical situations instead of real world decision-making. Our approach differs from the standard approach in that the stated preference questions are grounded in the revealed decisions made. In particular, survey recipients are asked what they did and what they would do if the chosen alternative were not available. This is taken as their next best alternative. The stated preference questions perturb each of the attributes of the original choice (For the last shipment, if the attribute changed x percent, would you continue with the original mode and destination or switch to your best alternative choice?). This framing of the question grounds the decision making not to hypothetical alternatives, but rather to alternatives commonly confronted by the individual making the decision.

In the survey, three such questions related to rate, time and reliability. The percentage change was randomly offered to each and ranged from 10 to 60 percent. This generates a very large range of values over which to identify the parameters of the profit-function on which decisions are made. In addition, if the shipper did not switch, they were asked what level of the attribute would induce a switch with outcomes presented in Tables 10, 11, and 12.

Six rate changes, from a 10 to 60 percent increase in rates, were used in the survey. A total of 425 responses are observed. At low values of rate changes, seventy-six percent of responses indicate they would not switch to the alternative. As the rate change increases, this proportion falls. However, even for large rate increases, 38 percent of respondents report they would still not switch. If they do switch, there are two alternatives utilized. First, they can switch to their next best mode/destination. At various rate changes, there are a total of 122 such switches. Second, they can switch to “shutdown”. Shutdown is and has been a major factor in all of the surveys conducted by these and other authors. In this sample, 57 of 425 (13.4 percent) report that they would shutdown at the rate increase prompt. As expected, both the switch to an alternative and the shutdown proportions tend to increase with the level of the rate change.

Table 10. Shipment Stated Preference – Rate Responses

(%)Rate Change	No Switch	Switch	Shutdown	Total	% NO	% Switch	% Shutdown
10	64	13	7	84	76	15	8
20	38	16	6	60	63	26	10
30	42	17	10	69	60	24	14
40	38	22	9	69	55	31	13
50	36	25	9	70	51	35	12
60	28	29	16	73	38	39	21
Total	246	122	57	425	57	29	13

The same information with respect to increases in transit time was examined, with transit times defined, again, as including the setup and waiting times as well as the time once loaded to reach the final destination. There were 417 responses. If time changes, shippers report that a total of 264 (63 percent) shipments would not change regardless of the time change. At small changes in time, the switch rate is higher than for rates, but at large changes in time, the switch rate is lower. As with rates, switch rates generally increase with progressively higher changes in transit times.

Table 11. Shipment Stated Preference – Time Responses

%Time Change	No Switch	Switch	Shutdown	Total	% NO	% Switch	%Shutdown
10	44	11	8	63	69	17	12
20	71	12	3	86	82	13	3
30	44	12	9	65	67	18	13
40	38	15	9	62	61	24	14
50	29	27	5	61	47	44	8
60	38	31	11	80	47	38	13
Total	264	108	45	417	63	26	11

The same information as Table 10 and 11 with respect to reliability is presented in Table 12 with a total of 412 responses. The same general pattern as with rate and time is indicated (as expected). For decreases in reliability, the switch rate increases with the percentage change in reliability. Generally, Table 10, 11, and 12 each follow expectations. Further, shippers appear to be more responsive to rates than to time and reliability, particularly for large rate changes.

Table 12. Shipment Stated Preference – Reliability Responses

%Reliability Change	No Switch	Switch	Shutdown	Total	% No	% Switch	% Shutdown
10	53	8	7	68	77	11	10
20	52	19	2	73	71	26	2
30	46	16	11	73	63	21	15
40	39	22	7	68	57	32	10
50	32	20	11	63	50	31	17
60	31	23	13	67	46	34	19
Total	253	108	51	412	61	26	12

Stated Preference and Annual Volume Responses

In addition to shipment choices, investment in transportation infrastructure which affects shipment characteristics may also affect the *volumes* shipped, both at the shipment level and annually. However, by and large, the shipment volumes tend to be mode specific and do not vary much across shippers. For example, the median value of shipment size for truck is about 27 tons (the approximate payload of a truck) and for barge 1600 tons (the approximate payload of a barge).[8] If logistics costs do change, it is unlikely to affect shipment volumes. However, if logistics costs change, they can affect the annual volumes shipped. Logistics costs can change due to changes in rates, time in transit and reliability.

Further, the annual volumes shipped depend on how these change vis a vis competitors. Specifically, the sample is dominated by firms that compete locally for the procurement of the commodity shipped. If a shipper experiences a rate increase/decrease that is not experienced by its competitors, annual volumes may respond quite differently than if the shipper and its competitors experience the same rate increase/decrease. The former might be expected if a railroad prices shippers differently or makes an investment that is shipper specific, while the later might be expected from improvements in the major

[8] Railroads seem to be quite different with shipment sizes taking a wide range. This may be due to the fact that different shippers have different car siding capacities. Indeed, shipment sizes increase an average of 90 tons per unit of rail car siding capacity. The 90 tons rate of increase is the approximate payload capacity of a hopper car. This figure was generated from a regression of shipment sizes on car siding capacity. The parameter of interest was 90.7 with t-statistic of 12.7 and an R-square of 62. There were 102 observations, and a few egregious outliers were excluded. These results, along with the truck and barge results, are consistent with the hypothesis that shipment sizes are capacity driven and not endogenously determined. Hence, we do not make them part of the mode/destination choice model.

corridors (rail lines to terminal markets or investments in the waterway whose benefits are experienced shared by all shippers in the study region).

In the survey, four questions were asked to evaluate this situation. First, shippers were asked how their annual volumes would change if rates were increased to them as well as their competitors. Second, shippers were asked the same question but with the rate change applying only to them. The last two questions asked their responsiveness of annual volumes if time and reliability changed. The results for each of the four questions are presented in Tables 13, 14, 15, and 16.

Generally, the pattern is the same for each. First, small changes in attributes often do not result in any impact on annual volumes. Specifically, there are large proportions of shippers who report their annual volumes are not affected by a 10 percent change in rates, time or reliability. Second, the proportion of shippers reporting a change in their annual volume increases as the level of the attribute change increases. Third, rate changes tend to impact volumes more than the time or reliabilities. This is both in terms of the proportion of shippers whose annual volumes are affected, but also in the magnitude of the change given a change occurs.

In summary, in Table 13, the questions are framed around rate changes available to all shippers, while in Table 14 the rate changes apply only to the shipper responding. There are striking differences in the two tables, with the former indicating that responses to rate changes are much more muted when all shippers face the same rate change than when the rate change applies to a single shipper. This result, of course, is a direct consequence, likely, of agricultural shippers. As noted above, they compete over space in the procurement of grain; a rate change (or a change in time or reliability) is a mechanism through which more grain may be procured. If a change applies to shippers symmetrically i.e., the benefits of improvements in transportation infrastructure is shares by all shippers, it stands to reason that the change in volume for a given shipper is less than if the improvement applied only to that single shipper.

Table 13. Annual Stated Preference – Rate Responses (change in rates applies to all)

Rate Change	Change	No Change	% Change given a Change Occurs	Implied Elasticity given a Change Occurs
10	8	48	15.8	1.58
20	23	56	23.3	1.17
30	17	48	32.8	1.09
40	37	38	30.6	0.77
50	38	44	38	0.76
60	39	33	42.6	0.71
Total	162	267	41.8	0.88

Table 14. Annual Stated Preference – Rate Responses (change in rates applies to single shipper)

%Rate Change	Change	No Change	% Change given Change Occurs	Implied Elasticity given a Change Occurs
10	29	49	31.25	3.13
20	42	28	35.46	1.77
30	41	39	35.18	1.17
40	49	26	52.08	1.30
50	56	15	55.02	1.10
60	34	12	61.85	1.03

Table 15. Annual Stated Preference – Time Responses

%Time Change	Change	No Change	% Change Occurs	Implied Elasticity given a Change Occurs
10	14	66	15.25	1.53
20	15	61	19.14	0.96
30	21	35	31.06	1.04
40	28	40	29.91	0.75
50	27	32	37.25	0.75
60	39	41	39.73	0.66
Total	144	275	31.57	0.86

Table 16. Annual Stated Preference – Reliability Responses

%Reliability Change	Change	No Change	% Change given a Change Occurs	Implied Elasticity given a Change Occurs
10	12	57	16.25	1.63
20	21	46	21.92	1.10
30	26	44	27.13	0.90
40	26	37	29.25	0.73
50	29	45	33.46	0.67
60	28	35	32.57	0.54
Total	142	264	28.19	0.84

In the following sections, we describe our analysis of shippers' choice of mode and destination (section 2) and shippers' changes in volume of shipments in response to rate increases (section 3.)

3. Shippers' Choice of Modes and Destinations

3.1 Data

In this section, we examine shippers' choice of mode and destination for their shipments. In particular, we examine the extent to which shippers would change modes and/or destinations, or even choose to shut down, in response to changes in rates, time, and reliability. The analysis constitutes one aspect of shippers' overall responses. The other way that shippers can respond is to change their volume of shipping, by, for example, reducing total volume in response to rate increases. This second component of response is examined in section 4.

The data that are used for the analysis of mode and destination choice are described in section 2 above. To summarized: Shippers were asked the mode(s) and destination of their last shipment, as well as alternative mode(s) and destinations, if any, that were available to the shipper for this shipment. For each available alternative, they were asked to provide rates, transit times and reliability measures. Transit times were to include the scheduling, waiting time for equipment, and travel time. Reliability was measured by asking the shippers to estimate the percentage of time that shipments like this arrive "on-time" at the final destination. Tables 5-9 above provides statistics for shippers' responses. Note from Table 5 that that 177 (471-294) of 471 respondents (over

35%) reported no shipping alternatives, such that their only other option was to shut down. A similarly large share of reportedly "captive" shippers (i.e., with no shipping alternatives from their chosen mode and destination) was obtained in the previous surveys of shippers in the Columbia/Snake area (Train and Wilson, 2005) and the Upper Mississippi region (Train and Wilson, 2004). However, unlike the previous studies, we ask respondents in the current survey about conditions that would induce them to shut down, and we explicitly include the "shut down" option in our modeling.

As described in section 1, the standard form of stated-preference questions were not used and an alternative, more realistic form was used instead. The usual procedure for stated-preference question is to present each shipper with a set of hypothetical options from which they choose one. The rate, transit time, and reliability of each hypothetical option is described, and the respondent's choice among the hypothetical options is used to infer the relative value placed on rates, time and reliability. In the current study, we implemented a procedure that we call "sp-off-rp," because the stated-preference (sp) questions are based on the revealed-preference setting and choice of the shipper. Recall that each shipper was asked about their last shipment and the alternative modes and destinations that they could have used, but didn't, for this shipment. For the sp-off-rp questions, the shipper was asked whether they would have remained with the mode and destination if its rate were x% higher, or would they switch to an alternative. For example, the shipper was asked "Suppose that the rates for your last shipment were 40% higher than currently. Would you still use that mode and destination, or would you choose a different alternative?" If the shipper said they would choose a different alternative, they were asked what they would do instead. Shutting down was included as an option, and some shippers chose this option in the face of sufficiently large rate increases. The percent increase in rates was varied over shippers, chosen randomly from 10, 20, 30, 40, 50 and 60 percent changes. Similar questions were also asked for an increase in transit time and decrease in reliability.

Note that these "sp-off-rp" questions relate to the shippers real-world choice situation, unlike standard sp questions that present the shipper with a set of hypothetical options. In answering the sp-off-rp question, the shipper is facing the same options, with all the same factors affecting their decision, as they actually faced when making their last shipment. The only change from the actual situation is in one of the attributes of their chosen option (rate, time or reliability); all other factors remain the same. This similarity to the real-world setting that the shipper faces gives them a greater realism, relative to standard sp choices, which can be expected to translate into more accurate and generalizable estimates of shipper response to changes in rates, transit times, and reliability.

Tables 10-12 above summarize shippers' responses to the "sp-off-rp" questions. A considerable degree of switching is evidenced overall, and the rate changes tend to induce slightly more reported switching than the time and reliability changes. Specifically, 42 percent of the surveyed shippers said they would switch in response to a rate increase (13 percent would shut down and 29 percent would switch to a different mode/destination); 37 percent of shippers would switch in response to a transit time increase, and 38 percent would change in response to a reliability decrease. Finally, as expected, the rates of switching increase with the level of the change. For example, for those that have rate increases of 50 percent, 47 percent report that they would switch, while those with rate increases of 10 percent, 23 percent report switching. In our econometric analysis of these data, we combine the shippers' responses to these hypothetical changes in rates, times and reliability with data on their actual choices. The analysis finds, as discussed below, that actual switch rates are estimated to be lower than those reported by shippers in these hypothetical situations, since shippers' real-world choices imply less response to rates, time, and reliability than their reported responses in these hypothetical situations.

3.2 Choice Model and Estimation

In this section, we describe the econometric method that is used to estimate choice models on the revealed-preference (rp) data and the shippers' responses to the "sp-off-rp" questions. As stated above, the sp-off-rp questions provide greater realism than standard sp questions, since the sp-off-rp questions relate specifically to the situation that the shipper faced for their last shipment. However, this realism has implications for the econometric techniques that are used to analyze the data. The sp-off-rp questions ask the shipper which option they would choose in the rp setting if the rate, time, or reliability of the option they actually chose were changed. These questions have two features that need to be addressed in the estimation. First, when answering the sp-off-rp questions, the shipper is choosing among options in the rp setting. This implies that the attributes of the options in the rp setting, including, importantly, the attributes that are not observed by the researcher, affect the shipper's answer to the sp-off-rp questions. Stated in econometric terms, the unobserved factors associated with each option in the rp setting can be expected to enter the shipper's evaluation of these options when answering the sp-off-rp questions. Second, the sp-off-rp questions ask the respondent about a change in the rate, time or reliability of the option that was chosen in the rp setting. In econometric terms: The sp-off-rp questions are conditional on the outcome of the rp choice. This conditionality implies that the distribution of unobserved attributes that enter the shipper's responses to the sp-off-rp responses is not the unconditional distribution, as in standard choice models, but rather the distribution conditional on the shippers' rp choice.

The econometric method that we develop and apply incorporates both of these implications, building upon the earlier work reported in Train and Wilson (2005). The unobserved factors in the rp setting enter the model of the shipper's response to the sp-off-rp questions, and the probability of each possible response is derived based on the distribution of these unobserved factors, conditional on the shipper's choice in the rp setting. We provide below the specification of the model. We first describe a version with fixed coefficients for rate, time and reliability. We then generalize the model to allow for random coefficients, reflecting the fact that the relative value of rates, time, and reliability differs over shippers. The next subsections present the alternative estimation strategies in more detail and outline the "choice framework." Essentially, shippers choose from the alternatives available to them in a manner that maximizes their payoffs, which are taken as a function of rates, times of transit and reliability. The specific form of the payoffs varies according to the treatment of the unknown parameters that are estimated. For readers interested primarily in the results may choose to skip to section 3.3.

3.2.1 Fixed coefficients

With fixed coefficients, the shipper's choice in the rp setting is a standard logit model. The shipper faces J alternatives for its last shipment, which are the alternatives that the shipper reports are available. The utility of each alternative depends on observed variables, namely, rate, transit time, and reliability, as well as unobserved factors.[9] The observed variables are denoted x_j for alternative j (with the subscript for the shipper omitted for simplicity), and the unobserved random factors are denoted collectively ε_j as for alternative j. Utility of alternative j is denoted $U_j=\beta x_j+\varepsilon_j$. Under the assumption that each ε_j is distributed iid extreme value, the probability that the shipper chooses alternative i is the logit formula:

$$P_i = \frac{e^{\beta x_i}}{\sum_j e^{\beta x_j}}$$

The researcher presents the shipper with a series of sp-off-rp questions that are constructed on the basis of the shipper's rp choice. We provide more general notation than is necessary for our particular sp-off-rp questions, to facilitate the use of the method in other settings that might use different types of sp-off-rp questions. (For example, our questions ask the shipper about a change that makes the option they chose worse; an alternative would be to ask the shipper about a change that improves an option that they did not choose.) The researcher asks T sp-off-rp questions, with attributes $\tilde{x}^i_{jt}$ for alternative j in question t based on alternative i having been chosen in the rp setting. For our questions, $\tilde{x}^i_{it} \neq x_i$ for the alternative that was chosen in the rp setting, while $\tilde{x}^i_{jt} = x_j \, \forall j \neq i$ for the non-chosen alternatives; however, more general specifications of $\tilde{x}^i_{jt}$ possible. The shipper is asked to choose among the alternatives in response to each sp-off-rp question. The shipper's choice can be affected by unobserved factors that did not arise in the rp setting, reflecting, e.g., inattention by the agent to the task, pure randomness in the agent's responses, or other quixotic aspects of the sp choices. These factors are labeled as η_j for alternative j. The relative importance of these factors will be estimated, as described below. The shipper obtains utility $W_{jt} = \beta\tilde{x}^i_{jt} + \varepsilon_j + \eta_{jt}$ from alternative j in sp-off-rp question t. That is, the shipper evaluates each shipping alternative using the same utility coefficients and with the same unobserved attributes as in the rp setting, with the addition of new errors that reflect quixotic aspects of the shippers' responses to the sp-off-rp questions

In the "sp-off-rp" questions, one alternative for the shipper is to shut down. This option has no associated rates, time, and other shipment attributes. The utility, or more precisely, the disutility of shutting down differs over shippers. The average disutility (relative to shipping alternatives) is denoted λ and the deviation of a given shipper's disutility from

[9] The model is framed in a utility context although the term profit maximization can be employed so long as there are no agency issues i.e., the shipper makes decisions consistent with the firm's objective of maximizing profit.

this average is denoted $\sigma \cdot \mu_s$, where μ_s is assumed to be distributed extreme value and σ is a parameter to be estimated that is proportional to the standard deviation over shippers of the disutility of shutting down. The shipper's disutility of shutting down is the same in each of the "sp-off-rp" questions. However, a second error component, labeled η_{st}, is also included to capture the quixotic aspects of responses to these question, similar to the η_{jt}'s above. Combining these concepts, the disutility of shutting down is specified as: $W_{st} = \lambda + \sigma \cdot \mu_s + \eta_{st}$ where subscript *s* denotes shutting down.

In response to each sp-off-rp question, the shipper chooses the alternative with the greatest utility. To complete the model, we assume that each η_{jt} is iid extreme value with scale *1/α*, which is proportional to the standard deviation of these errors. A large value of parameter *α* indicates that there are few quixotic aspects to the sp-off-rp responses and that the shippers choose essentially the same as they would in a rp situation under the new attributes. The sp-off-rp responses are, under this specification, standard logits with ε_j as an extra explanatory variable. Since the ε_j's are not observed, these logits must be integrated over their conditional distribution, as follows. The chosen alternative in response to question *t* is denoted k_t and vector $k = \langle k_1, \ldots, k_T \rangle$ collects the sequence of responses to the sp-off-rp questions.

For notation convenience, denote $V_{jt} \equiv \beta \tilde{x}^i_{jt} + \varepsilon_j$ for each $j \neq s$, that is, for each alternative other than shutting down, and denote $V_{st} = \lambda + \sigma \cdot \mu_s$ for the shut-down option. The probability of choosing alternative k_t in response to sp-off-rp question *t*, conditional on *i* being chosen in the rp choice is:

$$P_{k_t|i} = \Pr ob\left[V_{k_t t} + \eta_{k_k t} > V_{jt} + \eta_{jt} \forall j \neq k_t \mid \beta x_i + \varepsilon_i > \beta x_j + \varepsilon_j \forall j \neq i, s\right]$$

$$= \int \frac{e^{\alpha V_{k_t t}}}{\sum e^{\alpha V_{jt}}} f(\varepsilon \mid \beta x_i + \varepsilon_i > \beta x_j + \varepsilon_j \forall j \neq i, s) d\varepsilon.$$

This probability is a mixed logit (Train, 2003), mixed over the conditional distribution of the ε's that enter the *V*'s. It can be simulated by taking draws from the distribution of ε, calculating the logit formula for each draw, and averaging the results. The procedure for taking such draws is given in Train and Wilson, 2005.

Combining these results, and using the independence of η_{jt} over *t*, the probability of the agent's rp choice and the sequence of responses to the sp-off-rp questions is:

$$P_{ki} = \int \left[L_{1|i}(\varepsilon) \ldots L_{T|i}(\varepsilon)\right] f(\varepsilon \mid \beta x_i + \varepsilon_i > \beta x_j + \varepsilon_j \forall j \neq i, s) d\varepsilon \frac{e^{\beta x_i}}{\sum e^{\beta x_j}}$$

where

$$L_{t|i}(\varepsilon) = \frac{e^{\alpha V_{k_t t}}}{\sum e^{\alpha V_{jt}}}.$$

This probability is simulated by taking draws of ε from its conditional distribution as described above, calculating the product of logits within brackets for each draw, averaging the results, and then multiplying by the logit probability of the rp choice.

3.2.2 Random coefficients

Utility is as above except that β is now random with density $h(\beta)$ that depends on parameters (not given in the notation) that represent, e.g., the mean and standard deviation of β over shippers. The probability for the rp choice is the logit formula integrated over the density of β:

$$P_i = \int L_i(\beta)h(\beta)d\beta$$

where

$$L_i(\beta) = \frac{e^{\beta x_i}}{\sum_j e^{\beta x_j}}$$

This is a standard mixed logit. By Bayes' rule, the density of β conditional on i being chosen is $L_i(\beta)h(\beta)/P_i$.

For the responses to the sp-off-rp questions, let $L_{t|i}(\varepsilon,\beta)$ be the same as $L_{t|i}(\varepsilon)$ defined above but with β treated as an argument. The probability of the sequence of responses to the sp-off-rp questions is

$$\begin{aligned} P_{k|i} &= \iint L_{1|i}(\varepsilon,\beta)\ldots L_{T|i}(\varepsilon,\beta) f(\varepsilon \mid \beta, \beta x_i + \varepsilon_i > \beta x_j + \varepsilon_j) h(\beta \mid \beta x_i + \varepsilon_i > \beta x_j + \varepsilon_j) d\beta d\varepsilon \\ &= \iint L_{1|i}(\varepsilon,\beta)\ldots L_{T|i}(\varepsilon,\beta) f(\varepsilon \mid \beta, \beta x_i + \varepsilon_i > \beta x_j + \varepsilon_j) L_i(\beta) h(\beta) d\beta d\varepsilon / P_i. \end{aligned}$$

The probability of the rp choice and the sequence of responses to the sp-off-rp questions is P_i times the above formula, which is:

$$P_{ki} = \iint L_{1|i}(\varepsilon,\beta)\ldots L_{T|i}(\varepsilon,\beta) f(\varepsilon \mid \beta, \beta x_i + \varepsilon_i > \beta x_j + \varepsilon_j) L_i(\beta) h(\beta) d\beta d\varepsilon .$$

This probability is simulated as follows: (1) Draw a value of β from its unconditional density. (2) Calculate the logit probabiliuty for the rp choice using this β. (3) Draw a value of ε from its conditional density given β using the method described above. Calculate the product of logit formulas for the responses to the sp-off-rp questions for this draw. (4) Multiply the result from step 3 by the result from step 2. (5) Repeat steps 1-4 numerous times and average the results.

3.3 Estimation Results

Table 17 gives the estimated parameters of a standard logit model that was estimated on the rp data alone. The estimated coefficients of rate, time, and reliability all take the expected signs and are all significant at the 95 percent confidence level. The ratios of coefficients imply that a day of extra transit time is considered equivalent to about 26 cents per ton in higher rates[10] and that decreasing reliability by 1 percentage point is considered equivalent to 31 cents per ton in higher rates. These two estimated values are nearly the same as those obtained on the rp data in the Columbia/Snake study (27 and 26 cents, respectively; Train and Wilson, 2005.)

Table 17: Fixed Coefficients Model on Revealed-Preference Data

Explanatory Variable	Estimated parameter	Standard error	T-statistic
Rate, in dollars per ton	-0.0880	0.0299	2.94
Time, in hours	-0.000963	0.000460	2.09
Reliability	0.0271	0.00765	3.54
Price at destination, in $/ton	0.0141	0.0101	1.40
Distance, in miles	0.00411	0.00102	4.01
Rail constant	1.63	0.385	4.23
Barge constant	2.78	1.32	2.10
Number of observations	261		
Log-likelihood	-0.7383984		

Table 18 gives the estimated parameters of a fixed-coefficients logit estimated on the rp data combined with the responses to the sp-off-rp questions. Simulation was performed with 200 pseudo-random draws of the conditional extreme value terms, with different draws for each observation. As expected, the level of significance for the coefficients of rate, time, and reliability rise considerably. The scale parameter α is estimated to be 2.76, which implies that the standard deviation of the additional unobserved portion of utility that affects the responses to the sp-off-rp questions is a little more than a third as large as the standard deviation of unobserved utility in the rp choices. As discussed above, if there were no quixotic aspects to the responses to the sp-off-rp questions, such that shippers answered the same as in the rp setting with the changed attributes, then the standard deviation would be zero (α unbounded high.) The relatively small estimated standard deviation implies that respondents were apparently paying careful attention to the sp-off-rp questions and answering similarly to how they would behave in the rp setting.

[10] Calculated as: 0.000963 / 0.0880, times 24 hours per day.

Table 18: Fixed Coefficients Model on RP and SP-off-RP Data

Explanatory Variable	Estimated parameter	Standard error	T-statistic
Rate, in dollars per ton	-0.0923	0.0112	8.25
Time, in hours	-0.000468	0.000168	2.79
Reliability	0.0117	0.00181	6.48
Price at destination, in $/ton	0.00558	0.003395	1.64
Distance, in miles	0.00232	0.000320	7.25
Rail constant	1.25	0.201	6.24
Barge constant	1.57	0.486	3.24
Shut down constant	-1.86	0.509	3.69
Shut down standard deviation	1.49	0.191	7.79
Scale of sp error (α)	2.76	0.391	7.05
Number of observations	415		
Mean log-likelihood	-2.52267		

The values of time and reliability both drop when the responses to the sp-off-rp questions are utilized. In particular, the value of time drops from 26 to 12 cents per ton, and the value of reliability drops from 31 to 13 cents per ton. Stated equivalently, the importance of rates relative to time and reliability rises when the responses to the sp-off-rp questions are utilized. A value of time of 12 cents per ton is lower than found in previous analysis of shippers in the Upper Mississippi region (Train and Wilson, 2004). It is important to note, however, that time is defined differently in the current study than in the previous one. In particular, in the previous study of Upper Mississippi shippers, time was defined as time spent in transit only, while in the current study time is defined as the time required for all aspects of making the shipment including wait and scheduling time in addition to time actually in transit. Time is considerably larger under this more inclusive definition, such that the value of marginal changes in time can be expected to be smaller.

The average disutility of shutting down is estimated to be large in magnitude and highly significant. The standard deviation is also large, indicating considerable variation across shippers in how they view the option of shutting down. This inclusion of the option of shutting down constitutes important aspect of the current analysis that was not included in previous analyses. In particular, numerous shippers stated that they had no shipping alternatives, other than the one they used. For these shippers, their only alternative in the face of rising rates or time was to shut down. Even shippers who had shipping alternatives might choose to shut down in response to potential changes in rates, time, and reliability for their chosen shipment, rather than switch to their next-best shipping alternative. In fact, many shippers responded in this way to the hypothetical changes in rates, times, and reliability. The model explicitly accounts for these responses. As the estimates indicate, the shut-down option is considered onerous (as captured by the large negative coefficient), and the threshold for deciding to shut down varies considerably over shippers (as captured by the large standard deviation parameter.)

We next examine a random coefficients specification. The rate coefficient is specified to be truncated normal, with truncation at two standard deviations above and below the mean. A truncated normal is specified because the rate coefficient cannot logically be negative; also, in order to calculate values of time and reliability (which are the coefficients of these variables divided by the rate coefficient), the rate coefficient cannot be arbitrarily close to zero (otherwise, values close to zero produce unbounded large values of time and reliability due to division by a number close to zero.) The truncated normal prevents these occurances provided the mean is more than twice the standard deviation, as we find it to be. The reliability coefficient is specified to be distributed normally with censoring at zero.[11] That is, the coefficient of reliability is specified as the maximum of 0 and β_{rel}, where β_{rel} is normally distributed with mean and standard deviation that are estimated. This specification assures that the reliability coefficient is positive, as required, for all shippers. Also, by having a mass at zero, the specification allows for the possibility that some shippers do not care about reliability (at least within the ranges that are relevant.) The time coefficient is held fixed, primarily for pragmatic reasons. In particular, preliminary models that were estimated with a random coefficient for time obtained a very small and highly insignificant standard deviation for this coefficient. Also, as discussed by Ruud (1996), a choice model with all random coefficients is nearly unidentified empirically, especially with only one or a few observed choices per agent, since only ratios of coefficients are behaviorally meaningful. Holding at least one coefficient fixed assists with empirical identification. In our application, the time coefficient was insignificant and hence the most logical one to hold fixed. It is important to note, however, that a fixed coefficient for time does not imply that all shippers have the same value of time. Rather, variation in the rate coefficient creates variation in the value of time, since the value of time is the ratio of the time coefficient to the rate coefficient.

Table 19 gives the estimated parameters for the random coefficients model. Simulation was performed with 1000 draws of the random coefficients and extreme value terms. The estimated mean value of time is 13 cents per ton with a standard deviation of 6.8, and the estimated mean value of reliability is 14 cents with a standard deviation of 13. The mean values of time and reliability are essentially the same as those obtained with fixed coefficients, discussed above. Approximately than 9 percent of shippers are estimated not to care about reliability (i.e., the mass at zero is 0.091).

[11] See Train and Sonnier (2005) for a discussion and application of censored normals and other distributions with bounded support within mixed logit models.

Table 19: Random Coefficients Model on RP and SP-off-RP Data

Explanatory Variable	Estimated parameter	Standard error	T-statistic
Rate, in dollars per ton: mean	-0.119	0.0137	8.70
Rate, in dollars per ton: stdev	0.0473	0.0175	2.71
Time, in hours	0.000548	0.000312	1.76
Reliability: mean	0.0139	0.00232	5.99
Reliability: stdev	0.0104	0.00555	1.87
Price at destination, in $/ton	0.00621	0.00311	1.99
Distance, in miles	0.00303	0.000430	7.03
Rail constant	1.27	0.178	7.12
Barge constant	1.38	0.740	1.87
Shut down constant	-1.92	0.528	3.63
Shut down stdev	1.44	0.267	5.39
Scale of sp error (α)	2.76	0.423	6.53
Number of observations Mean log-likelihood	415 -2.51187		

3.4 Switching Rates and Elasticities for Each Alternative

The estimated model in Table 19 is used to forecast the impact of changes in rates, times, and reliability. We consider first the forecasted impact of rate increases. To forecast this impact, the rate for each of the shippers' last shipment was increased by a given percentage, and the estimated model was used to calculate the share of shippers who switch to another alternative. Table 20 gives the percent of shippers who are predicted to change alternatives when the rate for their chosen alternative is raised. Separate estimates are given for shippers who currently ship by barge, by rail, and by truck (where barge is considered to be any combination of modes that includes barge, rail is either rail alone or truck and rail, and truck is truck alone.) Consider, for example, the value of 5.67 that is given for a 10 percent rate increase for barge shippers. This number is interpreted as follows: if the rate for shippers' current mode and destination rose by 10 percent, and the rates for other modes and destinations remained the same, then the model predicts that 5.67 percent of the shippers who currently use barge would switch to another alternative (including perhaps shutting down.)

Table 20: Percent of shippers who are predicted to switch in response to rate increases

% Increase	Barge	Rail	Truck
10	5.67	8.62	2.4
20	11.39	16.71	4.79
30	16.73	23.94	7.13
40	21.7	30.36	9.4
50	26.36	36.08	11.6
60	30.82	41.23	13.72
70	35.1	45.87	15.76
80	39.17	50.06	17.72
90	43	53.84	19.6
100	46.58	57.24	21.42

As expected, larger increases in rates induce greater switching. For barge shippers, a 10 percent increase in rates induces 5.67 percent of shippers to switch to another alternative, while a 50 percent increase in rates induces 26.36 percent of the shippers to switch. Note, however, that some shippers do not switch even when rates are raised quite considerably. For example, over half of barge shippers would stay with their current mode and destination even if the rates for that alternative were doubled.

Switching rates are estimated to be greatest for rail shippers, and larger for barge shippers than for truck shippers. For example, a 10 percent increase in rates induces 8.62 percent of rail shippers to switch to another alternative, 5.67 percent of barge shippers to switch, and only 2.4 percent of truck shippers to switch.

Table 21 gives the arc elasticities that are implied by the switching rates given in Table 20. For example, consider the elasticity of 0.57 for barge shippers in response to a 10 percent increase in the rates. As shown in Table 20, the model predicts that 5.67 precent of barge shippers will switch to a different alternative if the rates for their current shipping option rose by 10 percent. Since there is a 5.67 percent reduction in response to a 10 percent increase in rates, the arc elasticity is 0.57 (=5.67/10 rounded to nearest decimal).

The elasticities decrease somewhat as rates increase. For example, the arc elasticity for a 50 percent increase in rates is lower than that for a 10 percent increase in rates. This relation does not imply, of course, that larger rate increases induce less switching than smaller rate increases. Rather, it implies that the number of shippers who switch in response to the rate increases rises less than proportionally with the size of the rate increase.

Table 21: Arc Elasticities with respect to Rates

% Increase	Barge	Rail	Truck
10	0.57	0.86	0.24
20	0.57	0.84	0.24
30	0.56	0.8	0.24
40	0.54	0.76	0.24
50	0.53	0.72	0.23
60	0.51	0.69	0.23
70	0.5	0.66	0.23
80	0.49	0.63	0.22
90	0.48	0.6	0.22
100	0.47	0.57	0.21

Tables 22 and 23 give switch rates and arc elasticities for increases in transit times. These switch rates and elasticities are lower than those for rates, which suggests that shippers are more responsive to changes in rates than changes in transit time. This comparative result has been found in previous analyses (Train and Wilson, 2005, 2004). However, the magnitude of the response to time are quite low in magnitude, lower than found in previous analysis for the Upper Mississippi. This small response to time is at least partly due to the definition of time that is utilized in the current study, as discussed above. Time includes all aspects of the shipment, such that marginal changes in this total time have less impact on shippers' behavior than would changes in transit time alone.

Table 22: Percent of shippers who are predicted to switch in response to Transit Time increases

% Increase	Barge	Rail	Truck
10	0.26	0.53	0.1
20	0.53	1.07	0.2
30	0.79	1.61	0.29
40	1.06	2.13	0.39
50	1.33	2.65	0.48
60	1.6	3.15	0.57
70	1.88	3.64	0.65
80	2.15	4.13	0.73
90	2.43	4.62	0.81
100	2.7	5.09	0.88

Table 23: Arc Elasticities with respect to Transit Times

% Increase	Barge	Rail	Truck
10	0.026	0.053	0.01
20	0.026	0.054	0.01
30	0.026	0.054	0.01
40	0.026	0.053	0.01
50	0.027	0.053	0.01
60	0.027	0.052	0.009
70	0.027	0.052	0.009
80	0.027	0.052	0.009
90	0.027	0.051	0.009
100	0.027	0.051	0.009

Tables 24 and 25 give switching rates and arc elasticities for decreases in the reliability of shipments, where reliability is represented as the chance that the shipment will arrive on time. The switch rates and elasticities are lower than those for rates but higher than those for transit time. This finding that reliability elasticities are larger than transit time elasticities suggests that shippers are more concerned that the shipment arrives when scheduled than in the amount of scheduled shipment time. Previous analyses have also obtained this result of reliability being more important than time (Train and Wilson, 2005).

Table 24: Percent of shippers who are predicted to switch in response to Reliability decreases

% Increase	Barge	Rail	Truck
10	2.11	2.94	4.66
20	4.32	5.99	9.22
30	6.51	9.02	13.42
40	8.63	11.96	17.2
50	10.65	14.77	20.57
60	12.57	17.45	23.59
70	14.41	19.99	26.31
80	16.19	22.42	28.8
90	17.92	24.72	31.12
100	19.63	26.92	33.3

Table 25: Arc Elasticities with respect to Reliability

% Increase	Barge	Rail	Truck
10	0.21	0.29	0.47
20	0.22	0.3	0.46
30	0.22	0.3	0.45
40	0.22	0.3	0.43
50	0.21	0.3	0.41
60	0.21	0.29	0.39
70	0.21	0.29	0.38
80	0.2	0.28	0.36
90	0.2	0.27	0.35
100	0.2	0.27	0.33

3.4 Summary and Conclusions for Mode and Desatination Choice.

The demand for transportation by mode and destination is an essential part of planning infrastructure. For planning infrastructure, there is a need not only for demand functions by mode, but also for a wide variety different shipment attributes such as rates and transit times. Often, revealed data do not provide significant variation in the attributes. This means that the demand functions are more difficult to estimate precisely and the range of attributes (rates) over which the estimation occurs does not coincide with the rate of attributes (rates) needed for planning. While stated preference methods overcome both difficulties, they are often criticized for presenting the decision-maker with hypothetical, and perhaps, irrelevant alternatives. In this study, we use a methodology that employs both types of data. Specifically, we "ground" the stated preference information in the revealed choice made by the shipper. The stated preference information is directly tied to the revealed choices made by the shipper, circumventing the irrelevance issue and, yet, providing sufficient variation in the attributes which allow for precise estimation of demand parameters and provides estimates over a wide range of attribute values necessary for planning.

In this report, the methods are applied to the shipment of agricultural commodities in the Upper Mississippi region. We framed the choice of which alternative to use in terms of rates, transit times and reliability of each option and calculated elasticities with respect to each attribute. We found that elasticities vary by mode (with rail largest and truck smallest), the attribute (with rates largest and time smallest) and the level of the rate change (with arc elasticities falling slightly as the size of the change rises.)

These findings are of direct relevance to the Army Planning Models, since they provide a direct connection between choice modeling and the elasticity of barge transportation. The results imply that barge shippers have low elastiticities with respect to rates and exceedingly low elasticities with respect to shipment time including waiting and scheduling time. The elasticities, while low, are nevertheless higher than those used in the Army Corps Modeling, which assumes a perfectly inelastic demand up to a threshold.

4. ANNUAL VOLUME ADJUSTMENTS TO CHANGES IN ATTRIBUTES

In this section, we develop and estimate a model of changes in annual volumes with respect to changes in rates, time in transit, and reliability. In the survey, each respondent is confronted with a percentage change in rates, time, and reliability. They were asked to state whether their annual volumes would change and, given they change, the level of the change.

We analyze the responses with a Heckman model that contains two equations. First, there is a model of whether or not the respondent changes their quantity; this is a discrete binary choice. Second is a model of the level of the change given a change occurs. This second model is a regression on the subset of respondents who stated that they would change their volumes. As pointed out by Heckman, the second model is a selected sample (namely, those shippers who make a change), and estimation by OLS may introduce bias due to a possible correlation between the errors of the model that selects the sample and that of the level of the change. Stated equivalently, the unobserved factors that induce change may also impact the level of the change. Whether this correlation is actually present can be tested, and if it is found to exist, the analysis can incorporate it appropriately.

An equation that determines whether a change is made, and an equation that determines the level if a change is made, must both be specified. Let z represent a set of variables that determine whether change occurs or not, and let x represent a set of variables that determine the level of the change. To illustrate, we begin with a simple model in which both z and x are functions only of the size of the attribute change. This serves as a "base" model to which more complicated models are assessed. The levels model are all based on a log specification of quantities after the attribute change relative to that before the attribute change i.e., $log(q_1/q_0) = log(1\text{-}\% \text{ change in } q)$. The righthand side consists of the $log(a_1/a_0)=log(1+\% \text{ change in attribute})$ where a_1 and a_0 represent the attribute after and before the change. In all cases, elasticities are calculated by predicting the % change in q from a % change in the attribute and are calculated as % change in q divided by a % change in the attribute. Whether a firm chooses to adjust its quantity may or not is the selection equation. With a two-step estimation procedure, this equation is a probit model. In our specifications, we let the log of the change in the attribute be one of the explanatory variables[12] and assess empirically whether to include other variables in each equation.

Rate Changes that apply to the shipper and its competitors

As noted in Section 2, two different rate prompts were given to the respondent. Both questions are of the form: if rates increased by a given percentage, would annual volumes change, and if so how much. The first question adds the caveat that the rate increase applies not only to the respondent but also its competitors. The second question differs in that the rate increase applies only to the respondent, but not its competitors. The motivating concept for this distinction is that, in agricultural markets, the shippers (elevators) compete locally for the procurement of grain to ship. Rate changes affect the bids that these elevators make to sellers of the commodities e.g., farmers. If all shippers are confronted with the same rate change, due, e.g., to congestion or improvements in the transportation infrastructure, then the response is expected to be different than if the rate change applies only to a single shipper. The latter is expected to induce a larger response to the rate change.

Table 26 contains the results for the case of a rate increase applying to the shipper and its competitors. This table contains results for the base model and for a limited set of more complicated models. In each column, there are two sets of results. These include the level equation (given a change, the size of the change) and the selection equation (does a change occur).

The base model (column (1)) contains a single explanatory variable, $\log(r_1 / r_0)$, which is the log of the rate after the increase and the rate before the increase, or, stated equivalently, the log of the percent increase in rates. A binary probit model of whether the shippers change their quantity (the column labeled "Selection") predicts that as the level of the rate change increases, the probability of a change in annual volumes increases. (The positive coefficient on the variable indicates that a larger rate increase is

[12] Rather than using $\log(r_1/r_0)$ as in the level equation, we used $\log(\% \triangle$ in the attribute) instead. This has the advantage of requiring that there is no change in levels if there is no change in the attribute. That is, if the attribute does not change, then the natural log has a limiting value of minus infinity which produces a zero value for the probability of a change.

associated with a higher probability of changing volumes.) The levels equation predicts that, given a change, a larger rate increase causes a greater reduction in volume. (The negative coefficient indicates that a larger rate increase is associated with a smaller volume, or equivalently, with a larger reduction in volume.)

Two types of elasticities are relevant with these models. First is a conditional elasticity i.e., the elasticity given a change occurs. Second is an unconditional elastiticy that accounts for the probability of making a change as well as the change in volume given that a change is made. The conditional elasticity is larger in magnitude than the unconditional elasticity, since the conditional elasticity is calculated only on those shippers who make a change while the unconditional elasticity is calculated for all shippers even though who do not make any change. In this simple model, the conditional elasticity ranges from -3.14 to -.69 (depending on the rate change level).[13] The unconditional elasticity ranges from -.56 to -.36 (depending on the rate change level).[14]

As noted above, our approach allows testing of whether or not unobserved factors are correlated across the two equations. In the present case, the hypothesis of no correlation cannot be rejected, suggesting that selection bias need not be present.[15]

The remaining columns of Table 26 include additional explanatory variables. Virtually all shippers have access to truck, some have access to rail, to barge, or to both. Dummy variables were introduced for both types of access, initially included in both the level the selection equation. There was no evidence from this preliminary specification that the access variables affect the level of annual volumes, and so they were excluded from the levels equation.[16] The results are reported in column (2).

The results suggest, as before, that if a larger rate increase occurs, then (i) a change in annual volumes is more likely and (ii) the amount of reduction in volume (given a change occurs) is greater. In addition, however, the results also suggest that a change is more likely for elevators with both rail and barge loading capabilities. As before, there is no evidence of correlation in unobserved factors across the two equations.

We next considered the impact, if any, of the storage capacity, the car-loading capacity, the distance to the nearest rail and barge loading facilities, primary commodity shipped, and the number of options held by a shipper. After preliminary estimation with various combinations of variables, we determined the specification in Column 3. None of the variables omitted from the levels equation is statistically significant in explaining levels, and the one variable omitted from the selection equation (namely, number of options) is

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[13] The estimates are -3.14, -1.48, -1.05, -.87, -.76, and -.69 for a rate change of 10, 20, 30, 40, 50, and 60, respectively.
[14] The estimates are -.56, -.42, -.38, -.37, -.36 and -.36 for a rate change of 10, 20, 30, 40, 50 and 60, respectively.
[15] This means that the levels equation can be estimated on the basis of an OLS regression using only the observations for which a change occurs.
[16] In the Heckman model where the sample selection and the level equation are posited with the same variables, identification occurs through the non-linearity of the inverse mills ratio. By excluding irrelevant variables, identification is much stronger.

not statistically significant in explaining whether a change in made. Distance to barge has an important effect on predicting whether change occurs, but only when distance to rail is excluded.[17]

The results in Column 3 suggest that the probability of a volume change is larger for shippers that have barge and rail access, a large rail-car loading capacity, and a large distance to a rail car facility. In addition, the results suggest that firms with greater storage capacity are less likely to switch.

As discussed earlier, the models provider both conditional (given a change occurs) and an unconditional (factoring in the probability of a change) elasticities. The estimated elasticities are presented in Table 27 for the parameter estimates given in column 3 and median values of the continuous variables and zero values for the binary variables (truck only access shippers). As expected, the conditional elasticities are larger in magnitude than the unconditional. Generally, the latter estimates are small, indicating relatively inelastic demands. A key factor in the difference is the probability of a change in annual volumes which is also provided in the table. As is clear, the probability of a volume change is small for small changes in rates, but rises progressively with the level of the rate change. Nevertheless, even with very large changes in rates, the probability of making a change in volume is only .35 for the median firm.

To assess the range of response over shippers, we calculate the probability of a volume change for each surveyed shipper, as well as their conditional and unconditional elastiticities. The average probability of changing volume is .36 with a minimum value of .04 and a maximum value of .88. Even, however, for the shipper with the largest probability of a volume change, the conditional and unconditional elasticity estimates are only -.74 and -.68, respectively. Shippers with a high (low) probability of a changing volumes are those with both rail and barge access (which by definition means distance to rail is zero), little storage capacity, and large car-loading capacity. If a firm does not have rail access, it is more likely to change volumes as distance from the nearest rail loading facility increases.

Rate Changes that apply to the shipper but not its competitors

The models described above were also applied to shippers responses to rate changes that apply to the shipper but not its competitors. The results are in Tables 28 and 29. The estimated coefficient of the rate change, and the resultant elasticities, are larger in magnitude than those discussed above. This result is consistent with the theoretical argument that changes should be more frequent and larger when rate changes apply only

[17] Inclusion of both rail and barge distances resulted in a loss of significance on barge distance. While often points to multicollinearity between the two, the correlation is small. Inspection suggests that a number of observations are lost due to missing values on distance to nearest waterway which may explain the inability to separately identify the effects.

to the responding shipper than when rate changes apply to both the responding shipper and its competitors.

Modal access is not found to be a statistically significant. However, storage capacity and rail car loading capacity do appear to have a statistically important effect.
As before and as required, the unconditional elasticities are larger in magnitude than the conditional elasticities. The unconditional elasticities range in value from -.66 for small rate changes to -.76 for other rate changes. The conditional elasticities range from -2.7 for small rate changes to -1.0 for larger rate changes.

Also as before, there is considerable heterogeneity in the predicted elasticities of different shippers. The average conditional elasticity is -1.6 and the unconditional is -.86. The conditional elasticity ranges from -.99 to -3.3, while the unconditional elasticity ranges from -.37 to -1.66. The probability of a volume change averages .51 with a range from .09 to .95. Shippers with large rail-car capacity and little storage capacity are more likely to react to rate changes than shippers with no rail access and a large storage capacity.

Transit Time Responses

The transit time models are presented in table 30 with elasticity and probabilities in table 31. As with all previous models, the prompting variable has a statistically important effect. And as before, it is positive in the selection equation and negative in the levels equation. Unlike the rate models, storage and rail car loading capacity are not statistically significant. However, shippers with greater access i.e., access to barge and rail are less like to adjust volumes in response to transit time changes.

The elasticity estimates for the median firm are presented in table 31 for the median firm. The conditional estimates range from -1.84 for a 10 percent increase in transit times to -.694 percent for a 60 percent change in transit times. The unconditional elasticity (which include zero change in volumes) are much lower and range from -.31 to -.35. This is due to a relatively low probability of the median shipper adjusting volumes due to a change in transit times. This probability is about .16 for a 10 percent change in transit times to .437 for a 60 percent change in transit times.

For the sample, the average conditional and unconditional elasticities are -1.06 and -.31, respectively. The range in the conditional elasticity is -2.6 to -.64, and the range in the unconditional probability is -.09 to -.49. The unconditional elasticities are associated with probabilities of adjustment that are, on average, .29 with a range of .03 to .61.

Reliability Responses

The final set of results reported is with respect to reliability. Each shipper was asked about their changes in annual volumes due to a given percentage *decrease* in reliability. Thus, a large value of the prompt (i.e., a large decrease in reliability) represents a worsening of the shippers' situation, the same as in the case of increases in rates and transit times. The coefficient estimates for the models are presented in table 32 with elasticities in table 33.   The basic result of the models is that, as expected, larger declines in reliability increase the likelihood that firms adjust their annual volumes. And, consistent with the other attributes, a greater reduction (less volume) is associated with a larger decrease in reliability.

Generally, the other variables do not significantly influence changes annual volumes with respect to changes in reliability. There is modest support in the second model for the hypothesis that shippers with rail access are more likely to adjust volumes than those without, but in model 3 the effect becomes insignificant.

As with the other attributes, the expected elasticities are smaller in magnitude than the conditional elasticities. In addition, as with the other attributes, the elasticities tend to decrease in magnitude with the size of the prompt for the median shipper. The conditional elasticity ranges from .56 to 2.4 for large and small decreases in reliability. The unconditional elasticity ranges from .23 to .62 for large and small decreases in reliability. Finally, the probability of a volume change ranges from .23 for small reliability decreases to .36 for large decreases.

Calculation of these same statistics over the sample gives a sense of the range of values. The conditional elasticity averages 1.10 with a range from .46 to 2.9. The unconditional or expected elasticity averages .33 with a range from .21 to .65. Finally, the probability of the shipper adjusting volumes averages .30 with a range of .16 to .50.

Table 26. Coefficient Estimates for Annual Volumes and Rate Changes (to respondent and competitor).

	(1)		(2)		(3)	
Variable	**Level**	**Selection**	**Level**	**Selection**	**Level**	**Selection**
Log(r1/r0)=log(1+△)	-1.380		-0.864		-0.901	
	(5.41)***		(2.71)***		(2.82)***	
Log(r1/r0-1)=log(△)		0.502		0.616		0.706
		(4.93)***		(4.89)***		(5.31)***
Access Barge				0.305		0.067
				(0.54)		(0.12)
Access Rail				0.162		0.077
				(1.14)		(0.25)
Access Barge and Rail				1.245		0.902
				(3.10)***		(1.70)*
Log(Storage Capacity)						-0.149
						(2.15)**
Log(Rail Car Loading Capacity)						0.211
						(2.50)**
Log(Distance to Rail)						0.169
						(2.11)**
Number of Options					0.064	
					(2.09)**	
Constant	0.579	0.131	-0.202	0.173	-0.306	1.290
	(6.16)***	(0.99)	(1.12)	(1.05)	(1.66)*	(1.80)*
Observations	404	404	404	404	370	370

Note: Absolute value of z statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 27. Elasticity Estimates for Annual Volumes in Response to a Rate Change for the median shipper.

Percentage Change in Rates	Conditional Elasticity	Unconditional Elasticity	Probability of a Volume Change
10	-1.407	-0.075	0.050
20	-1.116	-0.153	0.123
30	-0.954	-0.208	0.191
40	-0.845	-0.246	0.251
50	-0.764	-0.272	0.304
60	-0.700	-0.289	0.350

Table 28. Coefficient Estimates for Annual Volumes and Rate Changes (to respondent, but not competitors).

	(1)		(3)		(5)	
Variable	**Level**	**Selection**	**Level**	**Selection**	**Level**	**Selection**
Log(r1/r0)=log(1+△)	-1.995		-2.275		-1.760	
	(5.21)***		(6.31)***		(3.70)***	
Log(r1/r0-1)=log(△)		0.493		0.530		0.573
		(4.91)***		(5.55)***		(4.47)***
Access Barge				-0.031		1.026
				(0.15)		(1.52)
Access Rail				0.097		-0.134
				(1.50)		(0.45)
Access Barge and Rail				0.205		0.207
				(1.38)		(0.35)
Log(Storage Capacity)						-0.141
						(1.99)**
Log(Rail Car Loading Capacity)						0.191
						(2.36)**
Log(Distance to Rail)						-0.009
						(0.12)
Number of Options					-0.037	
					(0.92)	
Constant	0.493	0.604	0.564	0.607	-0.027	1.962
	(4.03)***	(4.04)***	(4.77)***	(4.27)***	(0.09)	(2.62)***
Observations	340	340	340	340	309	309

Note: Absolute value of z statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 29. Elasticity Estimates for Annual Volumes in Response to a Rate Change for the median shipper but not its competitors.

Percentage Change in Rates	Conditional Elasticity	Unconditional Elasticity	Probability of a Volume Change
10	-2.709	-0.657	0.215
20	-1.840	-0.737	0.347
30	-1.493	-0.761	0.436
40	-1.284	-0.759	0.502
50	-1.136	-0.742	0.553
60	-1.023	-0.719	0.594

Table 30. Coefficient Estimates for Annual Volumes and Transit Time Changes

	(1)		(3)		(5)	
Variable	**Level**	**Selection**	**Level**	**Selection**	**Level**	**Selection**
Log(t1/t0)=log(1+△)	-0.955		-0.937		-1.082	
	(2.41)**		(2.54)**		(2.31)**	
Log(t1/t0-1)=log(△)		0.483		0.494		0.479
		(4.20)***		(4.27)***		(3.96)***
Access Barge				-0.558		-0.480
				(0.88)		(0.75)
Access Rail				0.009		-0.378
				(0.06)		(1.28)
Access Barge and Rail				-0.443		-1.103
				(0.96)		(1.74)*
Log(Storage Capacity)						0.049
						(0.71)
Log(Rail Car Loading Capacity)						0.085
						(1.06)
Log(Distance to Rail)						-0.034
						(0.45)
Number of Options					0.016	
					(0.56)	
Constant	-0.161	0.007	-0.180	0.036	0.038	-0.376
	(0.50)	(0.05)	(0.63)	(0.21)	(0.09)	(0.53)
Observations	383	383	383	383	352	352

Note: Absolute value of z statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 31. Elasticity Estimates for Annual Volumes in Response to a Time in Transit Change.

Percentage Change in Rates	Conditional Elasticity	Unconditional Elasticity	Probability of a Volume Change
10	-1.841	-0.310	0.155
20	-1.179	-0.321	0.247
30	-0.960	-0.335	0.312
40	-0.839	-0.344	0.362
50	-0.756	-0.348	0.403
60	-0.694	-0.349	0.437

Table 32. Coefficient Estimates for Annual Volumes and Reliability

	(1)		(3)		(5)	
Variable	**Level**	**Selection**	**Level**	**Selection**	**Level**	**Selection**
Log(rel1/rel0)=log(1+△)	-0.526		-0.719		-0.644	
	(2.26)**		(3.58)***		(3.00)***	
Log(rel1/rel0-1)=log(△)		0.391		0.285		0.215
		(3.35)***		(2.68)***		(1.91)*
Access Barge				-0.119		-0.038
				(0.54)		(0.17)
Access Rail				0.135		-0.189
				(2.01)**		(1.18)
Access Barge and Rail				-0.000		-0.435
				(0.00)		(1.71)*
Log(Storage Capacity)						0.030
						(0.75)
Log(Rail Car Loading Capacity)						0.054
						(1.53)
Log(Distance to Rail)						-0.048
						(1.07)
Number of Options	-0.229	-0.063	0.310	-0.234	0.292	-0.493
	(1.14)	(0.42)	(4.28)***	(1.59)	(3.52)***	(1.15)
Constant					-0.004	
					(0.32)	
Observations	377	377	377	377	348	348

Note: Absolute value of z statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 33. Elasticity Estimates for Annual Volumes in Response to a Reliability Change.

Percentage Change in Rates	Conditional Elasticity	Unconditional Elasticity	Probability of a Volume Change
10	2.417	0.619	0.231
20	1.259	0.388	0.279
30	0.906	0.311	0.309
40	0.735	0.272	0.331
50	0.632	0.248	0.348
60	0.561	0.231	0.363

Note: The figures presented are in response to a decrease in reliability. Hence, the elasticities should be positively valued unlike the previous attributes.

5. CONCLUDING REMARKS

This report continues a series of demand studies aimed at providing shipper level information that can be used by the Army Corps of Engineers to evaluate the benefits of waterway improvements. The shipper based surveys that have been developed and modified over the last three and one-half years are designed to collect information on shipper and shipments. These data, in turn, are used to estimate the responsiveness of mode and destination choices and annual volumes to changes in rates, time in transit and reliability.

The choice models were estimated with a mixed logit methodology applied to both revealed and stated preference data. The results suggest that while demands are responsive to changes in rates, time in transit and reliability, the response is somewhat small and point to relatively inelastic demands i.e., demand elasticities less than one in magnitude. The annual volume models were estimated with a Heckman selection model using stated preference data. Generally, the results suggest that shippers respond to rates, time in transit and reliability, but as with the choice models, the response is somewhat small with most elasticities less than one in magnitude.

The demand functions appear to be reasonably steep and point to a large degree of captive shippers i.e., shippers that do not switch to alternatives even for large changes in the attributes. While this result points to relatively large benefits to infrastructure investments, there are limits. A novelty of this research is the incorporation of the option of no longer shipping i.e., shutting down. Indeed, about 33% of the shippers reported that if the mode/destination they chose was not available, they would need to shutdown (they have no alternatives). This finding has been a consistent theme throughout this line of research. In the present case, shutdown is explicitly represented in the choice model. Hence, attributes, and, in particular, rates, cannot increase without bound, since eventually shippers will opt out of the market. This reaction places limits on the benefit calculations necessary for the ACE planning models.

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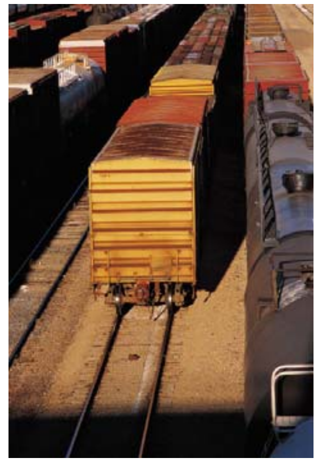
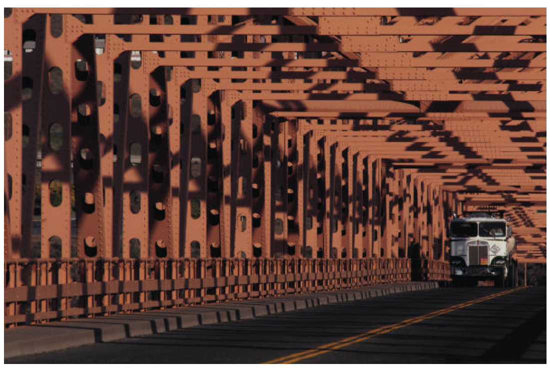
2006 Survey of Agricultural Shipping Needs in the Midwest





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Your responses to this survey will help us determine the need for transportation investments in your region. This information will be used by Federal and State Transportation agencies to evaluate and support public provision of transportation infrastructure improvements. The survey should take only about 15 minutes.

According to the Paperwork Reduction Act of 1995, an agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it has a valid Office of Management and Budget (OMB) control number. The valid OMB number for this information collection is OMB 0710-0001and the expiration date is November 2007. The time required to complete this information is estimated to average 15 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Your participation is voluntary and all responses will be kept confidential.

Shipment Information

Choice: Consider your last shipment from this elevator: ***«NAME»***
«ADDRESS1»
«CITY», «STATE» «ZIP»

Q1. What is the <u>primary</u> commodity you ship from this elevator? ___________ commodity

Q2. At this location, do you have loading capabilities for…

	Yes	No
a. Trucks	☐1	☐2
b. Rail Cars	☐1	☐2
c. Barges	☐1	☐2

Q2b. If YES to Rail loading capability, what is your rail car loading capacity?

______ # of cars

Q2c. If NO to Rail loading capability, how close is the nearest rail loading facility to this elevator?

_______ miles

Q2d. If NO to Barge loading capability, how close is the nearest barge loading facility to this elevator?

_______ miles

Your last Freight Shipment

Q3. What commodity was shipped in <u>your last shipment</u>? ___________ commodity

Q4. Where was this commodity shipped to: _________________________ city __________ state

Q4b. What type of destination is this?

☐1 River terminal ☐2 Another Elevator ☐3 Railroad terminal ☐4 Processing Plant
☐5 Other (please specify): _____________________

Q5. How large was this shipment (payload weight)?

______________________________ payload weight, in

☐1 Tons ☐2 Cwt. ☐3 Gallons ☐4 Bushels ☐5 Other (specify): _______________

Q6. What type of transportation was used for this shipment, approximately what distance did each travel (in miles), and what was the approximate transportation rate?

Mode (check if used)	Distance traveled	Transportation rate	Tons	Cwt	Gallons	Bushels	Shipment	Other	(Specify)
☐ Truck	______ miles	______ rate	☐1	☐2	☐3	☐4	☐5	☐6	______
☐ Rail	______ miles	______ rate	☐1	☐2	☐3	☐4	☐5	☐6	______
☐ Barge	______ miles	______ rate	☐1	☐2	☐3	☐4	☐5	☐6	______
What were the *total* transport costs? ______			☐1	☐2	☐3	☐4	☐5	☐6	______

(Per Unit type for commodity)

What was the *total* shipment distance in miles? ______

Q7. What do you estimate was the shipment time (include scheduling time, wait for equipment and transit time)

______ days + ______ hours.

Q8. How reliable is the service? That is, for shipments like this one, what percent of the time do you expect them to arrive on time?

______ percent on-time arrivals

Q9. What price did you receive for your commodity at the destination terminal?

______ dollars per

☐1 Tons ☐2 Cwt. ☐3 Gallons ☐4 Bushels ☐5 Shipment ☐6 Other (specify): ______

SHIPPING ALTERNATIVES

We want to know what options you could take if the mode and destination you used for your last shipment had not been available and would never be available. For example, if the rail system were shut down, shippers who used rail could use truck instead of rail, or could use barge with truck access to a barge loading facility, or could have sent the shipment to a different destination. We need to know what these alternatives are for you. Nearly everyone has some kind of shipping alternatives. If not, then the only alternative is to shut down and go out of business. Please provide us with information on these alternatives for you.

Q10. If the mode and destination you used for my last shipment had not been available and would never be available, then you would …

☐1 Shut down and go out of business → **skip to Q25**
☐2 Continue your operations but in a different, perhaps more costly way

FIRST SHIPPING ALTERNATIVE

Q11. Where would this commodity be shipped to? ________________ city _______ state

Q11b. What type of destination is this?

☐1 River terminal ☐2 Another Elevator ☐3 Railroad terminal ☐4 Processing Plant
☐5 Other (please specify): ______________________

Q12. What transportation would be used for this shipment, approximately what distance would each travel (in miles) and what would be the transportation rate?

Mode (check if used)		Distance traveled		Transportation rate		Per Unit type for commodity: Tons	Cwt	Gallons	Bushels	Shipment	Other (Specify)	
☐	Truck	_________	miles	_________	rate	☐1	☐2	☐3	☐4	☐5	☐6	_______
☐	Rail	_________	miles	_________	rate	☐1	☐2	☐3	☐4	☐5	☐6	_______
☐	Barge	_________	miles	_________	rate	☐1	☐2	☐3	☐4	☐5	☐6	_______

What would be the *total* transport costs? ________ ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 _______

What would be the approximate *total* shipment distance in miles? ___________

Q13. What do you estimate would be the shipment time (include scheduling time, wait for equipment and transit time)

_________ days + _________ hours.

Q14. How reliable is the service? That is, for shipments like this one, what percent of the time would you expect them to arrive on time?

__________ percent on-time arrivals

Q15. How large would your shipment be (payload weight)?

____________________________ payload weight, in

☐1 Tons ☐2 Cwt. ☐3 Gallons ☐4 Bushels ☐5 Other (specify): __________________

Q16. What price would you receive for your commodity at the destination terminal?

__________ dollars per

☐1 Tons ☐2 Cwt. ☐3 Gallons ☐4 Bushels ☐5 Shipment ☐6 Other (specify): __________________

OTHER SHIPPING ALTERNATIVES

Please complete the table below for your other shipping alternatives. <u>If you have no other alternatives, skip to Q24</u>

	Second Alternative	Third Alternative
Q17. Where would it be shipped to?	______________ city _______ state	______________ city _______ state
Q18. What type of destination is this?	☐$_1$ River terminal ☐$_2$ Another Elevator ☐$_3$ Rail terminal ☐$_4$ Processing Plant ☐$_5$ Other (specify): ________________	☐$_1$ River terminal ☐$_2$ Another Elevator ☐$_3$ Rail terminal ☐$_4$ Processing Plant ☐$_5$ Other (specify): ________________
Q19. What type of transportation modes would be used for this shipment?	Mode (Check if used) ▼ / Distance traveled ▼ / Transportation rate ▼ ☐ Truck _____miles ____rate ☐ Rail _____miles ____rate ☐ Barge _____miles ____rate ☐$_1$ Tons ☐$_2$ Cwt. ☐$_3$ Gallons ☐$_4$ Bushels ☐$_5$ Shipment ☐$_6$ Other (specify):	Mode (Check if used) ▼ / Distance traveled ▼ / Transportation rate ▼ ☐ Truck _____miles ____rate ☐ Rail _____miles ____rate ☐ Barge _____miles ____rate ☐$_1$ Tons ☐$_2$ Cwt. ☐$_3$ Gallons ☐$_4$ Bushels ☐$_5$ Shipment ☐$_6$ Other (specify):
Q20. What do you estimate would be the shipment time?	_____ days + _____ hours	_____ days + _____ hours
Q21. How reliable is the service?	_____% on-time arrivals	_____% on-time arrivals
Q22. How large would the shipment be?	__________ payload weight ☐$_1$ Tons ☐$_2$ Cwt. ☐$_3$ Gallons ☐$_4$ Bushels ☐$_5$ Other (specify):	__________ payload weight ☐$_1$ Tons ☐$_2$ Cwt. ☐$_3$ Gallons ☐$_4$ Bushels ☐$_5$ Other (specify):
Q23. What estimated price would you receive for your commodity at the destination terminal	__________ dollars ☐$_1$ Tons ☐$_2$ Cwt. ☐$_3$ Gallons ☐$_4$ Bushels ☐$_5$ Shipment ☐$_6$ Other (specify):	__________ dollars ☐$_1$ Tons ☐$_2$ Cwt. ☐$_3$ Gallons ☐$_4$ Bushels ☐$_5$ Shipment ☐$_6$ Other (specify):

BEST ALTERNATIVE CHOICE

Q24. Of the alternative shipments, if any, what is your "preferred alternative"? That is, if you could not make the shipment you made what shipment would you have made?

☐$_1$ First Alternative
☐$_2$ Second Alternative
☐$_3$ Third Alternative
☐$_4$ Other Alternative (please specify): ____________________

TRANSPORTATION RATES

In each of the next three questions relating to rate and service changes, please regard the changes as **permanent** changes. Also, **if you marked you have no alternatives in Q10, page 3, please consider "out-of-business" as your alternative.**

Q25. For your last shipment, if the transportation rate increased «Percent_change1»%, would you continue with the original mode and destination or switch to your best alternative choice?

- ☐1 Continue to use Original mode
- ☐2 Switch to Best Alternative Choice → **Skip to Q26**
- ☐3 Go out-of-business → **Skip to Q26**

Q25b. If you would continue to use your Original mode, what percentage increase in the transportation rate would be necessary to cause you to switch to the Alternative transportation mode?

______ % increase

TRANSIT TIME

Q26. For your last shipment, if the transit time (including scheduling and wait for equipment) for the original option increased «Percent_change2»%, would you continue with the original mode and destination or switch to the alternative at this location?

- ☐1 Continue to use Original mode
- ☐2 Switch to Best Alternative Choice → **Skip to Q27**
- ☐3 Go out-of-business → **Skip to Q27**

Q26b. If you would continue to use your Original mode, what percentage increase in the transit time would be necessary to cause you to switch to the Alternative transportation mode?

______ % increase

RELIABILITY

Q27. For your last shipment, if the reliability (percentage of time shipments arrived on-time) of the original option decreased «Percent_change3»%, would you continue with the original mode and destination or switch to the alternative at this location?

- ☐1 Continue to use Original mode
- ☐2 Switch to Best Alternative Choice → **Skip to Q28**
- ☐3 Go out-of-business → **Skip to Q28**

Q27b. If continue to use Original mode, what percentage decrease in the reliability would be necessary to cause you to switch to the Alternative transportation mode?

______ % increase

VOLUME

Q28. If the average transportation rate you pay increased by «Percent_change4»%, would your annual volume shipped decrease (assume the rate increase applies to *BOTH* you and to your competitors)**?**

- ☐1 Yes
- ☐2 No → **Skip to Q29**

Q28b. If yes, by how much would the volume decrease (assuming the rate increase applies to both you and to your competitors)**?**

__________ volume decrease

Q29. If the average transportation rate you pay increased by «Percent_change5»%, would your annual volume decrease (assume that the rate increase applies *ONLY* to your firm and *NOT* to your competitors)**?**

☐1 Yes
☐2 No → **Skip to Q30**

Q29b. If yes, by how much would the volume decrease (assuming that the rate increase applies ONLY to your firm and NOT to your competitors)**?**

__________ volume decrease

Q30. If the average time in transit increased by «Percent_change6»%, would your annual volume decrease?

☐1 Yes
☐2 No → **skip to Q31**

Q30b. If yes, by how much would the volume decrease?

__________ volume decrease

Q31. If the average time that shipments arrive on-time decreased by «Percent_change7»%, would your annual volume decrease?

☐1 Yes
☐2 No → **skip to Q32**

Q31b. If yes, by how much would the volume decrease?

__________ volume decrease

SHIPPER CHARACTERISTICS

Q32. How long has this elevator been at its current location?

_____ years

Q33. How large is your elevator?

__________________ **Total Amount of Annual Units Shipped**

please check the type of unit for this elevator
☐1 Tons ☐2 Cwt. ☐3 Gallons ☐4 Bushels ☐5 Other (specify): ________________

________________ **Total Amount of Storage Capacity**

☐1 Tons ☐2 Cwt. ☐3 Gallons ☐4 Bushels ☐5 Other (specify): ________________

Q34. Does your firm (or parent firm) own export or import facilities?

☐1 Yes
☐2 No

Q35. How many facilities such as this one does your firm own and/or operate?

_______________ number of elevators.

Q36. Finally, if we have any questions and wish to follow up, may we contact you?

☐1 Yes
☐2 No → **Skip to Q37**

Q36b. Name: ______________________ Telephone: ______________________

Email: ______________________

Q37. Would you like a copy of the survey results?

☐1 Yes
☐2 No → **Skip to Q38**

Q37b. Yes, please email the website for the report. Email: ______________________
Yes, please send a hard copy to:

Name: ______________________

Address: ______________________

City, State Zip: ______________________

Q38. Thank you for your help with this study. We would welcome any additional comments you would like to provide about shipping.

Please return your completed questionnaire to:

Social & Economic Sciences Research Center
Washington State University
PO Box 644014
Pullman, WA 99164-4014

«ID» - 1