The Navigation Economic Technologies Program

November 1, 2004

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SHIPPERS' RESPONSES TO CHANGES IN TRANSPORTATION RATES AND TIMES

The Mid-American Grain Study

US Army Corps of Engineers®

IWR Report 04-NETS-R-02

Navigation Economic Technologies

The purpose of the Navigation Economic Technologies (NETS) research program is to develop a standardized and defensible suite of economic tools for navigation improvement evaluation. NETS addresses specific navigation economic evaluation and modeling issues that have been raised inside and outside the Corps and is responsive to our commitment to develop and use peer-reviewed tools, techniques and procedures as expressed in the Civil Works strategic plan. The new tools and techniques developed by the NETS research program are to be based on 1) reviews of economic theory, 2) current practices across the Corps (and elsewhere), 3) data needs and availability, and 4) peer recommendations.

The NETS research program has two focus points: expansion of the body of knowledge about the economics underlying uses of the waterways; and creation of a toolbox of practical planning models, methods and techniques that can be applied to a variety of situations.

Expanding the Body of Knowledge

NETS will strive to expand the available body of knowledge about core concepts underlying navigation economic models through the development of scientific papers and reports. For example, NETS will explore how the economic benefits of building new navigation projects are affected by market conditions and/or changes in shipper behaviors, particularly decisions to switch to non-water modes of transportation. The results of such studies will help Corps planners determine whether their economic models are based on realistic premises.

Creating a Planning Toolbox

The NETS research program will develop a series of practical tools and techniques that can be used by Corps navigation planners. The centerpiece of these efforts will be a suite of simulation models. The suite will include models for forecasting international and domestic traffic flows and how they may change with project improvements. It will also include a regional traffic routing model that identifies the annual quantities from each origin and the routes used to satisfy the forecasted demand at each destination. Finally, the suite will include a microscopic event model that generates and routes individual shipments through a system from commodity origin to destination to evaluate non-structural and reliability based measures.

This suite of economic models will enable Corps planners across the country to develop consistent, accurate, useful and comparable analyses regarding the likely impact of changes to navigation infrastructure or systems.

NETS research has been accomplished by a team of academicians, contractors and Corps employees in consultation with other Federal agencies, including the US DOT and USDA; and the Corps Planning Centers of Expertise for Inland and Deep Draft Navigation.

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The Mid-American Grain Study

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Shippers' Responses

to

Changes in Transportation Rates and Times:

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by

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Report prepared for the

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U.S. Army Corps of Engineers

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"Price responsivenss is so important to estimating the benefits of waterway improvements that informed judgments about the merit of waterway improvements cannot be made without careful study of these demand and supply elasticities." (p. 9)

National Research Council (2004)

I. Executive Summary and Introduction

The nature of transportation demand is a cornerstone of the Army Corps of Engineers (ACE) planning models. ACE uses a variety of models to assess the benefits and costs of navigation projects. Such models include the Tow Cost Model (TCM), the Essence Model (EM), the Ohio River Navigation Investment Model (ORNIM), etc. In each of these models, particular demand and supply structures along with both intra-modal and inter-modal assumptions of rivalry are used to generate equilibrium values with and without waterway improvements, which lead to the calculation of levels of benefits.

Recent experience with the Upper Mississippi and Illinois Waterway projects points to the need to carefully assess the assumptions that are made in the models. The estimates of benefits from improving the waterway vary considerably with the particular assumptions that are made about demand. These assumptions relate to the responsiveness of shippers to changes in transportation costs and time.

In the summer of 2003, ACE engaged the authors of this report to design and implement a survey of shippers. The purpose of the survey was to examine shipper demand and the response of demand to changes in transportation rates and times. A total of 369 shippers were interviewed between December 2003 and February 2004, using a survey instrument that was developed specially for this project. The surveyed shippers are grain elevators sampled from a list of elevators obtained from the USDA and supplemented by trade association lists. A stratified sampling procedure was implemented to assure that a proportionate share of surveyed shippers were located near the waterway system.

This report describes the results from the survey. The survey instrument was designed to obtain data on the three major components of transportation demand, namely:

- which mode or modes are used for each shipment and the origin/destination (O/D) of the shipment (which are usually determined together)
- the total volume of shipments that are generated annually
- the location of the shippers' facilities

Information was obtained on the shippers' current practices and operations (called "revealed preference data"). Data were also obtained on how the shippers report they would change their operations in response to changes in transportation rates and times ("stated preference data.") Econometric models of shippers' decisions were estimated on the combined data. These models are directly useable within ACE's models, TCM, EM, and ORNIM, for forecasting and benefit estimation for waterway projects. Independent of the ACE's suite of models, the analysis provides information that facilitates the understanding and measurement shippers' responses to time and cost.

The "top-level" findings of the report can be summarized as follows:

- Both rates and transit times affect shippers' demand. Transit time is important in itself independent of its impact on transportation rates. This finding reflects the fact that the full cost of transportation includes time-related factors, such as inventory costs, in addition to the rates that are charged.
- The elasticity of the mode and O/D component of demand with respect to rates ranges from .62 to 1.38, depending on the level of rate change.
- The elasticity of the mode and O/D component of demand with respect to time ranges from .45 to .8, depending on the level of the time change.
- A large share of shippers is essentially insensitive to changes in transportation rates and time. If rates double for shippers' current mode and O/D, 38 percent of shippers will not switch to another mode or O/D. The analogous figure for a doubling of transportation times is 55% percent.
- Annual volumes (for all modes and O/D's) change in response to transportation rates and transit times. The arc elasticities for the annual volume component of demand range from .23 to .41 depending on the level of the rate and time changes. This

volume response is considerably lower than the response of the mode and O/D component of demand.

- The location of existing facilities is fairly insensitive to changes in transportation rates and times. However, the choice of where to locate new facilities is highly sensitive to transportation rates. The short run elasticity of the location component of demand is very low, while the long run elasticity is large.
- The estimated models can be implemented within the ACE planning models to improve the measurement of the benefits of waterway improvements.

More detailed conclusions are the following:

- A large share of shippers do not have viable alternatives available to them. 26% of the surveyed shippers reported that they would have to shut down if the mode and O/D that they currently use were not viable.
- Of the shippers who have alternatives available to them, a considerable number would switch to their next-best alternative if the rates for their current mode and O/D choices rose. A ten percent increase in transportation rates for the mode and O/D of a shipment is predicted to induce 14% of shippers to switch to the next-best alternative.
- As implied by the previous point, the arc elasticity of mode and OD choice with respect to transportation rates is 1.4 for a 10% increase in rates.
- Though some shippers are very response to rates, other shippers would continue using their current mode and O/D choices in the face of large rate increases. A doubling of rates for their current mode and O/D is predicted to induce 62% of shippers to switch to their next-best alternative. The remaining 38% would not switch even when their rates doubled.
- As implied by the previous point, the arc elasticity of mode and O/D choice with respect to rates is 0.6 for a 100% increase in rates.
- The arc elasticity decreases as the magnitude of the rate increase rises, from 1.4 for a 10% cost increase to 0.6 for a 100% cost increase. This difference reflects the fact that small rate increases induce the shippers who are readily able to

switch to do so, leaving only the shippers who are captive or nearly so to respond, as possible, to larger rate increases.

- Shippers respond to transit times in addition to rates in their choice of mode and O/D. That is, transit time has an impact in itself, independent of the fact that longer times usually translate into higher transportation rates.
- While transit time matters, it matters less than rates. Stated precisely, shippers respond less to a percent increase in transit time than they do to the same percent increase in transit rates.
- The arc elasticity of mode and O/D choice with respect to a 10% change in transit times is 0.8. This elasticity is considerably smaller than the equivalent rate elasticity, which, as given above, is 1.4.
- As with the rate elasticity, the arc elasticity of mode and O/D choice with respect to transit time decreases as the percent increase in times rises. The arc elasticity for a doubling of transit times is 0.4, which is lower than the elasticity of 0.8 for a 10% rise in times.
- Shippers' annual volume of shipments responds to changes in transit rates and times.
- In response to rate and time changes, shippers change their volumes considerably less than they change their modes and O/Ds.
- The arc elasticity of annual shipment volume with respect to transportation rates is 0.3 for a 10% increase in rates. This elasticity is statistically different from zero, which means that there is indeed a volume response to transportation charges. However, as expected and as stated in the previous point, the elasticity of volume is considerably lower than the analogous elasticity of mode and O/D choice.
- For existing facilities, the location of the facilities is fairly insensitive to changes transportation costs (where costs include all logistics and transportation costs). Over 60% of surveyed shippers would not switch to another location no matter how low transportation costs were at a different location.
- When choosing a location for a new facility, shippers' choices are highly sensitive to transportation costs. 76% of the surveyed shippers would choose a location that

had lower transportation costs but higher investment costs over a location with higher transportation costs and lower investment costs (within the range of costs considered.)

- The previous two points imply that facility location is fairly insensitive to transportation costs and times in the short run, but that in the long run, when new facilities are built, the location choice is highly sensitive to transportation costs.

The report is organized around the three components of demand that it addresses. In particular:

- Section II describes the sample of surveyed shippers.
- Section III gives results for shippers' choice of **mode and O/D** for their shipments.
- Section IV gives results for shippers' annual **volume** of shipments.
- Section V gives results for shippers' choice of **facility location**.

II. Survey design

The Center for Business and Economic Research (CBER) at Marshall University implemented the survey between December 1, 2003 and February 25, 2004. The sample was drawn from a list of elevators that was provided by the United States Department of Agriculture (USDA) and supplemented by CBER with contact information from trade associations. The USDA list contains 6467 elevators throughout the United States.[1] The sampling procedure was designed to provide a representative sample without re-weighting while assuring that a proportionate share of sampled shippers are relatively close to the waterway system. In particular, two stata were defined on the basis of whether or not the elevator was located within ninety miles of the Midwestern inland navigation system, and the same sampling proportion was applied in each stratum. A total of 369 completed surveys were obtained, with the sample shares in each statum being within 5 percent of the population shares.

Table 1 gives the percent of elevators in each state, for the USDA list and the survey sample. The main differences are that the survey contains a larger share than the USDA list in Illinois, a smaller share in Kansas, and a smaller share in the other, non-enumerated states.

The USDA file contains information on the shipment options at each elevator.[2] We assumed that all elevators have the ability to load and unload trucks. The USDA data identify whether the elevator can ship by barge and/or rail directly from their facility. The percent of elevators that have each shipment option at their facility are given in Table 2, for the USDA list and the sample. Almost one-half of the USDA-listed elevators have only truck as a shipment alternative at the facility. These elevators can use rail or barge only by trucking to the rail/barge loading facilities. The sample contains a smaller share

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[1] The list of elevators provided by USDA represents elevators that operate under a Uniform Grain and Rice Storage Agreement. Information of the program and detailed information on the elevators is in the website http://www.fsa.usda.gov/approved_whses/ugrsa/approved_ugrsa_whses.asp.

[2] The raw data file includes truck, barge, and railroad names in a single script. These were separated into options to the shipper.

of elevators that have only truck available than is contained in the USDA list, and a larger share of elevators with rail and/or barge available.

Table 1.—Elevator Locations (percents)

State	USDA list	Survey sample
AR	2.04	1.90
IA	12.98	7.32
IL	13.44	33.88
IN	3.43	3.52
KS	10.89	4.61
MN	6.88	7.86
MO	3.84	7.05
ND	4.94	3.52
NE	7.58	7.86
OH	4.08	3.52
OK	3.76	3.25
SD	3.09	2.71
WI	2.52	3.25
Other	20.53	9.64

Table 2.—Elevators with each shipping option at their facility (percents)

Options	USDA list	Survey sample
Truck only	48.28	41.50
Truck & Barge	1.31	3.46
Truck & Rail	49.12	48.70
Truck & Rail & Barge	1.29	5.96

The survey instrument was designed in the fall of 2003. Industry analysts were asked to review the original design, and the survey was revised on the basis of the comments received. The revised survey was pre-tested on a small number of shippers to determine whether the questions were worded clearly and whether the respondents felt comfortable and willing to answer the questions. Some of the questions were revised in response to ambiguities that were identified in the pre-tests. The final survey instrument is shown in the appendix.

The questionnaire was designed to examine the impact of changes in shipment rates and times on the choices made by shippers. The decisions that the survey investigates relate to the modes that are used for shipments, the originating and terminating points, the volume of shipments, and the location of the shippers' facility. Information was solicited in the survey that would allow us to estimate models of these decisions by shippers. Data were obtained on both the shippers' current practices (i.e., "revealed preference data") and on how these practices would change if transit rates and times changed (i.e., "stated preference data.")

Shippers were asked about their annual volumes, revenues, modes used, and other relevant factors about their shipping practices and operations as whole. The shippers were also asked specific information about one shipment; in order to avoid bias in respondents' choice of which shipment to describe, we asked the shipper to provide information about the last shipment that they made. The commodity, origin, destination, size, modes used, rate on each mode, and transit time for the last shipment were determined.

Tables 3-5 provide summary statistics regarding the commodity, origin, and destination of these shipments. Most of the shipments were corn (219), with soybeans (26), and wheat (54) and a host of other commodities (70) accounting for the rest. The shipments take place from origins throughout in the Midwest (Table 4) and terminate in a wide array of different states (Table 5).[3]

[3] We note that the location of the firm or facility interviewed was not necessarily the same as the origin of the shipment.

Table 3.--Commodity Shipped.

	Frequency	%
Agricultural		
Corn	219	59.35
Soybeans	26	7.05
Wheat	54	14.63
Other	70	19.97
Total	369	100.00

Table 4.—Shipment Origins

State	Frequency	%
IA	29	7.86
IL	125	33.88
IN	13	3.52
KS	17	4.61
MN	28	7.59
MO	26	7.05
ND	13	3.52
NE	27	7.32
SD	10	2.71
WI	12	3.25
OTHER	69	18.70
Total	369	100.00

Table 5.—Shipment Destinations

State	Frequency	%
IA	25	6.78
IL	81	21.95
KS	15	4.07
LA	22	5.96
MN	27	7.32
MO	27	7.32
NE	15	4.07
OH	11	2.98
OK	10	2.71
TX	15	4.07
WI	13	3.52
Other	108	29.27
Total	369	100.00

Table 6 provides statistics on the rates, speed, distance, and size of the sampled shipments, by mode.[4] The differences across modes are generally as expected. Barge movements typically cost the least per ton-mile but take the longest to travel. Rail shipments cost more than barge but less than truck. Rail shipments are also faster than barge but slower than truck. Finally, as is well recognized, barge shipments are longer than rail, but both are quite long (over 750 miles on average). Truck shipments, in contrast, are more expensive, faster, and of shorter lengths. Shipment sizes are much larger for rail and barge than for truck.

[4] All rates were converted to a per-ton basis and all times-in-transit to an hourly basis for this table and for our econometric analysis in the following sections.

Table 6.--Rate, Speed, Distance, and Size of Sampled Shipments by Mode

Choice	Rate per ton-mile (cents)	Miles per hour	Miles	Shipment Size (tons)	Number of Respondents
Barge	1.19	4.26	863	1740	24
Rail	3.16	8.64	775	2752	92
Truck	12.90	34.78	123	25.2	244
Multi-mode	18.48	28.92	644	27.3	9

Note: Rates, miles per hour, and miles are averages. Shipment sizes are medians.

Of considerable importance to modeling transportation is the identification of shippers' alternatives. The survey instrument was designed to obtain information on the "next-best" alternative that was available to the shipper for its last shipment. After the shipper described its last shipment, the shipper was asked what it would have done if the choice it made for its last shipment were not available. For example, if the last shipment was by barge, the shipper was asked what it would have done if sending the shipment by barge were not an option. The responses are summarized in Table 7. The majority of shippers said that they would use a different mode, without changing origin or destination. About 16% said that they would choose a different origin or destination. More than a quarter of the shippers said that they have no alternatives and would have to shut down. These statistics are consistent with the general observation that switching is more by mode than location, and that many shippers are essentially insentive to rate and time changes, with no viable alternatives.

Table 7.—Alternative Choices

Alternative	Frequency	Percent
Origin Locations (mode switch)	211	57.7
Different Locations	57	15.6
Shutdown	98	26.8
Total	366	100.00

Note: Three respondents did not respond or provided incomplete or inconsistent information.

For the shippers who had an alternative (that is, did not say that they would have to shut down), detailed information was obtained regarding the rates, travel time, modes, origin, destination, and size of the shipment for this alternative. The shipper was also asked a series of questions to determine whether the shipper would switch to the alternative under specified increases in the rates and time. These questions and the responses are described and analyzed in section III below.

Shippers were asked questions regarding whether, and if so the extent to which, their annual volume of shipments would change in response to changes transportation rates and times. These questions are described an analyzed in section IV. Finally, shippers were asked about their location decisions and the importance of transportation times and costs in these decisions, as discussed in section V.

III. Shippers' Choice of Mode and Origin/Destination

1. Motivation

The Army Corps of Engineers (ACE) has developed several models to estimate the impact of changes in the locking system on shipment volume and shippers' benefits and costs. The predictions from these models depend critically on the models' representation of how shippers make decisions regarding mode and O/D. This component of the ACE's models has come under intense scrutiny. For example, a criticism of the models that have been used is that the models do not allow sufficient response by shippers to changes in costs and time. Other models have been proposed that lead to different benefits and costs, depending on the degree of shipper responsiveness. The National Research Council (NRC) review of the ACE's models identified this issue as being critically important and deserving of more study.

The shipper survey was designed to collect information regarding shippers' mode and O/D and the responsiveness of these choices to rates and time. This goal conforms with, and is in response to, NRC's recommendations for further study and modeling of this component of demand. The information that is obtained in the survey can be used to inform and improve, to the extent indicated, the ACE's models of shipper behavior.

The following sections describe the data, estimation procedure, and results. In particular, the relevant aspects of the survey are described in section III.2. The statistical procedure that is used to analyze the data is described in section III.3, with estimation results given in sections III.4 and 5. Section III.6 describes how the estimation results can be implemented in the ACE's suite of models and compares the assumptions about shipper demand that are currently used in the ACE's models with the demand curves obtained from the survey data.

2. Survey questions

The ACE's models compare the cost of each shipment with the cost of using an alternative mode for the same shipment. For a river shipment, the cost of shipping on the river and the cost of shipping overland are calculated. For estimating the impact of changes in river costs, the shipment is predicted to stay on the river or switch to the overland mode, depending on which cost is lower. If the cost of shipping by river rises sufficiently to exceed the cost of shipping overland, the shipper is assumed to switch to the overland mode. If river costs rise less than this amount, then the shipment is assumed to stay on the river.

This procedure reflects the fact that a shipper has alternatives available. Even though the shipper is observed to use a given mode and O/D, another mode and O/D could have been chosen. Importantly, the alternative mode or O/D might have been chosen if costs and times had differed.[5]

A series of questions in the survey were designed to obtain information on the conditions that would induce a shipper to switch from their chosen mode and O/D to their next-best alternative. Each shipper was asked to describe its last shipment. The origin, destination, mode, shipment size, rate and time for this last shipment were determined. The shipper was then asked to suppose that the shipment could not be made by the mode and O/D that the shipper had actually used. The shipper was asked to describe what would have been done instead under these circumstances. The origin, destination, mode, shipment size, rate and time for this "next-best alternative" where ascertained from the shipper.

The answers to these questions provide information on the shipper's chosen alternative (the shipment that was actually made) and the next-best alternative (the shipment that would have been made if the chosen mode and O/D were not possible.) We then asked questions to investigate conditions that might induce the shipper to switch from the

[5] "Mode" is used in its singular form even though a shipment might entail several modes (such as trucking to rail) under the concept that each possible combination of modes is considered a different mode.

chosen alternative to the next-best alternative. First, a hypothetical rate increase was randomly selected from the numbers 10%, 20%, and so on up to 60%. For the sake of this explanation, suppose that 40% is selected. The shipper was then asked, "If the rate for your original choice was 40% higher than what you paid, would you make the original choice or the alternative?" The shipper's response was recorded. The same type of question was then asked for a randomly selected increase in transit time. This information provided the data to estimate models of shippers' choice between the chosen and next-best alternative and the importance of rates and time in this choice. The specification of these models is described in the next section.

3. Specification of statistical model of shippers' choice

Readers who are uninterested in the details of the econometric specification can skip to section 4 where the estimation results are presented. The results are described in a way that does not necessitate knowledge of the statistical methodology.

The origin, destination, mode, rate, transit time, etc. of the last shipment collectively describe the "chosen alternative." We denote this alternative as 1, with the rate, time, and other attributes of the alternative denoted c_1, t_1, and vector x_1, respectively. The "next best" alternative is denoted as 2, with rate c_2, time t_2, and other attributes x_2. For notational simplicity, we do not denote the shipper, since the same specification is applicable to each surveyed shipper.

The utility that the shipper obtains[6] from the last shipment is U_1, which can be decomposed into two parts: $U_1 = V(c_1, t_1, x_1 \mid \beta) + \varepsilon_1$, where β represents the shipper's decision parameters and ε_1 captures the impact of all other unobserved factors. The decision parameters vary over shippers, reflecting the fact that the different shippers place different levels of importance on rates, time, and other factors. The density of these parameters in the population of shippers is denoted $f(\beta \mid \theta)$ where θ represents the

[6] Utility can be strictly profits or can reflect profits and other factors such as risk, convenience, and so on.

parameters of this density, such as the mean and variance of β among shippers. The remaining unobserved component of utility ε_1 also varies over shippers.

The utility that the shipper would obtain from the alternative shipment is decomposed analogously as $U_2 = V(c_2, t_2, x_2 \mid \beta) + \varepsilon_2$. Since the shipper did not chose this alternative, we know that $U_1 > U_2$.

Consider now the changes in rates and time about which the shipper was asked. As stated in the previous section, a rate increase was randomly selected from the numbers 10%, 20%, etc. The rate increase that was selected for the shipper is denoted *cp* and called the "rate prompt." The shipper was asked whether it would switch to the alternative if the rate for the last shipment rose by *cp*. The rate for the shipment under this scenario becomes the original rate c_1 times (1+ *cp/100)*. The utility of the last shipment under this new, higher rate is therefore $U_{1,CP} = V(c_1\ (1+cp/100), t_1, x_1 \mid \beta) + \varepsilon_1$, where the subscript "*1, CP*" refers to alternative 1 with rate higher by the rate prompt. Note that the unobserved component of utility is the same, since all factors other than rate remain the same. Since the higher rate translates into lower utility, $U_{1,CP} < U_1$. In deciding whether to switch in response to the higher rates, the shipper compares $U_{1,CP}$ with U_2. The shipper would switch if $U_{1,CP} < U_2$ and would not switch if $U_{1,CP} > U_2$.

Similar notation and comparisons apply to the increase in transit time. The time increase that was randomly selected is denoted *tp* and called the "time prompt." The utility of the last shipment under this higher time is $U_{1,TP} = V(c_1, t_1\ (1+tp/100), x_1 \mid \beta) + \varepsilon_1$. The shipper would switch if $U_{1,TP} < U_2$ and would not switch if $U_{1,TP} > U_2$.

We condition on the two best alternatives available to the shipper, as well as the rate and time prompts. We can derive the formula for the probability of each possible outcome to the shipper's choices between these two alternatives, in the original choice and in response to the rate and time prompts. Consider a shipper who is observed to choose alternative 1 over alternative 2 and, in response to the prompts, chooses alternative 2 when the rate of alternative 1 is raised by the rate prompt (i.e., says "I would switch to the alternative" in response to the rate prompt), and chooses alternative 1 when its time is raised by the time prompt (i.e., says "I would not switch to the alternative" in response to the time prompt.) The probability of this event is

$$\text{Prob}(\ U_1 > U_2 \ \text{and}\ U_{1,CP} < U_2 \ \text{and}\ U_{1,TP} > U_2\ )$$

$$= \text{Prob}(\ V_1 + \varepsilon_1 > V_2 + \varepsilon_2 \ \text{and}\ V_{1,CP} + \varepsilon_1 < V_2 + \varepsilon_2 \ \text{and}\ V_{1,TP} + \varepsilon_1 > V_2 + \varepsilon_2\ )$$

$$= \text{Prob}(\ e < V_1 - V_2 \ \text{and}\ e > V_{1,CP} - V_2 \ \text{and}\ e < V_{1,TP} - V_2\ )$$

where:

$V_1 = V(c_1\ , t_1\ , x_1 \mid \beta),$

$V_2 = V(c_2\ , t_2\ , x_2 \mid \beta),$

$V_{1,CP} = V(c_1\ (1+cp/100), t_1\ , x_1 \mid \beta),$

$V_{1,TP} = V(c_1\ , t_1\ (1+tp/100), x_1 \mid \beta),$ and

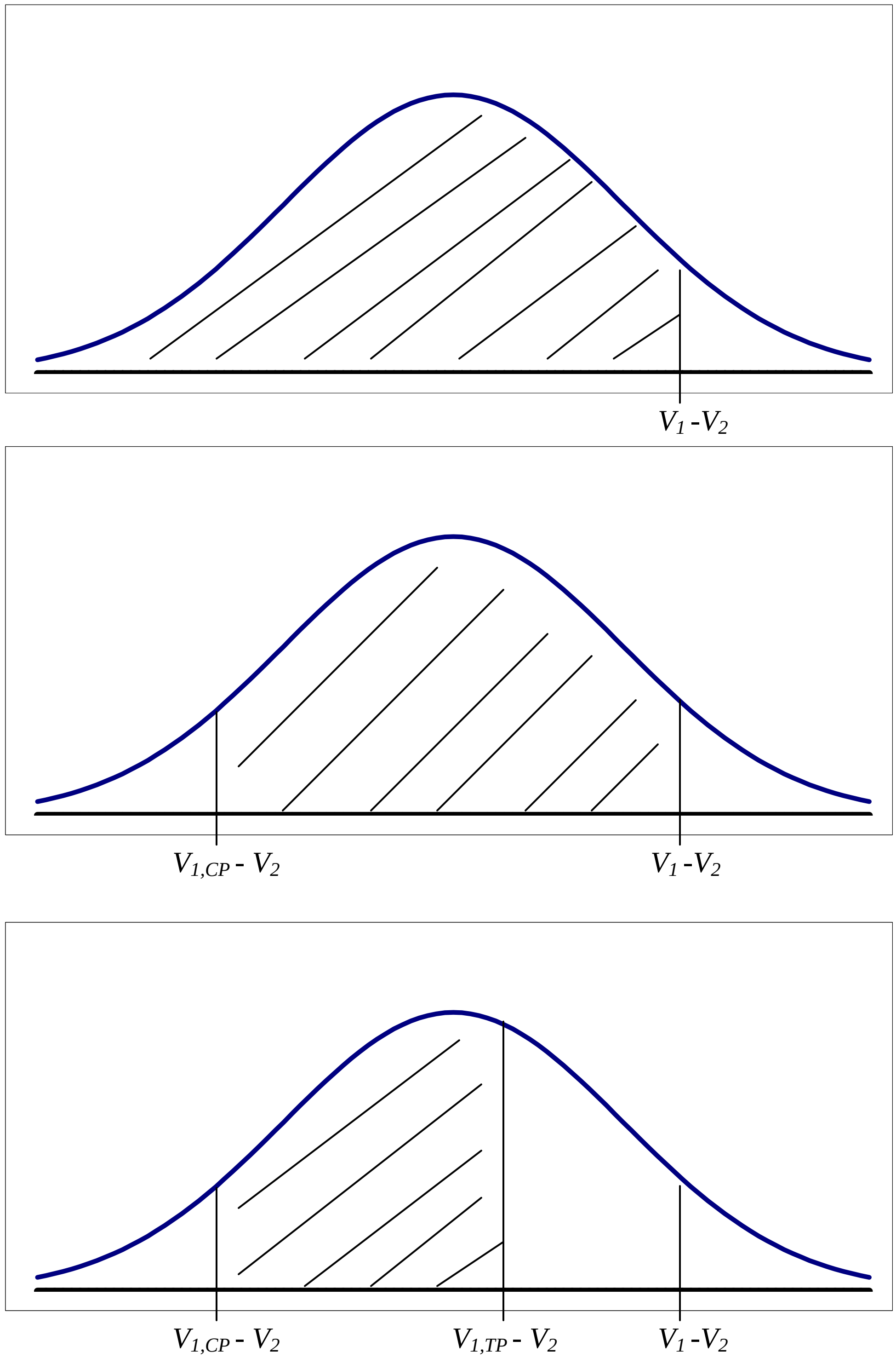
$e = \varepsilon_2 - \varepsilon_1$.

For estimation, we assume that ε_1 and ε_2 are distributed iid extreme value, such that their difference, e , follows a logistic distribution. This assumption provides the convenient logit formula for elements within the probabilities, as described below.[7]

The probability of this event can be visualized if we condition on β, such that the V's are non-stochastic. Figure 1 depicts the density of e. The event occurs only for values of e that satisfy all three of the conditions list in *Prob(…)* above. The top panel gives the values of e for which the first condition is met, i.e., that $e < V_1 - V_2$. If we only observed

[7] Note the discussion and caveats on pages 22-23 regarding conditional densities.

Figure 1.—Probability of Event



the shipper's real-world choice, then the probability of its choice (conditional on the attributes of only the two best alternatives) would be the shaded area of this panel: the probability that e is below $V_1 - V_2$. The second panel gives the values of e for which the first and second condition are both met, i.e., e is below $V_1 - V_2$ for the first condition and is above $V_{1,CP} - V_2$ for the second condition. If these were the only observed choices for this shipper, then the probability of these two choices would be the shaded area between $V_{1,CP} - V_2$ and $V_1 - V_2$. The third panel gives the value of e for which all three conditions are met, i.e., e is below $V_1 - V_2$, above $V_{1,CP} - V_2$, and below $V_{1,TP} - V_2$. Note that since $V_{1,TP}$ is necessarily lower than V_1 (since $V_{1,TP}$ has higher transit time), the first condition is redundant. The probability that all three conditions is met is the probability that e falls between $V_{1,CP} - V_2$ and $V_{1,TP} - V_2$. Since e is distributed logistic, this probability is

$$r(\beta) = \frac{e^{V_{1,TP}}}{e^{V_{1,TP}} + e^{V_2}} - \frac{e^{V_{1,CP}}}{e^{V_{1,CP}} + e^{V_2}}.$$

One additional detail is required. In the figure, $V_{1,TP} - V_2$ is to the right of $V_{1,CP} - V_2$, such that there exists a range of e that meets the conditions, or stated equivalently, for which the formula for $r(\beta)$ gives a positive number. If $V_{1,TP} - V_2$ is lower than $V_{1,CP} - V_2$, then event is impossible under preferences β. Taking this fact into consideration, the probability of the event conditional on β is

$$p(\beta) = MAX\left[0, \frac{e^{V_{1,TP}}}{e^{V_{1,TP}} + e^{V_2}} - \frac{e^{V_{1,CP}}}{e^{V_{1,CP}} + e^{V_2}}\right]$$

As stated above, this probability is conditional on β. The unconditional probability is the integral of the conditional probability over all values of β:

$$P = \int MAX\left[0, \frac{e^{V_{1,TP}}}{e^{V_{1,TP}} + e^{V_2}} - \frac{e^{V_{1,CP}}}{e^{V_{1,CP}} + e^{V_2}}\right] f(\beta \mid \theta)\, d\beta$$

Note that the unconditional probability is nonzero even if the conditional probability $p(\beta)$ is zero for some values of β. Stated more intuitively: the event might be impossible for some preferences, but not for all possible preferences. Any shipper who makes the choices described in this situation has preferences under which the event is possible.

The probability can be simulated by taking draws of β from its density, calculating the conditional probability $p(\beta)$ for each draw, and averaging the results. See Train (2003), especially section 7.6 on general mixed models.[8] The simulated probability is then used within a maximum likelihood estimator.

The probabilities of other situations are determined similarly. There are four possibilities for responses:

- *Choose alternative 1 over 2, choose 2 with rate prompt, choose 1 with time prompt.*

This situation is described above.

- *Choose alternative 1 over 2, choose 1 with rate prompt, choose 2 with time prompt.*

This situation is analogous to the previous one, but with $V_{1,CP}$ and $V_{1,TP}$ exchanged. The probability is

$$\text{Prob}(\, U_1 > U_2 \text{ and } U_{1,CP} > U_2 \text{ and } U_{1,TP} < U_2 \,)$$

$$= \text{Prob}(\, e < V_1 - V_2 \text{ and } e < V_{1,CP} - V_2 \text{ and } e > V_{1,TP} - V_2 \,)$$

[8] *Discrete Choice with Simulation* (Cambridge University Press).

Using the same concepts as for the previous situation, this probability becomes

$$P = \int MAX\left[0, \frac{e^{V_{1,CP}}}{e^{V_{1,CP}} + e^{V_2}} - \frac{e^{V_{1,TP}}}{e^{V_{1,TP}} + e^{V_2}}\right] f(\beta \mid \theta)\, d\beta$$

- *Choose alternative 1 over 2, choose 1 with rate prompt, choose 1 with time prompt.*

The probability is

Prob($U_1 > U_2$ and $U_{1,CP} > U_2$ and $U_{1,TP} > U_2$)

= Prob($e < V_1 - V_2$ and $e < V_{1,CP} - V_2$ and $e < V_{1,TP} - V_2$)

All three conditions are met if e is below the lowest of the three thresholds. That is, only one of these conditions is binding; the other two are redundant. $V_1 - V_2$ is necessarily higher than the other two thresholds. The binding threshold is therefore the lower of $V_{1,CP} - V_2$ and $V_{1,TP} - V_2$. The probability is:

$$P = \int MIN\left[\frac{e^{V_{1,CP}}}{e^{V_{1,CP}} + e^{V_2}}, \frac{e^{V_{1,TP}}}{e^{V_{1,TP}} + e^{V_2}}\right] f(\beta \mid \theta)\, d\beta .$$

- *Choose alternative 1 over 2, choose 2 with rate prompt, choose 2 with time prompt.*

The probability is

Prob($U_1 > U_2$ and $U_{1,CP} < U_2$ and $U_{1,TP} < U_2$)

$= \text{Prob}(\ e < \ V_1 - V_2 \ \text{and} \ e > V_{1,CP} - V_2 \ \text{and} \ e > V_{1,TP} - V_2\ ).$

The three conditions are met if e is below $V_1 - V_2$ and above the greater of $V_{1,CP} - V_2$ and $V_{1,CP} - V_2$. The probability is:

$$P = \int \left[\frac{e^{V_1}}{e^{V_1} + e^{V_2}} \right] - MAX \left[\frac{e^{V_{1,CP}}}{e^{V_{1,CP}} + e^{V_2}}, \frac{e^{V_{1,TP}}}{e^{V_{1,TP}} + e^{V_2}} \right] f(\beta \mid \theta)\, d\beta .$$

Two notes are useful for clarification. First, it is not possible for alternative 2 to be chosen over 1 given our notation. This is not a restriction and does not imply that the shipper is not free to choose either of the two best alternatives. The distinction is simply notational. Consider two shippers who face the same two alternatives as their best two. Label these alternatives J and K. Suppose one shipper chooses alternative J and the other chooses alternative K. In our notation, alternative J is 1 and alternative K is 2 for the first shipper and vice versa for the second shipper. Each shipper chooses alternative “1”. But alternative 1 is different for the two shippers. The probability of choosing alternative “1” incorporates in the numerator of the logit formula the attributes of alternative J for the first shipper and of alternative K for the second shipper. The rate and time prompts are then applied to whichever alternative is chosen.

The second note relates to the density of preferences. The probabilities are conditional on the attributes of only the best two alternatives rather than the attributes of all the alternatives that are available to the shipper. This conditioning is consistent with the data: we (the researchers) observe the attributes of the best two alternative but not the attributes of the other alternatives. However, this conditioning implies that the density of preferences that is used to calculate the probabilities is similarly conditional. That is, the densities of β, ε_1, and ε_2 in the above formulas are the densities of of these unobserved factors conditional on knowing that the two alternatives are considered by the shipper to be better than all other alternatives. In general, the distribution of unobserved factors conditional on observed choices (in this case, the choice of the best two) differs from the unconditional distribution (Train, 2003 Ch. 11.) In particular, the conditional density differs over shippers to the extent that the shipper's choice of which two alternatives are best reveals differences in unobserved factors. In our analysis, we do not incorporate this difference. We treat the densities as being the same for all shippers, the same as the unconditional density of preferences.

The question arises of how greatly does the true conditional distribution differ over shippers, or, stated equivalently, how much do the conditional and unconditional densities differ? Let $f(\beta \mid \theta)$ be the unconditional density of β, and let the unconditional densities of ε_1 and ε_2 be extreme value Suppose we observed the attributes of all alternatives and the identity of the best two. The density of β conditional on this information is:

$$g(\beta \mid V_1, V_2, \widetilde{V}) = \left(\frac{e^{V_1} + e^{V_2}}{e^{V_1} + e^{V_2} + \sum_{i \neq 1,2} e^{V_i}} \right) f(\beta \mid \theta) / k$$

where k is the normalizing constant and $\widetilde{V}$ is the vector of observed utility for all the alternatives that the shipper faces other than 1 and 2 (i.e., the vector of V_i for all alternatives i other than 1 and 2.) As shown in Train (2003, Ch. 11), g can differ considerably from f. Essentially, knowing which two alternatives the shipper considers best compared to all the other alternatives would provide considerable information on the preferences of the shipper and how these preferences differ from those of shippers in general. Similar conditioning applies to ε_1 and ε_2.

In our situation, however, we do not observe the attributes of all alternatives. Since the V's are not observed for any alternatives except 1 and 2, the density of β conditional on the information we observe is the integral of g over all possible value of $\widetilde{V}$. This conditional density, which is the one that is appropriate for calculation of our probabilities, is:

$$\bar{g}(\beta \mid V_1, V_2) = \int g(\beta \mid V_1, V_2, \widetilde{V})\, h(d\widetilde{V} \mid V_1, V_2)$$

where h is the density of $\widetilde{V}$ conditional on V_1 and V_2 . Calculating this density requires knowledge of h, which we do not have. However, due to the integration over $\widetilde{V}$, $\bar{g}$ can be expected to differ over shippers (and differ from f) far less than g does. Stated intuitively, comparatively little information can be inferred about a shipper's preferences from knowing its two best alternatives but *not* knowing what these alternatives are better than (that is, not knowing the other alternatives.) As a result, treating $\bar{g}$ as if it did not differ over shippers, and is hence the same as f, is less problematic than might at first appear.

4. Estimation results

The portion of utility the depends on observed variables is specified to be:

$$V(c\,, t\,, x \mid \beta) = -\ \beta_c\, ln(c)\ -\ \beta_t\ ln(t)\ +\ \beta_x\, x\ .$$

The negative of the rate and time coefficients, i.e., β_c and β_t, are assumed to be lognormally distributed over shippers. Since the lognormal distribution has support only on positive numbers, this distribution assures that, for all shippers, utility decreases when time or rate increases. The mean and median of the lognormal distributions are estimated.[9] The standard deviation is a function of the difference between the mean and median: a larger standard deviation is associated with a larger difference between the mean and median. The other coefficients in utility, β_x are assumed to be fixed.

[9] We have found that parameterizing the lognormal in terms of its mean and median facilitates convergence relative to other parameterization (such as the mean and standard deviation of the log of the coefficient.) This procedure seems to resolve some of the numerical difficulties discussed in, e.g., Brownstone and Train, 1999, *Journal of Econometrics,* Vol. 89, pp, 109-12).

Table 8 gives the estimation results. This model was obtained after extensive testing of specifications and variables. We discuss the estimated model first and then briefly describe the other specifications and variables that were tried.

Rates are measured in dollars per ton,[10] and time is measured in hours. Since rates and time enter in log form, their coefficients represent the change in utility for a percent change in rates and time, respectively. The estimated parameters of the distribution of the rate coefficients are highly significant, which indicates, as expected, that rate is an important factor in shippers' decision-making. The estimated parameters relating to the time coefficient are also highly significant. This result indicates that shippers make their decisions on the basis of transit times in addition to rates. That is, transit time matters in itself, not simply because greater transit times usually translate into higher rates.

The average rate coefficient is about twice that of time (-3.96 compared to -1.92). The median rate coefficient is also about twice as large as the median time coefficient (-3.24 compared to -1.79.) This difference indicates, loosely speaking, that rates are more important than time. Stated more precisely, a percent change in rates has more impact on utility than the same percent change in time. Figure 2 graphs the estimated distributions of the rate and time coefficients among surveyed shippers. As required by their respective means and medians, the distribution of rate coefficients is further to the right than the distribution of time coefficients, reflecting the fact that rates are more important than time.

[10] Many shippers reported the costs of their last and alternative shipments in other units, such as bushels. These other units were converted to dollars per ton.

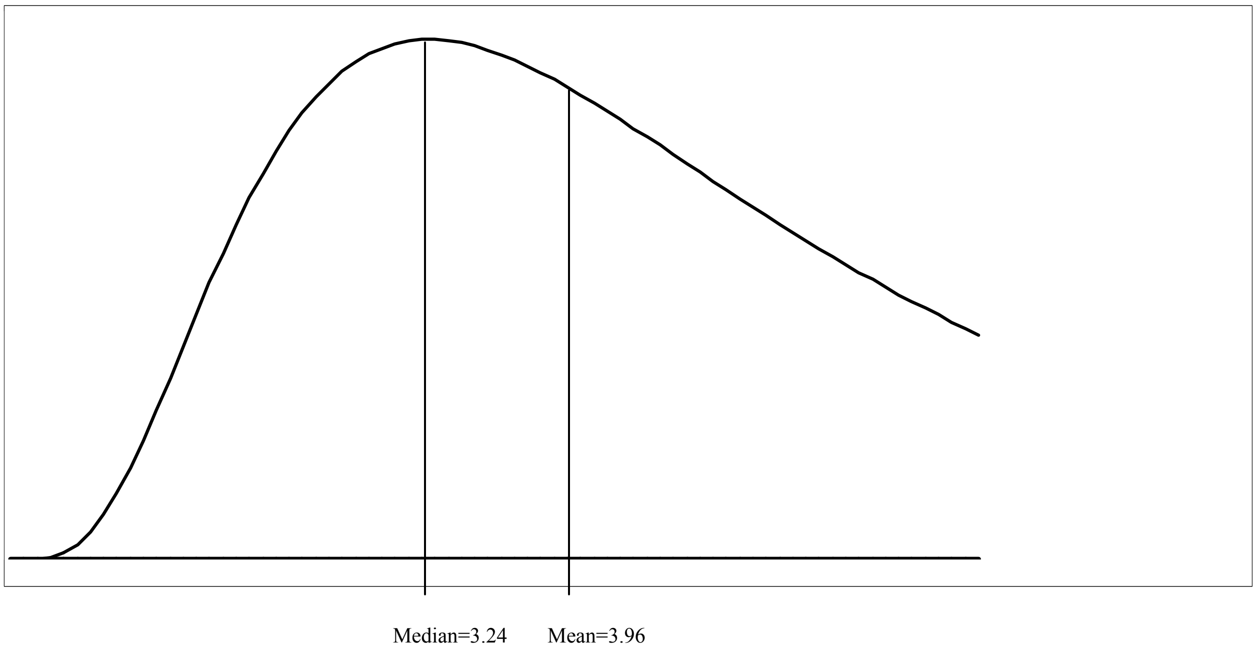
Table 8.--Model of Shippers' Choice between Two Best Alternatives

Parameters	Estimates	Std. err.	T-statistic
Median rate coefficient	-3.2436	0.3750	8.649
Mean rate coefficient	-3.9629	0.5061	7.830
Median time coefficient	-1.7942	0.1649	10.882
Mean time coefficient	-1.9232	0.1841	10.446
Rail dummy	3.7036	0.3313	11.179
Barge dummy	4.7048	1.0167	4.627
Time coefficient factor if not corn/wheat/soy	0.7972	0.1774	4.494
Shipment distance	3.3566	0.5213	6.439

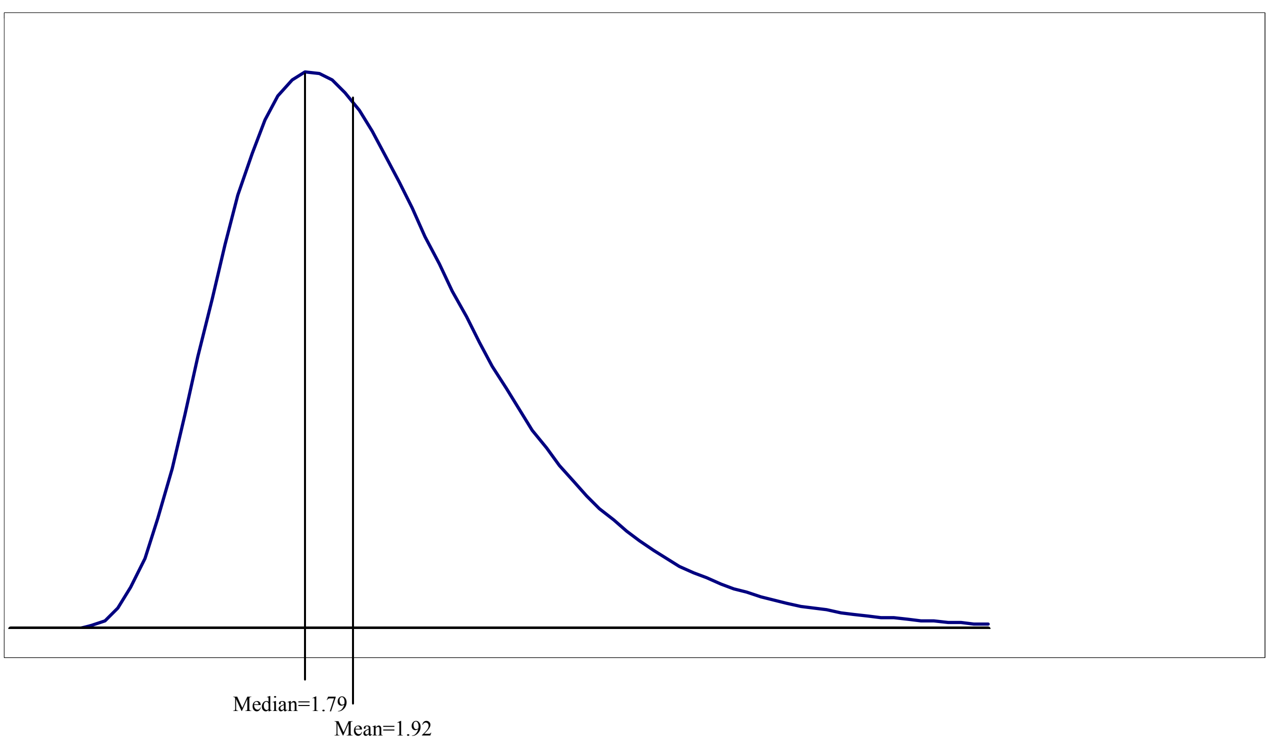
Number of observation: 208
Mean log-likelihood at convergence: -2.40314
All parameters are significant at the 99 percent confidence level.

Figure 2.—Density Coefficients of –log(rate) and –log(time).

Panel a: Rate Coefficients



Panel b: Time Coefficients



The standard deviation of a log-normal distribution is equal to $m\sqrt{\left(m/d\right)^2 - 1}$ where m is the mean and d is the median. The estimated means and medians imply standard deviations of 2.78 for the rate coefficient and 0.74 for the time coefficient. This difference in standard deviations is the reason the distribution of time coefficients in Figure 2 is "tighter" than that for rate coefficients.

The dummy variables for rail and barge indicate whether the shipment used either of these two modes (either alone or in combination with other modes.) The third mode, truck, is taken as the base, with its dummy normalized to zero. The coefficients of the rail and barge dummies are therefore interpreted as being relative to truck. Both are positive, which indicates that rail and barge would be preferred to truck if the rates and times were the same. The coefficient of the barge dummy exceeds that for rail, which indicates that barge would be preferred to rail if rates and times were the same. Of course, rates and times are not the same on the different modes, such that the coefficient of the dummies do not indicate that, all things considered, barge is preferred to rail and rail is preferred to truck. Rather, the dummies seem to be reflecting a scale effect, namely, that barges hold more than rail cars, and rail cars hold more than trucks. If the modes all somehow had the same rate per ton and transit time, then using the mode that carries more tons is preferable, since loading and unloading costs are lower on a per-unit basis and larger capacity provides greater flexibility for handling unexpected fluctuations in amount shipped.

Most of the shipments in the survey were corn, wheat or soybeans, but some were for other products. The next parameter in Table 8 is a factor that adjusts the time coefficient for shippers of these other products relative to corn/wheat/soybean shippers. Since the time coefficient varies randomly over shippers but is necessarily negative, a positive multiplicative adjustment is applied so as to guarantee that the sign of the time coefficient is unchanged for all shippers and only its magnitude is adjusted. In particular, for shippers of "other" products, the time coefficient is multiplied by $exp(\alpha)$ where α is estimated. Note that $\alpha=0$ translates into no adjustment (since $exp(0)=1$), a positive/negative value of α provides an upward/downward adjustment. As given in Table 8, the estimated value of α is .7972, which implies that the time coefficient is multplied by *exp*(.7972) = 2.22. This estimate indicates that shippers of products other than corn, wheat, and soybeans place about twice as much importance on time as shippers of corn, wheat, and soybeans. This difference may reflect differences in the value of the commodity and/or its susceptibility to damagae and spoilage. Since the mean and median time coefficients without this adjustment are about half as large as the mean and median rate coefficients (as described above), the combined results indicate that the mean and median time coefficient for these shippers are about the same as their mean and median rate coefficients.

The last parameter is the coefficient of shipment distance. If the shipper's last shipment and the next best alternative shipment have the same origin and destination, this variable does not affect the probabilities, since it enters each *V*. It only enters the probabilities when the last shipment and the next best alternative have different origins or destinations. The positive coefficient indicates that, if time and rates are the same, shipping a greater distance is preferred. Of course, shipping a greater distance usually entails higher rates and more time. This coefficient indicates that a given rate and time become more attractive as the distance that the rate and time apply to increases. The coefficient is also perhaps reflecting a differential in delivered price. The delivered price of a product is usually higher when the product is shipped further. Therefore, for a given shipment rate and time, the profit that the shipper makes is greater at a distant destination than a closer one.

As stated above, other specifications and variables were tested. In particular, we found none of the following to be significant: (1) differences over commodities in the distribution of rate coefficients, (2) difference over commodities in the distribution of the time coefficient, other than the differences for non-corn/wheat/soybean shippers that was incorporated into the model, (3) whether the shipper had rail or barge loading facilities (the differences attributable to these facilities are apparently captured directly in the rate and time variables), and (4) shipment size (presumably because size only entered the choice if the best alternative was a different size than the last shipment, which seldom occurred in the survey.) We also attempted to estimate models that incorporated follow-up response by the shippers. Specifically, if the shipper said that it would not switch in response to the rate prompt, the interviewer asked the shipper what rate increase it would take to induce it to switch. A similar follow-up question was asked in relation to the time prompt. We specified a model that incorporated these responses. The rate increase at which a shipper would switch provides an exact value of e conditional on β, rather than a range of values. The probability of this value is the density of e evaluated at this value. Unfortunately, we encountered numerical difficulties with the models that incorporated these follow-up responses with exact values of e. Convergence could not be achieved under satisfactorily stringent criteria for convergence. However, the parameters close to convergence were similar to those presented in Table 8, as would be expected if the responses simply provide more, rather than different, information. We are investigating these models further, including specifications that do not entail taking the responses as exact indications of e conditional on β but rather as indications of a range that is narrower than without the follow-up responses.

5. Forecasted switch rates for the surveyed shippers

The estimated model can be used to forecast the response of shippers to changes in rates and time. Suppose, for example, that the rate for each shipper's last shipment rose by 40%. The model can be used to forecast the share of shippers who would switch to their next best alternative in response to this rate increase, and the share that would make the same shipment without switching. Table 9 gives the share of shippers in our survey who would switch to their next best alternative if the rate for their last shipment rose, along with the arc elasticities that are implied by the degree of switching. The shares switching are graphed in Figure 3. The statistics are calculated for those shippers who were used in the model estimation and thereby exclude those who said that they would shut down if their last shipment alternative was no longer available. Also, the statistics are for the share of shippers who would switch, not the share of tonnage that would be switched.[11]

If the rate for the last shipment were 10% higher, the model indicates that nearly 14% of surveyed shippers would switch to their next-best alternative. This relatively high dehree of switching is consistent with the fact that many shippers are highly sensitive to rates, and will change shipment modes and destinations in response to small changes in rates. The arc elasticity is 1.4 for this magnitude of rate change; for a 20% rise in rates, the arc elasticity is about 1.2.

With larger rate increases, more shippers switch of course. However, even very large rate increases do not induce all shippers to switch. For example, a doubling of rates induces 62% of shippers to switch, leaving 38% that do not switch. This result is consistent with the fact that some shippers are essentially rate/time insensitive, facing only very unattractive alternatives. This diversity of shipper response, with some shippers highly responsive to small price changes and others nearly completely insensitive, is one of the distinguishing characteristics of the industry.

[11] The share of tonnage switched, though not shown, can be calculated from the data and model if needed an any application.

Figure 3.—Estimated Share of Switches due to Rate Increases

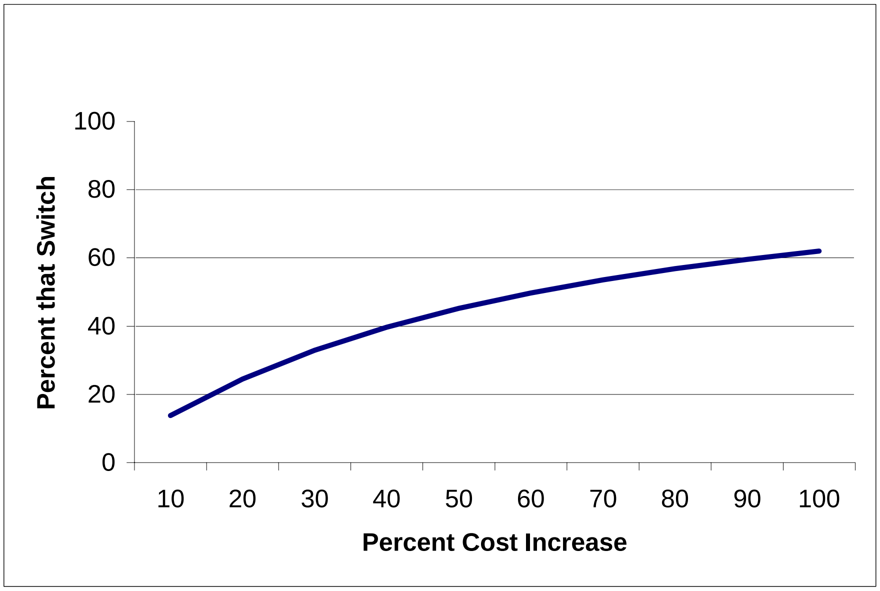


Table 9.--Share of surveyed shippers forecasted to switch to their best alternative if their transportation rates rise.

Percent rate increase	Percent switching	Arc elasticity
10	13.79	1.38
20	24.53	1.23
30	32.95	1.10
40	39.69	0.99
50	45.18	0.90
60	49.73	0.83
70	53.56	0.77
80	56.81	0.71
90	59.59	0.66
100	62.01	0.62

Table 10 and Figure 4 present switch rates in response to increases in transit times. As expected, fewer shippers switch in response to an increase in transit time than to the same percent increase in rates. For example, a 10% increase in transit time for the last shipment would induce 8% of shippers to switch to their next-best alternative. This switch rate is not at all trivial, and its not being zero indicates that shippers do response to time as well as rates. However, it is less than the 14% switch rate that arises from the same percent increase in rates. The arc elasticity for a 10% increase is time is .8 and for a 20% increase is .7. A doubling of transit time is forecast to induce slightly fewer than half of the shippers to switch.

Figure 4.—Estimated Share of Switches due toTime Increases

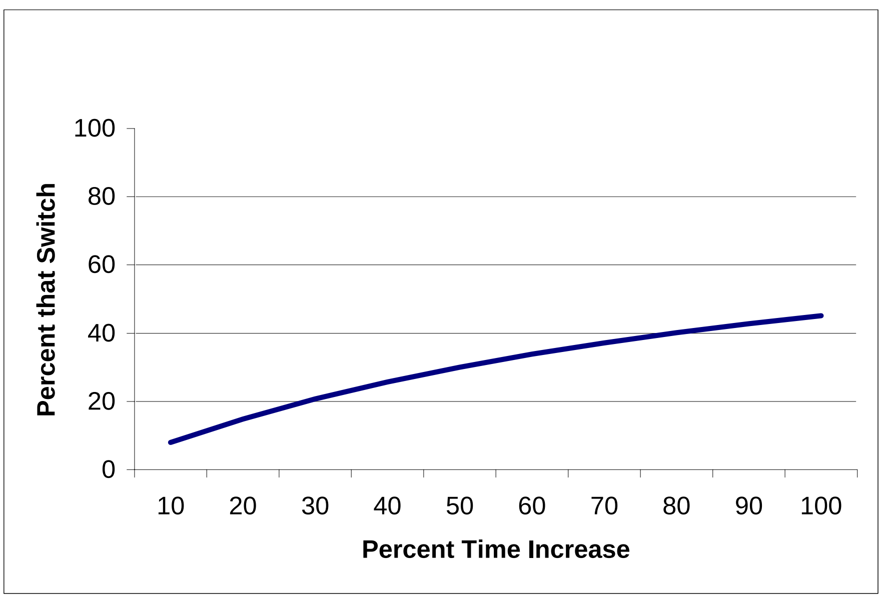


Table 10.--Share of surveyed shippers forecasted to switch to their best alternative if their transit times rise

Percent time increase	Percent switching	Arc elasticity
10	8.02	0.80
20	14.86	0.74
30	20.70	0.69
40	25.72	0.64
50	30.05	0.60
60	33.84	0.56
70	37.16	0.53
80	40.11	0.50
90	42.73	0.47
100	45.08	0.45

The above forecasts are for increases in time holding transit rates constant. Usually, an increase in transit times translates into a increase in transit rates, due to the extra labor, fuel, and other factors whose use rises when time increases. Table 11 and Figure 5 present forecasts for increases in times and rates together, with rate raised by an amount that represents the impact of the time increase on rates. For each percent increase in time, rates were raised .5 percent for truck shipments and .3 percent for rail and barge shipments. These proportions were obtained through regression analysis of the rates and times for the surveyed shippers (where the dependent variable was log of transit rates and the explanatory variables were log of transit times differentiated by mode.) The proportion is smaller for rail and barge than for trucks, since fixed charges (i.e., non-distance related charges) constitute a larger share of rates for rail and barge than for trucks. Stated alternatively, time-dependent rates constitute a smaller share of total rates for barge and rail than for trucks. Even though we present forecasts based on these proportions, the model can be used to forecast the combined impact of changes in times and any associated changes in rates.

We call the estimated impacts “congestion effects” since congestion causes transit times to rise which in turn causes rates to rise. The first row of Table 11 gives the impact of a

10% increase in transit time for each surveyed shippers' last shipment. The time increase translates into a 4.4% rise in rates, on average (5% for trucks and 3% for rail and barge, averaged over the survey shipments.) This combined change in time and rates is forecast to induce 14.5% of shippers to switch to their next-best alternative. The arc "congestion" elasticity, given in the last column, is defined as the percent of shipments that switch due to the total effect (on rates and time) of a percent increase in transit times. The arc elasticity for a 10% increase in congestion (i.e., transit times) is 1.45. This is larger, of course, than the arc elasticity in Table 10, which represents the impact of higher transit times holding rates constant.

Figure 5.—Estimated Share of Switches due toTime and Resultant Rate Increases

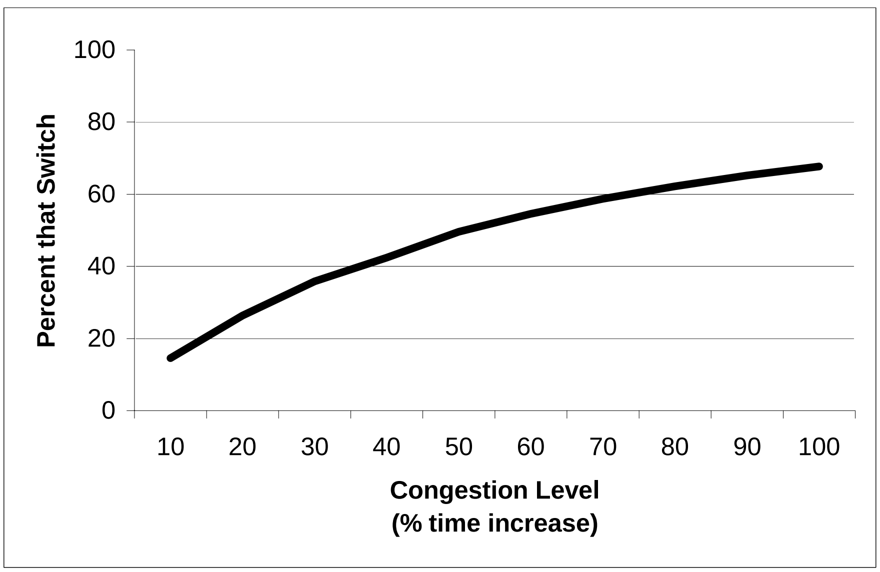


Table 11.--Share of surveyed shippers forecasted to switch to their best alternative if their transit times rise and their rates rise due to the increased transit time

Percent time increase	Percent rate increase, avg	Percent switching	Arc congestion elasticity
10	4.40	14.54	1.45
20	8.81	26.37	1.32
30	13.2	35.85	1.19
40	17.6	43.45	1.09
50	22.0	49.59	0.99
60	26.4	54.61	0.91
70	30.8	58.76	0.84
80	35.2	62.24	0.78
90	39.6	65.19	0.72
100	44.0	67.71	0.68

6. Use of the model in estimating benefits for waterway upgrade projects

The model of shippers' choices (Table 8) is directly useable in the Army's modeling and benefit calculations for waterway improvement projects on the Upper Mississippi and other rivers. The estimated model of shippers' choices was designed for, and can be used as, a component within the Army's Essence model and the Tow Cost/Equilibrium Model (TCM/EQ). Currently, the Army's models contain demand curves for barge volumes that are derived from assumptions about shipper behavior. The builders of Essence and TCM/EQ have long recognized the limitations of these demand curves; for example, Curlee discusses these limitations in his recent descriptions of Essence and TCM/EQ.[12] These limitations have also been the subject of criticism by the NRC committee that is reviewing the Army's Feasibility Study.[13] The model in our report, which we will call the "survey model," addresses and corrects these limitations. The survey model can be inserted into Essence and/or TCM/EQ to provide demand curves that are used instead of,

[12] T. Randall Curlee, "The Restructured Upper Mississippi River-Illinois Waterway Navigation Feasibility Study: Over view of Key Economic Modeling Considerations," Oak Ridge National Laboratory report, prepared for the Mississippi Valley Division, U. S. Army Corps of Engineers.
[13] "Review of the U.S. Army Corps of Engineers Upper Mississippi-Illinois Waterway Restructured Feasibility Study: Interim Report," Committee to Review the Corps of Engineers Restructured Upper Mississippi River-Illinois Waterway Draft Feasibility Study, National Research Council.

or in addition to, the currently used ones. The survey model was designed and estimated to allow the Army the ability to use the model in this way if it chooses to do so.

The key component of Essence and TCM/EQ is a sub-model that predicts the proportion of barge shipments that will switch to the next least cost alternative (usually rail) in response to increased barge costs. This sub-model determines the estimated impact of a waterway project on barge volumes as well as the estimated benefits of the project. The survey model is designed to replace, and improve, this component of Essence and TCM/EQ. To clarify how the survey model is used, we first describe how that Essence and TCM/EQ currently operate. This description follows that of Curlee (citation in footnote 10). We then show how our model fits within these models, replacing the key component in these models that has been the major source of their limitations.

TCM/EQ

TCM/EQ operates on a sample of 1900 barge movements that are taken as input. For each of these barge movements, the best rail alternative is identified, and the cost of sending the shipment by rail is calculated. Forecasts are obtained under scenarios for barge costs (i.e., with and without the project). For each of the 1900 barge movements, the cost of sending the shipment by barge under the scenario is calculated. The shipment is predicted to stay on barge as long as the barge cost is less than the rail cost. If the barge cost under the scenario is higher than the rail cost, then the shipment is predicted to switch to rail.

Figure 6 gives the demand curve for barge shipments that is used within TCM/EQ, based on these assumptions. This figure is the analogous to that as given by Curlee (his figure 2) in his explanation of the TCM/EQ model. The demand curve is applied to each of the 1900 shipments. The y-axis is the cost of barge for that shipment. The x-axis is the quantity shipped by barge. The quantity of the shipment (i.e., tons) is Q0, which is denoted on the x-axis. The y-axis gives the cost of sending the shipment by barge. The cost of barge under current conditions is C0, at which the Q0 quantity goes by barge (since the shipment is observed to go by barge under current conditions.) The cost of sending the shipment by rail is R0, which is denoted as a point on the y-axis. (Note that Q0, C0, and R0 are different for each of the 1900 shipments.) The kinked line gives the demand curve for the shipment. When the cost of barge is below the cost of rail, the shipment is assumed to go by barge, such that the quantity on barge is Q0. When the cost of barge is above the cost of rail, the shipment is assumed to go by rail, such that the quantity on barge is 0.

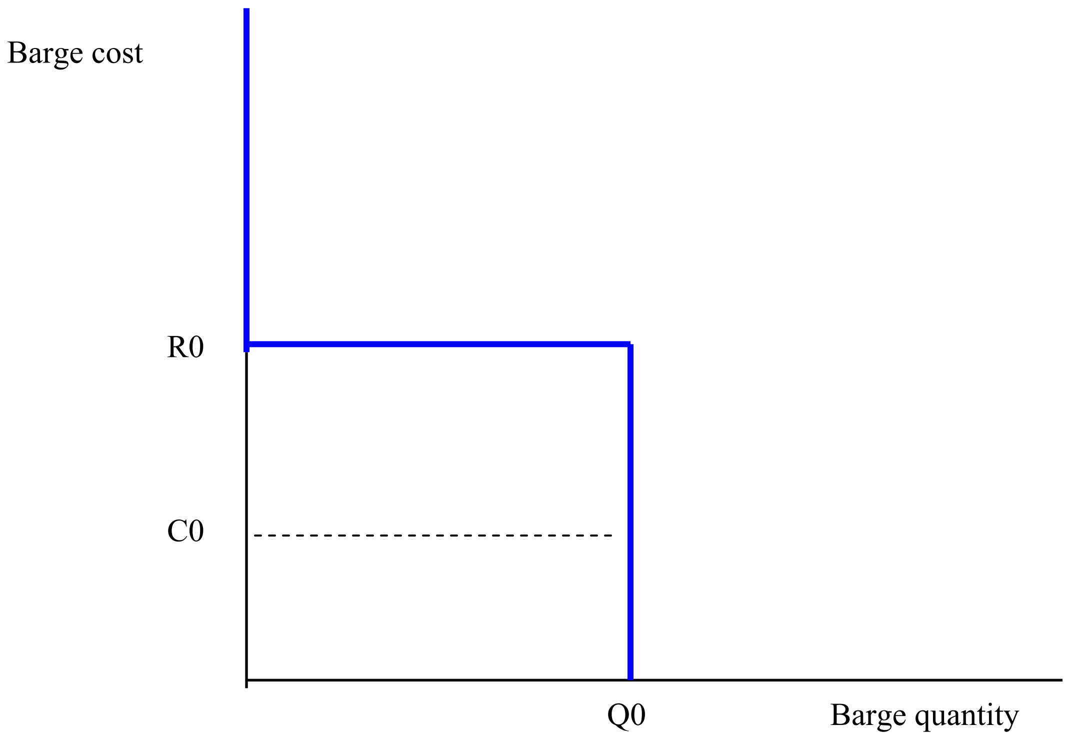


Figure 6. Demand Curve used in TCM/EQ

This demand curve is applied to each of the 1900 shipments. The predictions for each shipment are then added up to obtain the prediction of the total quantity shipped by barge. This prediction is done twice, with and without the project. The difference between the two sets of predictions gives the estimated impact of the project on the volume of barge shipments. This difference in shipments with and without the project can be used to calculate an arc elasticity of barge volume with respect to change in barge costs. Note, however, that this elasticity is the outcome of the demand curve in Figure 6 applied to each of the 1900 shipments. It is not an input to the model. Also, the arc elasticity does not affect the calculation of impacts or benefits; rather, it is an implication of the demand curve applied to each of the 1900 shipments.

The TCM/EQ model has been criticized for the fact that (1) the demand curve implies no switching to rail as long as the barge cost is below the rail cost for a shipment, and (2) the demand curve implies complete switching to rail when barge cost exceeds rail cost. As Curlee discusses, each of these assumptions is stark (no switching or all switching) and unrealistic.

Essence

Essence addresses the first of the two “stark” assumptions of the TCM/EQ demand curve. In the Essence model, barge quantity decreases as barge costs increase, even when the barge cost is less than the rail cost. Figure 7 gives the demand curve for each shipment that is used in Essence. (This figure is analogous to Curlee’s figure 4.)

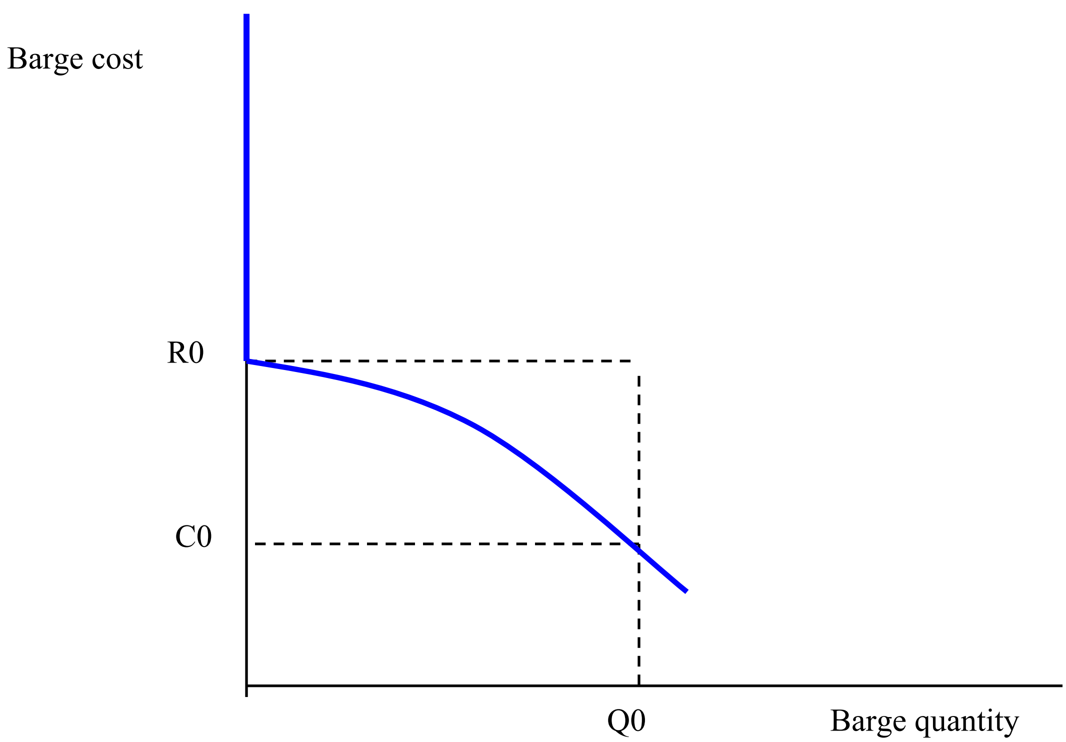


Figure 7. Demand Curve used in Essence

For barge costs below rail costs, the demand curve is downward sloping rather than, as in TCM/EQ, perfectly vertical. The curvature of the demand curve is determined by a parameter that is called "N". The value of N is not determined from data analysis. As pointed out by the NRC report, there is no way to know whether any value of N that is used in Essence actually provides a plausible demand curve shape. Nevertheless, Essence improves upon TCM/EQ by allowing a downward sloping demand curve rather than a perfectly vertical one.

Essence maintains the second "stark" assumption of TCM/EQ. That is, when the barge cost exceeds the rail cost, the entire quantity of the shipment is assumed to switch to rail.

Essence runs on the sample of about 1900 barge shipments, like TCM/EQ. That is, the demand curve in Figure 7 is applied to each of the 1900 shipments, using the quantity Q0, C0, rail cost R0 and the "N" value for that shipment. The total quantity on barge is obtained by summing the predictions for the 1900 shipments.

Survey model

The survey model provides a demand curve for each barge shipment that can be used instead of the demand curves in Figure 6 and 7. The survey model predicts the proportion of shipments that switch to the next best alternative. The model can be applied to each barge shipment to determine the proportion that switch to rail as barge costs rise though increases in rate and/or time. The demand curve from the survey model is depicted in Figure 8. The shape of the demand curve depends on the characteristics of the shipments, such as their commodities and transit times.

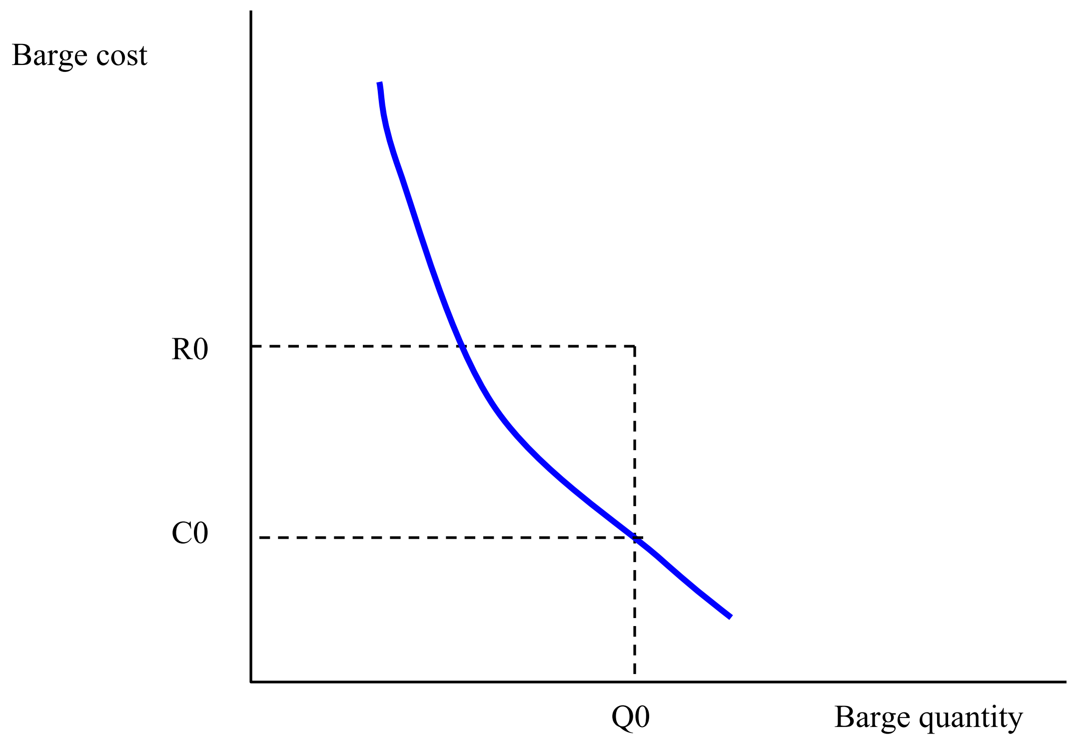


Figure 8. Demand Curve from the Survey Model

The survey model addresses both of the “stark” assumptions in TCM/EQ. First, for barge costs below rail costs, the demand curve is downward sloping rather than vertical. In this regard the survey model is like Essence, which also has downward sloping demand within this range. However, the slope of the survey model’s demand curve is determined through econometric analysis of data on shippers’ choices, unlike the slope in Essence’s demand curve, which is simply assumed. Second, for barge costs above rail costs, the survey model’s demand curve continues to be downward sloping, rather than assuming all barge quantity switches to rail. This aspect of the survey model is consistent with the fact that some barge shippers continue to use barge even if when the cost of barge exceeds the cost of rail. The Essence and TCM/EQ demand models do not incorporate this fact.

The survey model would be implemented within TCM/EQ and/or Essence by replacing the demand curves that are currently embedded in these models with demand curves from the survey model. The survey model would be applied to each shipment. Then the predictions for each shipment would be added up, just like the TCM/EQ and Essence models currently do, to obtain forecasts for total barge quantity. Two sets of forecasts would be conducted, one for the "without project" and one for the "with project" conditions. The difference between the two sets of forecasts gives the impact of the project. Like with Essence and TCM/EQ, the estimated impacts can be used to calculate an arc elasticity for barge quantity with respect to the change in barge costs that results from the project. And also like Essence and TCM/EQ, this elasticity is an output of the model, obtained from applying the demand curve to each shipment.

Use of the survey demand model within Essence and/or TCM/EQ would address many of the concerns and criticisms that have been raised, both by the NRC and the authors of the Essence and TCM/EQ models themselves:

- The NRC report criticizes the Feasibility Study for using demand curves that are based on assumptions rather than current data. The demand curves from the survey model are based on current data, using a detailed survey of shippers and econometric methods.

- Curlee states that each of the 1900 shipments has a different demand parameter but that, as a convenience, Essence applies the same demand slope to all shipments. The survey model provides a different demand curve for each of the 1900 shipments, based on the attributes of the shipment and the conditions that the shipment faces.

- Curlee and the NRC state that many factors other than costs enter into shippers' decisions, which Essence and TCM/EQ do not incorporate. The survey model incorporates factors other than cost. Transit time is included, such that the demand curve for each shipment depends on the time by rail and barge as well as the costs. The survey model also incorporates the impact of factors that are not observed by the researcher. The survey model contains a theoretically meaningful and econometrically estimated representation of the influence of unobserved factors.

- Curlee and the NRC recognize that some shippers will continue to use barge even when the cost of barge exceeds the cost of rail. The survey model incorporates this fact, while Essence and TCM/EQ do not.

Benefit Estimations

The benefits of a project can be estimated using the survey model within Essence and/or TCM/EQ. In each model, benefits are estimated for each shipment and then summed over all shipments to obtain total benefits. The estimated benefits for each shipment depend on the form of the demand curve that is used in the model.

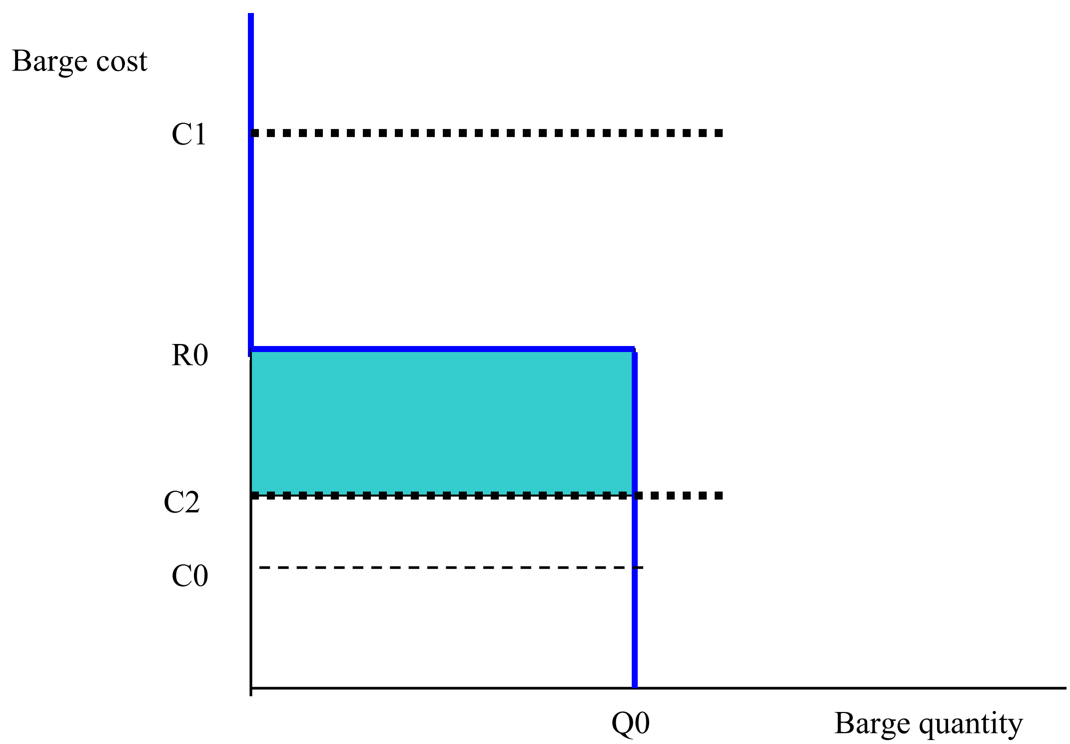


Figure 9. Estimated Benefits using TCM/EQ Demand Curve

Figure 9 depicts estimated benefits under the demand curve that is currently used in TCM/EQ. Future barge costs without the project are C1, which is higher than under current conditions (that is, above C0) because of congestion increasing over time. The project causes barge costs to be lower than they would without the project, at C2. The benefits of the project are estimated by the shaded area between R0 and C2 to the left of the demand curve. This shaded area is calculated for each shipment and summed over all movements to obtain total benefits.[14]

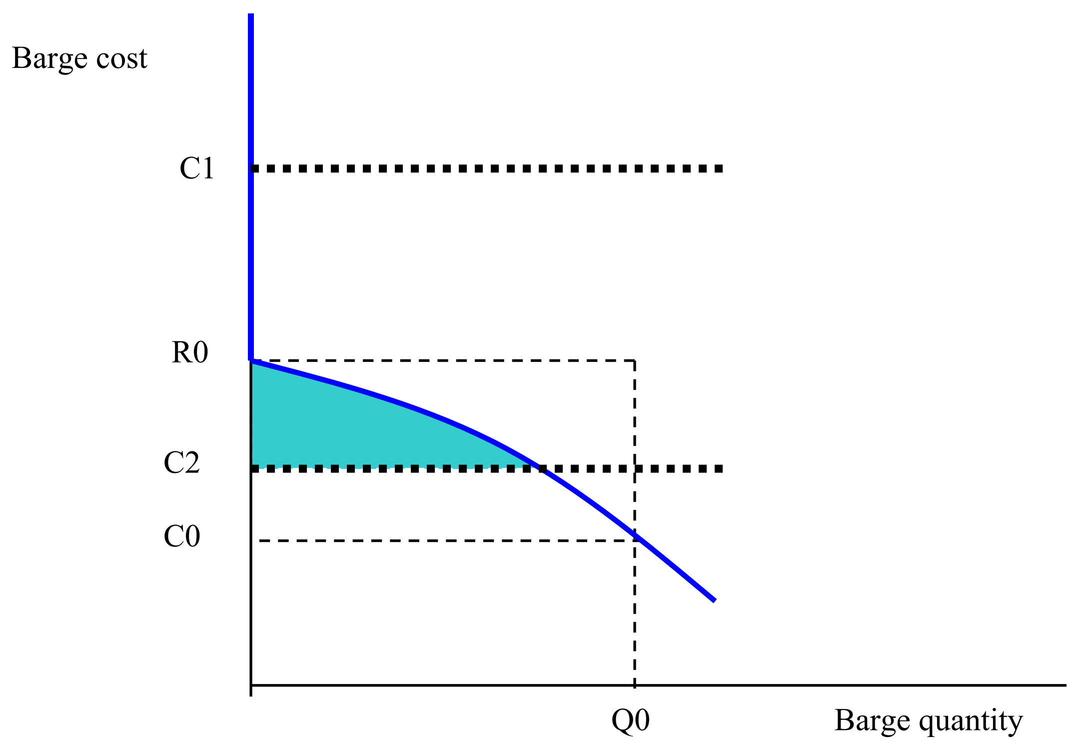


Figure 10. Estimated Benefits using Essence's Demand Curve

Figure 10 depicts project benefits estimated under the demand curve in Essence. Note that the benefit estimates under Essence are necessarily lower than those under TCM/EQ. That is, the un-shaded part of the quadrangle to the right of the shaded area is included in

[14] In the figure, C1 exceeds R0. In many (perhaps most) cases, C1 is below R0. We put C1 above R0 in order to facilitate the comparison of benefit estimates under TCM/EQ and the survey model. One of the differences in benefit estimates arises only when C1 exceeds R0. Also, the difference between C1 and C2 that is given in the figure is greater than usually occurs for projects. A large difference is used to make the figure easier to read.

the estimated benefits under TCM/EQ but not under Essence. The slope of the demand curve determines the amount by which the estimated benefits under Essence are less than those under TCM/EQ.

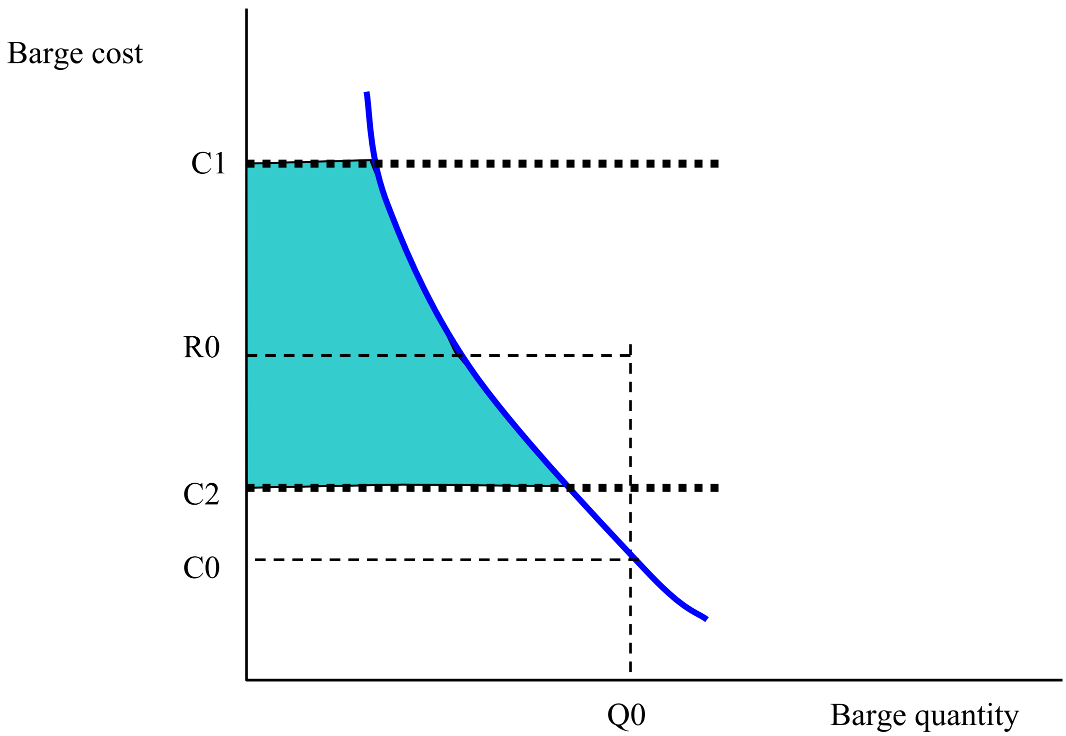


Figure 11. Estimated Benefits using the Survey Model's Demand Curve

Figure 11 depicts estimated benefits under the demand curve calculated from the survey model.[15] Estimated benefits under the survey model can be either higher or lower than those under TCM/EQ. The estimated benefits are reduced, relative to TCM/EQ, because the demand curve is downward sloping for barge costs below rail costs, while TCM/EQ's demand curve is perfectly vertical in this range. The un-shaded part of the quadrangle to the right of the shaded area, below R0 and to the left of Q0, is included in the TCM/EQ estimate but not under the survey model. On the other hand, the estimated benefits may

[15] The survey model includes transit rates and times as explanatory variable while Figure 6 depicts the benefits from a change in transit cost. In implementation, whatever change in costs that TCM/EQ or Essence currently specifies for a given scenario needs to be decomposed into its time and rate dimensions. These changes in rates and times are input to the survey model, which then forecasts the resultant change in demand.

be increased because the survey demand curve allows barge demand to be positive when barge costs are above rail costs, while the TCM/EQ model assumes that barge demand is zero in this range of costs. That is, the shaded area above R0 is included in the survey model's estimation of benefits but not in the TCM/EQ estimates.[16] As Curlee states, the estimated benefits from TCM/EQ can be biased either upward or downward because of its two "stark" assumptions about the demand curve. Stated equivalently, estimated benefits from the survey model's demand curve, which does not incorporate these two assumptions, can be either greater or less than those from TCM/EQ.

[16] Note that this extra estimated benefits arises only when C1 exceeds R0, which need not be the case.

IV. The Impact of Rates and Time on Annual Shipment Volume

1. Motivation

In this section, we examine shipper's annual volume of shipments (by all modes and all O/D's) and the impact that changes in rates and time have on this volume. Economic theory implies that rising rates and transit times translate into lower shipment volumes, all else held equal. The empirical analysis in this section provides an indication of the size of this reduction and whether it is statistically significant.

Section IV.2 describes the survey questions that we examine. The model specification is given in section IV.3, with results and forecasts in sections IV.4 and IV.5. We do not include a section on how to incorporate these findings into the ACE's models, as we did for our analysis of shippers' choice of mode and O/D. The ACE models do not currently contain a component for response of total annual volumes to transit times and rates. There are several ways that this component could be added, but decisions regarding the specification of such an addition is beyond the scope of this report.

2. Survey questions

Shippers were asked a series of questions regarding the operations of the facility, including: quantity shipped per year, total revenues, percent of annual shipments on each mode, length of time at the present location, distance to barge and rail loading facilities, the importance of logistics costs in their shipping decisions, and the fraction of delivered value of their commodity that represents logistics costs. These questions provided information on current conditions and factors that might affect the shippers' volumes under changes in costs and times.

Within this series of questions, we asked shippers whether and by how much their annual volume would decrease if rates or transit times increased by specified amounts. For each surveyed shipper, a percent increase was randomly selected from the numbers 10%, 20%,

…, 60%. For linguistic convenience, suppose the number was 40%. The shipper was then asked "If the average transportation rate you pay increased by 40%, would your annual volumes decrease?" If the shipper's response was "Yes," then the shipper was asked the follow-up question, "By how much?" Similar questions were asked about increased average transit time, using a different randomly selected prompt. The procedure by which the shippers' responses to these questions were analyzed statistically is described in the next section.

3. Specification

We observe the share that each shipper's volume would be reduced in response to rate and time increases. This reduction has a minimum of zero representing no reduction, and many shippers said that they would continue the same volumes under the increased rates and times. The share reduction has a maximum of 1, meaning that the shipper would not ship anything under the specified rate or time increase. The truncation points are represented though a Tobit model with truncation on both sides. The model is specificed as:

$$y = \beta x + \varepsilon$$

$$r = min(max(0,y),1)$$

where x is a vector that includes the percent increase in rates or time and attributes of the shipper, y is the latent dependent variable that is not truncated, and r is the observed share of quantity reduced, namely, the dependent variable with a minimum of 0 and a maximum of 1 as required. The random variable ε represents factors that affect the quantity reduction but are not observed by the researcher. We assume that ε is distributed normally, with a standard deviation σ that is estimated.

Three generic outcomes are possible, with a different probability formula for each: (1) the shipper can state that its volumes would remain the same, which means $r=0$, (2) the shipper can state that its volumes would fall by a given quantity labeled r* that is greater than zero and less than one, which means $r=r^*$ for "$0<r^*<1$" or (3) the shipper can state that its operations would shut down and it would have no volume, which means that $r=1$.

The probability for these three generic outcomes are as follow. The probability that $r=0$ is $Prob(y \le 0)=Prob(\beta x + \varepsilon \le 0) = Prob(\varepsilon \le -\beta x) = \Phi(-\beta x/\sigma)$, where Φ is the cumulative standard normal distribution. The probability that $r=r^*$ between zero and one is $Prob(y = r^*)=Prob(\beta x + \varepsilon = r^*) = Prob(\varepsilon = r^* - \beta x) = \phi((r^*-\beta x)/\sigma)/\sigma$, where ϕ is the standard normal density. And the probability that $r=1$ is $Prob(y \ge 1)=Prob(\beta x + \varepsilon \ge 1) = Prob(\varepsilon \ge 1 - \beta x) =1-\Phi((1-\beta x)/\sigma)$.

Figure 12 depicts the situation graphically. The upward sloping line is βx , which is the expected or average value of the latent dependent variable. The value of shippers' latent dependent variable is distributed above and below this line due to the impact of unobserved factors ε. These are represented by dots on the graph, above and below the line for any given value of x. The points that fall below 0 are observed as zero. These are denoted by squares. Note, of course, that the observed reduction for a shipper can be zero even if the reduction "predicted" by the line is above zero. The two squares in the third column of dots are examples. The dots that fall above 1 are observed as 1. They are denoted by diamonds.

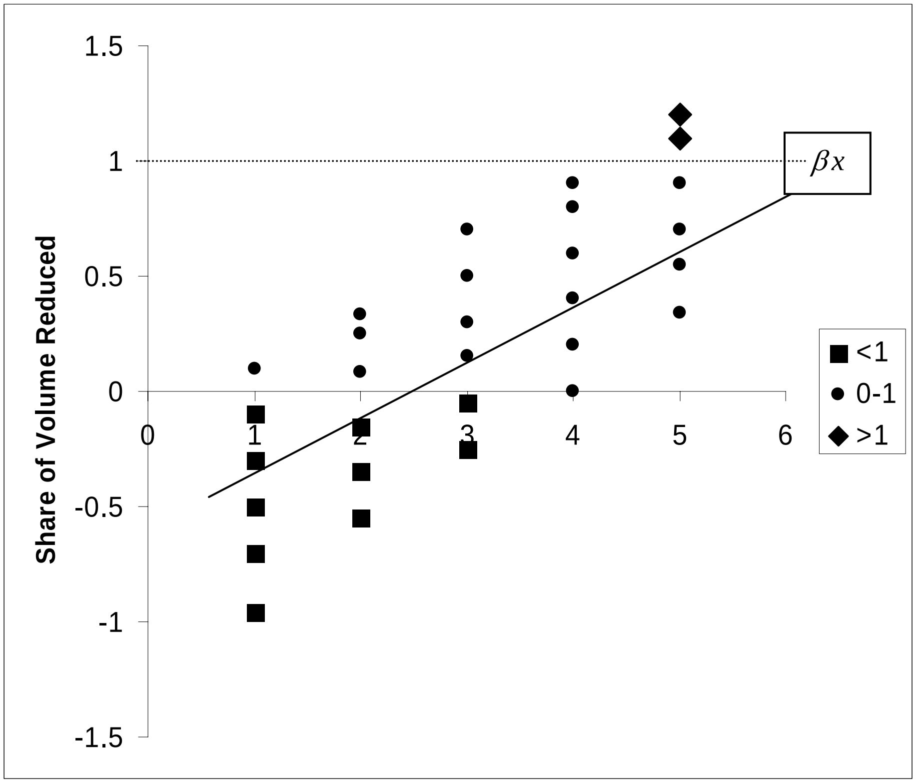
The expected or average reduction for any given value of x is

$$E(r \mid x) = 0 \cdot \Pr ob(r=0) + \int_{r^*>0}^{<1} r^* \cdot \Pr ob(r = r^*) dr^* + 1 \cdot \Pr ob(r=1)$$

$$= \int_{r^*>0}^{<1} r^* \cdot \phi((r^* - \beta x)/\sigma) dr^* / \sigma + 1 - \Phi((1-\beta x)/\sigma)$$

Note that $E(r \mid x) \neq \beta x$ due to the truncation.

Figure 12.—Double Truncated Tobit Model



4. Estimation results

The model was estimated separately for responses to the rate increase and the time increase. The model for is given in Table 12. The rate increase is expressed as a share of the average rates that the shipper currently faces (i..e., a 10% rate increase is entered as .10.) The positive coefficient indicates, since the dependent variable is the amount of reduction, that shippers' volumes drop when the rates they face rise, as suggested by economic theory. The coefficient is highly significant, such that the hypothesis that volumes do not change with rates can be rejected at any reasonable level of significance.

Table 12.--Model of Shippers' Reduction in Annual Shipment Volumes in Response to Increase Transportation Rates

Variable	Estimates	Std. Err.	T-Statistic
Rate increase	.8813	.1646	5.35**
Transportation rates as a share of product value	.7246	.3206	2.26**
Years at current location	-.00171	.00079	2.16**
Barge	.0906	.0783	1.16*
Constant	-.4933	.0956	5.16**
Standard deviation of ε	.3776	.0282	

Number of observation: 353
Mean log-likelihood at convergence: -0.4863
**Significant at 95 percent confidence. *Significant at 75 percent confidence.

The other variables in the model reflect the extent to which shippers differ in their volume reductions. Shippers whose transportation rates represent a larger share of the value of their product reduce their quantities more than shippers whose transportation rates constitute a smaller share of product value. Shippers who have been in their location for many years reduce their volume less than shippers who have more recently established their facilities. This result reflects the greater stability that comes from being long established in a location. Finally, shippers who use barge for at least some of their shipments reduce their volumes more than shippers who do not use barge.

The results of several specification tests warrant noting. (1) We found no significant differences based on commodity type. Apparently, the variable for transportation rates as a share of value captures the reason for any differences over commodities, such that no significant differences remain after controlling for this variable. (2) The survey asked shippers how important logistics costs were in determining the facility location. The answer to this question was found not to relate significantly to the volume reductions. (3) The rate increase was interacted with each of the other variables in the model as well as other variables. None of these interaction terms entered significantly.

We also estimated the model without accounting for the truncation at 0 and 1. Without these truncation points incorporated, the model is a simple linear regression. The results are given in Table 13. The coefficients in Table 13 are considerably smaller in magnitude than those in Table 12. The rate coefficient, for example, drops from 0.88 to 0.35. This difference is expected, since ignoring the truncation generally creates downward bias in the magnitude of the estimated coefficient. The size of the bias in this application indicates the importance of accounting for the truncation points.[17]

Table 13.--Model of Shippers' Reduction in Annual Shipment Volumes in Response to Increase Transportation Rates, Ignoring Truncation

Variable	Estimate	Std. Err	T-Statistic
Rate increase	.3356	.0560	6.17**
Transportation rates as a share of product value	.2893	.1192	2.43**
Years at current location	-.00057	.00029	1.99**
Barge	.0239	.0299	0.80
Constant	-.0350	.0305	1.15*

Number of observation: 353
R-squared: 0.1164
**Significant at 95 percent confidence. *Significant at 75 percent confidence.

Table 14 gives the model based on the time increases about which shippers were asked. The coefficient for the time increase is positive and highly significant, indicating that shippers do indeed reduce their volumes in response to increased transit times. The time coefficient is smaller than that in Table 12 for rate increases: .76 compared to .88. This difference indicates that shippers' volumes are less affected by increases in transit times than by the same percent increase in rates. The difference is not as great, however, as we

[17] We also estimated the model incorporating the truncation at 0 but not the truncation at 1. The estimates were nearly the same as those in Table 12, which suggests that ignoring the upper truncation is not problematic in this application. The reason is clear: few shippers said that their volumes would drop by close to 100%, while many shippers said that their volumes would not change (0 reduction.)

found for shippers' choice of mode and O/D, where median and mean time coefficients were about half of the median and mean rate coefficients.

Table 14.--Model of Shippers' Reduction in Annual Shipment Volumes in Response to Increase Transit Times

Variable	Estimates	Std. Err.	T-Statistic
Time increase	.7580	.1638	4.63**
Transportation rates as a share of product value	1.259	.3210	3.92**
Years at current location	-.00182	.00080	2.29**
Rail	.06615	.0503	1.31*
Constant	-.5414	.0990	5.47**
Standard deviation of ε	.3682	.0280	

Number of observation: 352
Mean log-likelihood at convergence: -0.4697
**Significant at 95 percent confidence. *Significant at 75 percent confidence.

Transportation rates as share of product value and years at current location are both significant and have the same signs as in the model for rate increases. Rail users are found to reduce their volumes more in response to a given transit time increase than non-rail users. This result differs from that for rate increases, for which is was found that the relevant distinction was between barge users and non-barge users. The results for mode in both models combined indicate that the response of volume to *time* is greater for rail users than non-rail users, while the response to *rates* is greater for barge users than for non-barge users. The difference should be viewed with caution, however, since the mode variables enter with only moderate significance in each model.

As with the model for rate increases, the estimated coefficients are considerably smaller in magnitude when the truncation is erroneously ignored, as given in Table 15.

Table 15.--Model of Shippers' Reduction in Annual Shipment Volumes in Response to Increase Transportation Rates, Ignoring Truncation

Variable	Estimates	Std. Err.	T-Statistic
Time increase	.2864	.0544	5.26**
Transportation rates as a share of product value	.4126	.1150	3.59**
Years at current location	-.00050	.00027	1.85*
Barge	.0224	.0182	1.23*
Constant	-.0488	.0299	1.63*

Number of observation: 352
R-squared: 0.1159
**Significant at 95 percent confidence. *Significant at 75 percent confidence.

5. Forecasted reductions in annual shipment volumes

The model in Table 12 was used to forecast the change in volume that the surveyed shippers would incur if their transportation rates increased. The forecasts are given in Figure 13 and Table 16. A 10% increase in the transportation rates of all the surveyed shippers would result in a 3% reduction in volume on average. The arc elasticity is 0.3. This elasticity is considerably smaller than the elasticity of 1.4 obtained in section III for shippers' choice of mode and O/D. This difference in elasticity is expected: shippers will switch to other alternatives for their volume when possible rather than reducing volume. Even though an elasticity of .3 is low, it is not zero (as the test of significance discussed above indicated). Volume changes are indeed one of the many ways that shippers respond to changes in transportation rates.

Analogous forecasts are given in Figure 14 and Table 17 with respect to transit time. As discussed above in relation to the estimated coefficients of the model, the volume reductions in response to time increases are similar to those for rate increases. A 10% increase in transit times induces a 3% reduction in volumes on average, which mirrors the results for rate increases. For large increases, however, the impact of time increases becomes less than that for rate increases. For example, a doubling of rates induces a 42%

reduction in volumes on average, while a doubling of transit times reduces volumes by 34%.

Figure 13.—Predicted Reduction in Annual Shipment Volumes from a Change in Rates.

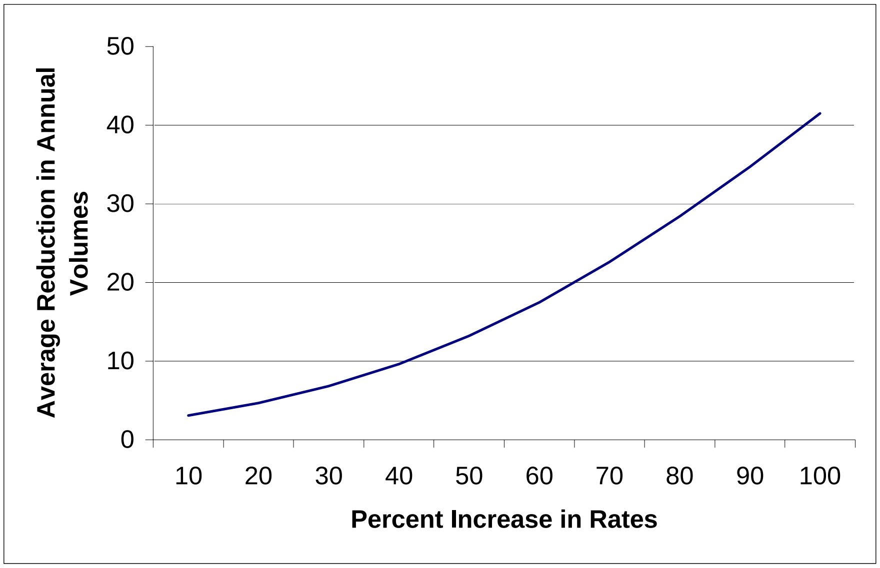


Table 16.--Forecasted share of volumes reduced, on average, in response to increased transportation rates

Percent rate increase	Percent decrease in volume	Arc elasticity
10	3.067	0.31
20	4.655	0.23
30	6.819	0.23
40	9.652	0.24
50	13.22	0.26
60	17.55	0.29
70	22.62	0.32
80	28.39	0.35
90	34.72	0.38
100	41.49	0.41

Figure 14.--Predicted Reduction in Annual Shipment Volumes from a Change in Transit Times.

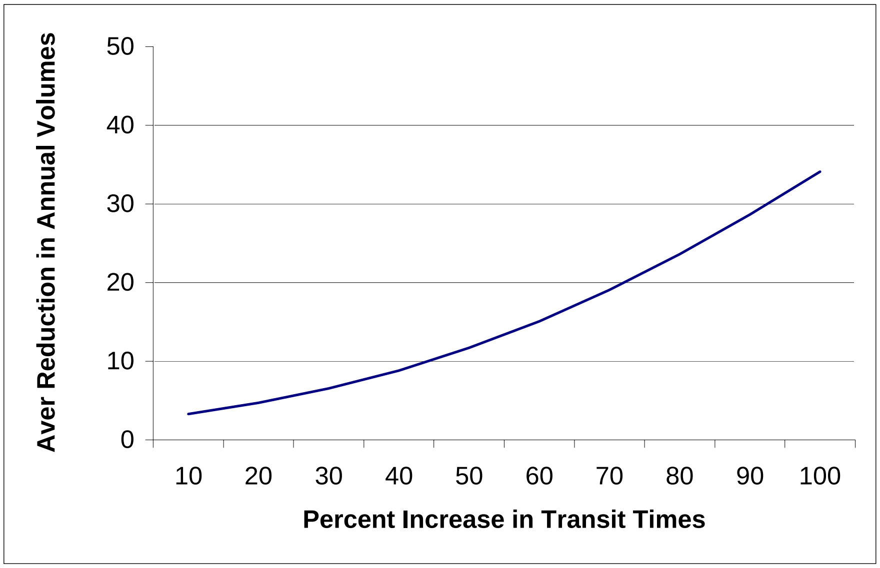
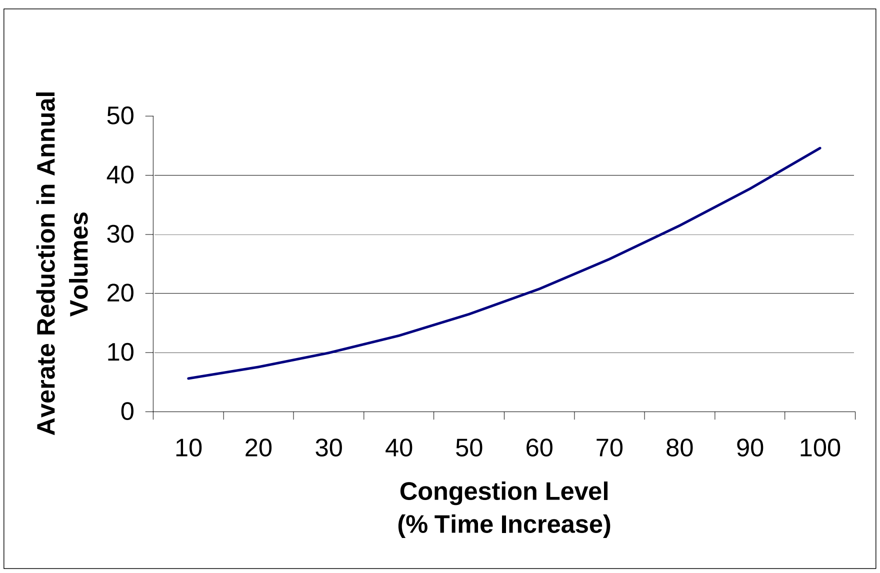


Table 17.--Forecasted share of volumes reduced, on average, in response to increased transportation times

Percent time increase	Percent decrease in volume	Arc elasticity
10	3.296	0.33
20	4.701	0.24
30	6.529	0.22
40	8.844	0.22
50	11.69	0.23
60	15.10	0.25
70	19.09	0.27
80	23.61	0.30
90	28.64	0.32
100	34.09	0.34

As discussed in section III, increases in transit time usually translate into increases in rate, since many rate items are time-related. Figure 15 and Table 18 present the reduction in volumes that is predicted due to increases in transit times and associated rates. The increase in rate is calculated the same as in section III, namely: each percent increase in time translates into a .3 percent increase in rates for shippers who use rail or barge and .5 for shippers who use only truck.[18] Volumes are predicted to fall more under these conditions, of course, than when transit times rise with rates held constant (as for Figure 14 and Table 17.) However, the arc elasticity is still fairly small in magnitude, considerably below the analgous elasticity for shippers' switching mode and O/D.

Figure 15--Predicted Reduction in Annual Shipment Volumes from Time and Resultant Rate Increases



[18] The reductions due to time and cost are assumed to be additive. To the extent that the volume reduction due to time constitutes part of the volume reduction due to cost, this assumption overestimates the magnitude of the total reduction. The predicted total reduction without this assumption is between the numbers given in Table 17 (with no reduction due to cost) and those in Table 18 (with an additive reduction due to cost.)

Table 18.-- Forecasted share of volumes reduced, on average, in response to increased times and the increased rate associated with the increased transit time

Percent time increase	Percent rate increase, avg	Percent decrease in volume	Arc congestion elasticity
10	4.19	5.65	0.57
20	8.38	7.55	0.38
30	12.6	9.95	0.33
40	16.8	12.9	0.32
50	20.9	16.5	0.33
60	25.1	20.8	0.35
70	29.3	25.8	0.37
80	33.5	31.5	0.39
90	37.7	37.7	0.42
100	41.9	44.6	0.46

V. Location choice

A component of the long-run demand for transportation is the location of facilities. To investigate this component of demand, surveyed shippers were asked how long they have been in their current location and how important logistics costs were in determining their location. The responses are summarized in Tables 19 and 20. As shown in Table 20, most shippers rated logistics costs as being very important in determining their locations. However, as indicated in Table 19, most shippers have been in the same locations for many years. Specifically, 85 percent of shippers have been in the same location for over 20 years. Since transportation costs and times have changed over the last 20 years, these two results combined suggest that transportation costs are important in the initial choice of location, but that, given that a facility has been established at a location, the sunk costs are sufficiently high such that movement in response to changes in transportation costs is rare.

Table 19.--Years of Shippers at the Same Location

Years	Frequency	%
0-10	25	6.9
11-20	29	8.1
21-50	139	38.6
51-100	148	41.1
>100	19	5.3
Total	360	100.0

Table 20.--Logistics Costs and Location Decisions

Importance	Frequency	%
1 very important	233	64.54
2	44	12.19
3 somewhat important	43	11.91
4	15	4.16
5 not important	26	7.20
Total	361	100.00

To further examine this issue, we asked shippers how much lower logistics costs would need to be at a different location in order to induce them to move to that location. The responses, summarized in Table 21, reinforce the previous findings: most firms require extremely large differences in transportation rates to change locations. Over 60 percent of the shippers maintain they would not move to another location no matter how low the logistic costs were at the other location.

Table 21.--Percent of Rate Decrease Necessary to Cause a Location Shift

Percent of Rate Decrease	Frequency	%
1-20	17	6.07
21-40	28	10.00
41-60	41	14.64
61-80	10	3.57
81-100	15	5.36
Won’t switch at any decrease	169	60.36
Total	280	100.00

While shippers seem to shift locations little in response to rate changes, in a dynamic industry there is continuous entry. To evaluate the role of new entry and logistic costs, we offered shippers a choice between two locations: one location had lower logistics costs but higher investment costs than the other. 76% of the shippers reported they would choose the location with lower logistics and higher investment costs. In combination, the results regarding location choice suggests that shippers are relatively unwilling/unable to change their existing locations in response to transportation rates, but that new shipper locations can be substantially affected by rates.

APPENDIX A

TRANSPORTATION CHOICE AND SATISFACTION SURVEY

SCRIPT

Identifying an Appropriate Respondent

Hello, my name is _________________________. I'm with Marshall University's Center for Business and Economic Research in Huntington, West Virginia. We're currently collecting information for the US Army Corps of Engineers regarding firm-level freight transportation practices and preferences. I was wondering who at _______FIRM NAME_________ might be able to provide me with this type of information. Great, do you have contact information for Mr./Ms. _____NAME_____?

Introducing the Survey

Hello, my name is _________________________. I'm with Marshall University's Center for Business and Economic Research in Huntington, West Virginia. We're currently collecting information for the US Army Corps of Engineers regarding freight transportation demand and shipper decisions to be used for planning purposes.

To minimize your efforts, what I'd like to do is walk you through a short survey that asks questions about your company's shipment decisions, patterns and costs. The survey should take around 10-15 minutes. All information you provide is strictly confidential. May I proceed? If not, is there a better time that I could call back.

Great, let's get started.

SURVEYOR INITIALS: ____________ **FIRM NAME:** ____________________________

DATE SURVEYED: ____________ **RESPONDENT:**____________________________

SURVEY LIST: ____________ PHONE#: ____________________________

Introduction

1. Where is your firm or facility located: (where does the firm receive to or ship from)

   City ______________ County _____________ State _____________

2. What is the primary commodity your firm or facility transports: ______________

Shipment Characteristics:

3. Consider the very last shipment of __***refer to question 2***___you made. Where did this shipment travel to and from (in the US)?

   From: City _______________ State ______________

   To: City_______________ State_______________

4. On this last shipment, what mode(s) did you use?

Barge	Yes	No
Rail	Yes	No
For-hire Truck	Yes	No
Private Truck (your own firm's trucks)	Yes	No

5. How large was the shipment? ***(just one needed)*** __________ tons

   __________ bushels

   __________ cwt (hundred weights)

6. How long did the shipment take (to reach its terminal point, US)?

   Days __________ Hours ____________

7. Did the shipment arrive on time? Yes No

   If not, how long was it delayed? Days ________ Hours _______

8. Approximately, how far did the shipment travel? __________miles

9. What was the rate for barge? $_________
What was the unit (per ton___, per cwt____, per bushel___, other ____specify_________)

What was the rate for rail? $_________
What was the unit (per ton___, per cwt____, per bushel___, other ____specify_________)

What was the rate for for-hire truck? $_________
What was the unit (per ton___, per cwt____, per bushel___, other ____specify_________)

What was the rate for private truck? $_________
What was the unit (per ton___, per cwt____, per bushel___, other ____specify_________)

Total rates for all modes _____________ Unit of measurement ______________

If a private (they own the trucks) shipment, what is your estimate of per unit cost?

$ ___________

Is that		
	Per ton	_________
	Per bushel	_________
	Per cwt (hundredweight)	_________
	Per mile	_________

Now, we would like some information about the alternatives you have. Suppose you could not ship to or from (SURVEYOR INSERT location from Q3) by (SURVEYOR INSERT mode from Q4),what would you have done?.

10. Would you ship by other modes to and from the same locations or would you choose other locations.

Other mode to same location ___________ Other locations ___________ Shut down ________

If other location, where? From: City _____________State_______________

To: City _____________State_______________

Well, does that mean you would shut down? ____yes _____no

If no, what would you do? FILL IN 10!

11. For this alternative shipment, what mode or modes would you use?

Barge	Yes	No
Rail	Yes	No
For-hire Truck	Yes	No
Private Truck (your own firm's trucks)	Yes	No

12. a. What would be an approximate the rate for barge? $_________

What was the unit (per ton___, per cwt____, per bushel___, other ____specify_________)

b. What would be an approximate rate for rail? $_________

What was the unit (per ton___, per cwt____, per bushel___, other ____specify_________)

c. What would be an approximate rate for for-hire truck? $_________

What was the unit (per ton___, per cwt____, per bushel___, other ____specify_________)

d. What would be an approximate rate for private truck? $_________

What was the unit (per ton___, per cwt____, per bushel___, other ____specify_________)

$_____________ Unit of measurement ________________

13. How long would the alternative shipment be expected to take (to reach its terminal point, US)?

Days __________ Hours ____________

14. How often do similar shipments arrive on time? _________ %

15. Approximately, how far would the alternative shipment travel? __________miles

16. How large would this alternative shipment be?
__________ tons
__________ bushels
__________ cwt (hundred weights)

We now like you to consider what conditions, if any, might cause you to switch from your original shipment to the alternative. Your last shipment was to/from ***(insert question 3 response)*** by ***(insert question 4 response)***. You said your alternative was a shipment was to/from ***(insert question 10 response)*** by ***(insert question 11 response)*.**

17. If the rate of the original choice was ____ percent higher than what you paid, would you make the original choice or the alternative? Original Alternative

If original, by what percentage would rates have to increase to induce a switch to the alternative? _________%

18. If the transit time of the original choice was ____ Percent higher than what you paid, would you make the original choice or the alternative? Original Alternative

If original, by what percentage would times in transit have to increase to induce a switch to the alternative? _________%

19. If the reliability of the mode your chose (i.e., Original Alternative

the percentage of time shipments arrived
on-time) fell by ____ percentage points, would
you make the original choice or the alternative?

If original, by how many percentage points would reliability have to increase to induce a switch to the alternative? _________%

Location decisions

20. How important are or were logistics costs in determining your plants location?
(logistics costs = shipping, handling, inventory)
(1= very important, 3=somewhat important, 5=not important) (Circle the best choice) 1 2 3 4 5

21. How long has your plant been at its current location? ____ years

22. If you were offered another plant location at lower logistics and transportation costs, what percentage lower would these costs need to be to cause you to relocate?
____% lower

23. Suppose you were a start-up business and you were offered two locations with different logistics costs and different investment costs. Location A has ____ lower logistics costs than Location B, but Location A has a ____ higher investment cost.
Investments have a 25-year life and all other relevant factors are the same.
Which location would you choose? (circle either A or B) A B

Perceptions

24. In order of importance, what the most important factors influencing your shipping decisions?

Most important ____

2nd most important ____

3rd most important ____

25. If the average transportation rate you pay increased by ___ percent, would your annual volumes decrease? Yes No

If yes, by how much? _____%

26. If the average transit time you incur (by all modes) increased by ___ percent, would your annual volumes be affected? Yes No

If yes, by how much? ____%

27. What do you consider to be the most important issues facing transportation shippers today?
____

Shipper Characteristics

28. How large is your firm or facility? (THEIR LOCATION ONLY)

Revenues per year _________________

Tons shipped per year ________________

Number of employees ________________

29. What modes do you use to ship your ________ (***insert commodity listed in question 2)***

Barge	Yes	No
Rail	Yes	No
For-Hire Truck	Yes	No
Private (your) truck	Yes	No

30. What percentage of your shipments involve:

Barge: _______%
Rail: _______%
For-hire Truck _______%
Private Truck _______%

31. What is the average price or value of the ______ ***(insert commodity from question 2)*** you pay or receive?

Price __________ Unit of measurement ________ (ton, bushel, cwt (hundred wt.))

Is this the value at your location or at the location being transported to or from? Yours Other

32. How far is the nearest rail loading facility? ___________miles

33. How far is the nearest barge loading facility? ___________miles

34. Do you have loading and unloading equipment for:

Barge Shipments	Yes	No
Rail Shipments	Yes	No
Truck Shipments	Yes	No

35. What fraction of the delivered value of your commodity represents logistics costs (i.e., rate + inventory + handling/landed price)?

____

Thanks so much for your help with this survey!

APPENDIX B

INDEPENDENT TECHNICAL REVIEW OF REPORT

Independent Technical Review Report Compiled by:

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Preface

This appendix provides a compiled documentation of three independent technical reviews of the study sponsored by the U.S. Army Corps of Engineers, Institute for Water resources (IWR) titled, *Shippers' Responses to Changes in Transportation Costs and Times: The Mid-American Grain Study.* The objective of the independent technical review (Delivery Order # 161) is to validate analytical procedures, verify conclusions, and enhance the quality of the said study.

PMCL@CDM was contracted to select two to three independent reviewers to evaluate this written product for IWR. Three external independent reviewers, who remain anonymous to IWR, were selected from a working list qualified peer reviewers that continues to evolve and expand.

The review documents prepared by each reviewer were required to follow a four-section editorial structure that was established in consultation with IWR: 1) summary paraphrasal of study conclusions, 2) summary review statement on validity and quality of findings, and 3) individual comments and issues for resolution. The compiled review report was to also be organized according to the same three-section editorial structure as the individual review documents. Under each major section, reviewer comments were to be organized by reviewer. The compilation of review comments was to be proceeded by a written statement by IWR on its original purpose and objectives for the study being reviewed.

While two of the reviews of the *Mid-American Grain Study* followed the established guidelines on how to organize the review document, the third review document was completed prior to the formulation of the editorial structure guidelines. Rather than modify the review so as to make it conform to editorial structure, it was deemed best to place it at the end of the report in its entirety. This approach reduced the risk of inadvertently influencing the emphasis of the third review document.

Therefore, following this introduction and in adherence to IWR's guidelines, Section I describes the purpose and objectives of the work being reviewed. Section II provides the summary of conclusions as paraphrased by two of the three reviewers, while Section III provides summary review statements on the validity and quality of findings. Individual comments and issues for resolution are provided in Section IV. Finally, Section V provides the review document from the third reviewer.

Note: the page numbers given by the reviewers refer to the draft report dated April 2004. The authors have revised their report in response to the reviewers' comments. The revised report is given above in the body of the current document. The page numbers given by the reviewers therefore do not necessarily correspond to those for the revised report as given above. Appendix C contains replies by the authors to the reviewers' comments.

I. Purpose and Objectives

The purpose of the work being reviewed was to develop an econometric model of shipper demand choices. This econometric model was to be based on optimizing behavior of shippers that use or can potentially use the Upper Mississippi river for shipments of grain and other commodities to market. The model was to estimate the effects of modal (e.g., barge, truck-barge, rail, etc) and market (e.g., New Orleans, Portland, feeder lots, etc) attributes on the shipment choice. The shipment choice was to simultaneously include both choice and quantity shipped.

II. Summary of Study Conclusions

Reviewer 1

This study provides several interesting results, many of which are summarized in the executive summary to the study. These include:

1. The quantity demanded of a particular mode and for transportation in general are both affected by rate and transit time.

2. The arc elasticity of the mode/OD component of demand with respect to transportation charges is 1.38 for 10 percent rate changes and decreases to .62 for 100 percent rate changes. The authors explain that this is due to some shippers being captive – i.e. they do not switch modes/OD no matter how high the rate increase.

3. The arc elasticity of mode/OD component of demand with respect to transit times is .8 for 10 percent time changes and decreases to .45 for doubling of transit times.

4. The total volume of grain transported by any mode also decreases with increases in transportation charges and transit times. However, the total volume shipped is less sensitive to these changes than the modal/OD choice (this makes intuitive sense, since the shipper will switch modes or destinations before reducing

volume). Specifically the arc elasticity with respect to transportation charge is .3 for a 10 percent increase in transportation charge and .4 for a doubling of transportation charge. The arc elasticity with respect to transit time is .33 for a 10 percent increase in transit time and .34 for a doubling of transit time.

5. Existing shipper locations are fairly insensitive to rate changes and transit time changes, but new facilities are highly sensitive to the level of rates and transit times.

6. Incorporating the estimated modal/OD demand function into the USACE's models makes at least three improvements over the previous methodology:

    a. The estimated modal/OD demand function is based on actual or stated shipper choices, not on an assumed relationship,

    b. The estimated modal/OD demand function does not assume that all shipments where barge rate is lower than rail rate would go by barge as in the TCM/EQ model. That is, demand is downward sloping in accordance with economic theory.

    c. The estimated modal/OD demand function does not assume that all shipments where rail rate is lower than barge rate would go by rail as in the TCM/EQ and Essence models.

Reviewer 2

This study uses data collected from 369 grain shippers using a specially designed survey to develop a theoretically based, quantitative model structure to predict the impact of changes in mode cost and/or time on mode choice, origin and destination choice, annual shipment volume and facility location. These models are needed to replace judgmental relationships that have been used for prediction of the response to change in the past.

The primary study conclusions are that

1. It is feasible to develop mode and destination choice, annual shipment and elevator locations models and that the models developed reasonably represent the likely future behavior of grain shippers.

2. The joint elasticity of mode and origin/destination choice to rate increases is in the range of 0.6 to 1.4, depending on the percent rate change (a higher percent change is associated with lower elasticity). The corresponding elasticity to time increases is in the range of 0.4 to 0.8. [It is not clear whether these elasticities are across all shippers or only those for which alternatives exist.] These results are based on a mixture of reported and stated response data.

3. The elasticity of total annual volume to the same changes is substantially lower based exclusively on stated response data.

4. The location of existing facilities is relatively insensitive to increases in transportation times and costs across all modes. However, the choice of new facility locations is reported to be highly sensitive to transportation times and costs (overall times and costs as well as times and costs for available modes and destinations).

5. The quantitative relationships reported can be directly incorporated into the evaluation structure currently used by the Army Corps of Engineers in place of current forecasting procedures.

III. Summary Review Statement on Validity and Quality of Findings

Reviewer 1

Overall, I think the authors did an excellent job of examining the responsiveness of modal/OD decisions to changes in transportation charges and transit times. Further, they did a good job of showing how to implement their findings into the existing USACE models. However, I have two significant concerns related to the study. Specifically:

1. A large percentage of shippers used in the model only have direct access to one mode of transportation (truck). The modal/OD demand model does not address potential differences in transportation charge or transit time parameters that may exist among shippers that have one option versus those that have more than one.

2. There is very little detail related to the shipper selection process. Although the number of shippers by state in the USDA sample is shown, as well as the number responding by state, there is no detail on the CBER selection process or on how much of the difference between USDA and CBER numbers by state was due to response and how much was due to selection.

The following paragraphs will briefly discuss these two issues.

Although the authors' model correctly predicts that captive shippers have a lower elasticity of demand with respect to transportation charge, it still may understate the true elasticity of modal demand with respect to rate changes due to a different relationship between transportation charge and modal choice for captive and competitive shippers. These points are explained subsequently.

The authors' logit model assigns a higher probability to sticking with the chosen mode/OD the greater the difference in transportation charges, holding other factors constant. This is shown by the negative coefficient on cost. As illustrated in a simple logit model (This is a very simplified version of the model presented in the paper. It is not the same as the model in the paper, which uses responses to transportation charge and transit time changes in addition to the transportation charges and transit times for the chosen and alternative mode/OD. The simple illustration is only meant to show implications of the logit model for the forecasts/simulations of responses made.):

$$\log\left(\frac{P_{Best}}{1-P_{Best}}\right)=\beta_0+\beta_1(Cost_{Best}-Cost_{Alt.})+\beta_2(Time_{Best}-Time_{Alt.})$$

$$implies$$

$$P_{Best}=\frac{1}{e^{-[\beta_0+\beta_1(Cost_{Best}-Cost_{Alt.})+\beta_2(Time_{Best}-Time_{Alt.})]}+1}$$

where: P_{Best} = the probability of choosing the best option
$Cost_{Best}$ = the transportation charge on the best option
$Cost_{Alt.}$ = the transportation charge on the next best alternative
$Time_{Best}$ = the transit time on the best option
$Time_{Alt.}$ = the transit time on the next best alternative

In this formulation, a negative sign on β_1 implies that the higher the transportation charge on the alternative mode is relative to that on the chosen mode, the higher the probability of using the chosen mode.

This higher probability of using the chosen mode translates into a lower elasticity of mode choice with respect to transportation charge, as shown in the following:

$$\frac{\partial P_{Best}}{\partial Cost_{Best}}=\frac{-e^{-[\beta_0+\beta_1(Cost_{Best}-Cost_{Alt.})+\beta_2(Time_{Best}-Time_{Alt.})]}\bullet(-\beta_1)}{\left(e^{-[\beta_0+\beta_1(Cost_{Best}-Cost_{Alt.})+\beta_2(Time_{Best}-Time_{Alt.})]}+1\right)^2}$$

$$=\left(\frac{1}{\left(e^{-[\beta_0+\beta_1(Cost_{Best}-Cost_{Alt.})+\beta_2(Time_{Best}-Time_{Alt.})]}+1\right)}\right)\bullet$$

$$\left(\frac{e^{-[\beta_0+\beta_1(Cost_{Best}-Cost_{Alt.})+\beta_2(Time_{Best}-Time_{Alt.})]}}{\left(e^{-[\beta_0+\beta_1(Cost_{Best}-Cost_{Alt.})+\beta_2(Time_{Best}-Time_{Alt.})]}+1\right)}\right)\bullet(\beta_1)$$

$$=\quad P_{Best}(1-P_{Best})\beta_1$$

$$\Rightarrow \varepsilon_{Best,C}=\frac{\partial P_{Best}}{\partial Cost_{Best}}\frac{Cost_{Best}}{P_{Best}}=(1-P_{Best})\beta_1 Cost_{Best}$$

where: $\varepsilon_{Best,C}$ = elasticity of best choice with respect to transportation charge
This shows, as the authors find, that a larger difference in transportation charges between the best choice and the next best alternative (i.e. more captivity) translates into more inelastic demand for the chosen mode (i.e. the larger the difference in transportation charges higher P_{Best}. A higher P_{Best} translates into a lower elasticity in absolute value). This also makes intuitive sense, since shippers that do not have a good alternative will require large increases in transportation charges before they switch modes.

However, in addition to this effect, it is likely that shippers with direct access to only one transportation choice attach an additional inconvenience to using an alternative mode, and therefore, are less sensitive to the differences in transportation charges between the chosen mode and that for alternative modes than if they had direct access to the alternative mode. This would suggest that an interaction term between multimodal access and transportation charge may be appropriate. If such an interaction term is appropriate, and it is excluded, this may bias downward (in absolute value) the parameter estimate on cost for shippers with more than one alternative. This suggests that the elasticity estimates may be understated for shippers with more than one alternative.

This problem is particularly relevant in considering the proposed use of the elasticity estimates. The estimates are used to estimate barge shipment volumes and the benefits of waterway transportation improvements. Thus, all shippers for which these elasticity estimates will be used have access to more than one form of transportation (i.e. barge and truck or barge, truck, and rail). To the extent that the model understates the elasticity of demand for such shippers, the estimated benefits of waterway improvements would be inaccurate.

This problem could easily be addressed by the authors. I suggest that they test for this possibility, and re-estimate the model if the parameter estimates vary by type of shipper (one option vs. two or more options). If the parameter estimates do not vary by type of shipper, this should be stated in the paper.

The second significant problem is with the documentation of the survey process. Because the validity of the results of the entire paper depend on this survey, I think it would be worthwhile to provide more detailed documentation. A short discussion of several aspects of this concern follows.

The paper makes several references to the selection of elevators in the Upper Mississippi River Valley and neighboring states being more prevalent due to the purpose of the survey. The authors should describe specifically how elevators were chosen, the number chosen in each state to survey, and the number responding. The vague discussion about choosing those near the river more frequently is likely to make the reader skeptical of the survey process.

The paper also refers to survey administrators stating one purpose of the study as examining mode choice. This reference may lead some readers of the paper to wonder: *"what else were shippers told about the purpose of the study? Were shippers told that* *this study was being done for the USACE to be used in its methodology for assessing the benefits of waterway improvements?"* An appendix showing the script of the survey administrators would be useful, as it should eliminate questions about the possibility of biased responses.

Again this problem is easily correctable, just requiring additional documentation of the survey process.

Aside from these two problems, which can certainly be addressed, the paper is well written, applies a sophisticated analysis to modal/OD and transportation demand, and represents a major improvement over currently used USACE demand functions. The random utility framework used in the study is sophisticated, yet explained in a very intuitive manner. Moreover, a good interpretation of results and their implications is presented. Finally, the comparison of placing the estimated demand function in the USACE's cost-benefit models with the currently used demand functions is excellent. It provides a useful and intuitive explanation of implications of using the current method and why it is an improvement over previous methods.

Reviewer 2

The overall study is well done using state of the art methods for at least the mode and origin/destination choice portion of the study; arguably the most important component. This is an important advancement as the state of modeling for freight transportation is substantially less well developed than the modeling of passenger transportation. However, there are a number of technical issues that should be addressed to enhance the models and clarify points that are confusing or not adequately explained.

The methodology used for the mode choice portion of the study is based on a combination of revealed (reported) shipping behavior (the most recent choice) and stated intentions about changes under two sets of hypothetical conditions. The combination of revealed and stated intentions data has been widely used in the last ten years and is generally accepted as a satisfactory approach in the absence of an extended period of observation which would allow data collection of changes in behavior in response to actual changes in times and costs. The use of choice models that take account of variations in responses to change across different shippers is a state of the art approach; however, the limitation to a binary choice between the most recently chosen alternative and a self-reported second best alternative fails to take account of the large variety of potential options (both mode and origin-destination alternatives) particularly with respect to origins/destinations. The authors address this point and make a strong, but not necessarily conclusive, justification for this approach.

There are two major issues that should be addressed to clarify the results obtained and provide additional insight into their validity. First, the combination of mode and origin/destination choice into a single binary choice structure makes it impossible to identify the distinct elasticities of these alternatives (change in mode and change in origin/destination). The authors should consider explicitly the issue of the differences in mode and origin/destination changes. This issue can be addressed by segmentation of the estimation in terms of whether the second alternative represents a mode or destination alternative.

Second, the empirical changes in shipping volume and elevator location are based exclusively on stated responses to future scenarios (an increase in average time or cost). The absence of any reported/observed response data raises questions about the validity of the model results. There does not appear to be any immediate approach to resolve this problem. However, this issue can be addressed in the longer term by monitoring changes in shipping volume and location over extended time periods. Such an analysis would require control for other factors (crop production levels and market factors) that influence overall grain shipment volumes.

Two additional issues should be addressed. First, the treatment of shippers who report the absence of any alternatives is not explicitly addressed. In particular, it is not clear whether the reported elasticities apply to the entire data set or only to those shippers for whom alternatives exist?

Second, the question of whether grain producers will switch elevator choice as a result of cost changes by specific modes or destinations is not considered in the study. In particular, it is unclear whether reductions in shipment volumes estimated to occur in response to changes in cost apply to shipments from that elevator or total shipments from the region.

IV. Individual Comments and Issues for Resolution

Specific Comments and Issues from Reviewer 1

1. All sections of the paper. The authors use the term cost to represent transportation charges throughout the paper. This is confusing, as some readers may assume that "costs" are total logistics costs including inventory carrying costs (which are captured in the transit time variable). I think the authors should substitute "transportation charges" for "costs" throughout the paper. This is particularly important for bullet point 7 on page 3. The bullet point talks about transit time having an impact on mode choice in addition to its impact on "costs". By impact on "costs", the authors mean its impact on transportation charges due to increased congestion, but the bullet point sounds like they mean transit time's impact on total logistics costs (through inventory holding costs).

2. Section 1, Page 2, Paragraph 2. The sentence reads, "The 'top-level' finding of the report can be summarized as follow:" It should read "The top-level findings of the report can be summarized as follows:"

3. Section 1, Pages 2-4. The summary of findings is good, but the authors should add a bullet point about how their demand function fits into the USACE models. Moreover, they should include a bullet point about the improvements in waterway benefits analysis that result from including their demand function in the USACE models.

4. Section 1, bullet point 2. "considerably" should read "considerable"

5. Section 2, Page 10, Paragraph 1. "transit-times" should read "speed". Table 6 does not contain transit times, but includes miles per hour. Also, in this paragraph the sentence "Barge movements typically cost less per ton-mile but take longer to travel" should read "Barge movements typically cost the least per ton-mile but take the longest to travel."

6. Section 2, Page 11, Table 6. The title should include speed (not time in transit). Also, the authors should include a column to show the number of responses by mode (they showed responses by origin state, destination state, and commodity in Tables 3-5, why not show responses by mode?).

7. Section 3, Page 13, Paragraph 1. "Engineer" should read "Engineers"

8. Section 3, General. The authors do a good job of laying out the motivation for examining mode/OD responsiveness to transportation charges and transit times. Also, the survey questions were well designed to obtain the data necessary to measure responsiveness of mode/OD to rate and transit time changes.

9. Section 3, Page 17-22. The authors do an excellent job of illustrating the probability of a shipper making mode/OD choices under various changes in cost and time prompts. In particular, Figure 1 on page 18 is very useful.

10. Section 3, Page 28, Paragraph 2. In the last sentence, the authors say "If the modes all somehow had the same cost per ton and transit time, then using the mode that carries more tons is preferable." The authors should add a sentence to explain why using a mode that carries more tons is preferable. The reason why using a mode that carries more tons is preferable is because the loading and unloading costs per ton (which are part of total logistics costs but are not part of the transportation charges paid) would be lower when using modes that can load and unload more at one time. This is another example that shows the need for the authors to clarify that their "cost" is only the transportation charge.

11. Section 3, Page 28, Paragraph 3. The authors discuss a factor that adjusts the time coefficient for shippers of non corn/wheat/soybean movements. The authors should explain in more detail what this factor is. Is it an interaction term between a commodity dummy and the log of time? If so, why take the exponential of this factor's parameter estimate and multiply it by the time coefficient? More explanation of the model is needed here.

12. Section 3, Page 33, Paragraph 1. The method for simulating the change in transportation charges resulting from an increase in transit time is somewhat

questionable (The authors use this simulated change in transportation charge with time changes to simulate switching due to congestion.). Specifically, the authors regressed transportation charge on transit times by mode. This relationship shows how transportation charges change with transit times, but not due to a "congestion effect". Transportation charges will almost always increase with distance (so will transit time). Thus, to measure congestion effects, the authors should obtain the transportation charge – transit time relationship by controlling for distance in their regression. This will show the effect of transit time on transportation charges when distance is held constant.

13. Section 3, Pages 36-47. The authors do an excellent job of laying out the use of demand in the USACE's current benefit-cost methodology, in showing the problems with current demand assumptions, and in showing how their model would be used in the USACE's methodology.

14. Section 3, Page 40, Last Paragraph. The last sentence is misleading. It makes it sound like there is and individual demand curve for each shipment, when individual shipments either use a particular mode or not. The individual shipment doesn't use a little less of the mode if the transportation charge goes up – it either stops using it or continues to use it. In aggregate, the simulated sensitivity of all shipments to rate changes constitutes a demand curve.

15. Section 4, Page 48. The authors may want to specify right away that they are looking at total shipment volume by all modes. Readers may think they are talking about the volume shipped by an individual mode at first.

16. Section 4, Page 48, Last Paragraph. The word "question" should read "questions"

17. Section 4, Page 50, Paragraph 2. "as follow." should read "as follows."

18. Section 4, Page 52, Table 12 (same applies to other statistical tables). The authors should put the level of significance on t-values. For example, Barge is not significant at conventional levels, but a reader of the table that does not know t-statistics may not know this.

19. Section 4, Page 53. The comparison to the simple linear regression is excellent, and shows why it is important to account for truncation.

20. Section 4, Tables 14 and 15. The variable "cost increase" should be "time increase"

21. Section 4, Page 58, Paragraph 1. The word "conditions" is misspelled.

22. Section 6, Page 60, Paragraph 1. The word "demands" should read "demand"

23. There is no Section 5.

Specific Comments and Issues from Reviewer 2

The following comments are grouped by broad categories of relevance to the validity/usefulness of the study and study results.

General Issues

1. It would be useful to distinguish between shippers who are captive to each mode (presumably none are captive to a single destination), those who have modal options but are insensitive to changes in time, cost or both and those that actively choose among a range of options. Elasticity results should clearly identify whether they apply to all shippers or only to those who have available options.

2. The sample (which is already small) is further reduced, for the purpose of choice modeling, by those shippers that have no available alternatives (98 of 366 observations) and other causes (60 of 268) resulting in a usable sample of only 208 cases.

3. Approximately 35 shipments reported by shippers for which barge is an option. If the same percent of modal availability applies to the estimation data, that data includes only about 20 cases for which barge is an available option. This is a small number to make accurate inferences about switching behavior for a study of impacts of changes on the times and costs of barge shipments. Further, it would be useful to know the exact number of cases in the choice estimation data for which barge is the chosen alternative and for which barge is the best alternative or both.

4. It is not clear if the shipment origin is the grain elevator or the crop location. If it is the grain elevator, there is no origin choice, only mode and destination choice. If it is the crop origin, the issue of producer choice of elevator must be taken into account.

Survey Design and Descriptive results (Generally, the only action to be taken is clarification in the report.)

5. The basis for selecting/obtaining 369 completed (366 usable) observations from a population of 6467 elevators with multiple shipments should be explained. What criteria and procedure(s) were used to select shippers to be sampled? What is the distribution of respondents/non-respondents and what factors influenced the response rates for different shippers? How did the time period of the survey correspond to the shipment of different crops? That is, to what extent is the sample random (stratified random) and representative of total shipments?

6. The stated preference responses are to increasing time or cost of the chosen alternative. No questions are asked about the response to decreasing time or cost of the chosen or second best alternative. Since the model is to be applied to cases of potential timesavings, this may limit the validity of the model in the prediction range. This would seem to be a relatively minor issue, as model formulations are generally not tested for consistency across ranges of increasing and decreasing attribute values.

7. The data and study are heavily dependent on stated responses (2 of every three choice responses and all volume and location responses). This raises questions about the reliability of the results.

8. Tables 3, 4 and 5 report the grain, origin and destination for single shipments. This information should be supplemented with information about the distribution of total shipments or volume by grain, origin and destination for each elevator. Further, if origin choice is relevant, it would be useful to report the spatial results in an origin-destination matrix.

9. References to “essentially captive” shipments/shippers might better be replaced with “time/cost insensitive shippers.”

10. The alternative choice data includes 211 cases of mode change, 57 cases or origin-destination change and 98 cases where no change was possible. No cases of mode and destination change are reported. There is no basis to evaluate whether this distribution of possible changes is representative of the market.

Choice Model Specification, Estimation and Interpretation

11. The model specification (variables included and their functional form) is reasonable and well justified. However, estimation is based on only 208 observations; a small sample for the purpose especially since on around 10% of those observations include barge is the chosen or best alternative. A variety of other variables should be considered for inclusion. These include:

    a. Partial (some variables) or full (all variables) segmentation of mode change and destination change data should be undertaken. Full segmentation requires estimation of distinct models for cases where the second best alternative includes a mode change or a destination change. Partial segmentation requires replacement of any selected variable by two variables (one that applies to cases of destination change and another that applies to cases of mode change).

b. Distinct rail and barge dummy variables for different types of grain. These can be tested for each grain type or for the two groups of grains determined to have significantly different time factors.

c. Cost factor(s). These are similar to the time factor in the model and can be tested for each type of grain of for the two groups as above.

d. Multiple time factors instead of one distinguishing two groups of grain. These should be considered for inclusion even if not significantly different if they are of a magnitude to indicate substantially different responses. [The factor of 2.2 between the two groups used is great enough to encourage inclusion of intermediate factors.]

e. Cost and/or time variables relative to the value of each commodity. Such variables can replace the use of cost and time factors to represent different sensitivity in terms of grain value.

f. Destination variables. Variables describing the capacity, types of loading facilities, ongoing modes, delay time, etc. at different destinations are likely to influence destination changes and may influence mode changes if such changes are associated with any change in destination characteristics.

12. If origins are distinct, similar consideration of origin characteristics should be considered.

13. It would be useful to include variables to test whether responses differ for those cases in which barge is the reported or alternative choice. This can be undertaken by full or partial segmentation of cases for which barge is the chosen alternative, the second best alternative, both or neither. Such segments are unlikely to be significant due to the small sample but will provide qualitative insight into the question of whether a change to or from barge is similarly to a change between other modes.

14. Joint estimation across reported and stated or "what if" responses is a useful way to examine variable changes outside the range of current data. However, models pooled over these distinct data should include inertia variables (resistance to change partially related to self-justification in reporting) and differential scaling (to represent different error distributions for reported and "what if" 'choices') is consistent with current practice.

15. The description of the increased importance of costs for 'other' products indicated by the model does not include any discussion of the reasonableness of this result. The most logical explanation is that the value of these crops is different than that

of other crops. The lack of significance of cost coefficients within the two groups identified in model does not necessarily justify excluding these from the model as the differences may be important even if not significant.

Prediction of Future Demand Changes in Mode

The prediction of future demand is based on 1900 barge shipments and a pre-identified best alternative for each. This does not allow for any case in which a response to time or cost change or a change in other circumstances results in a switch to barge. Further, it does not allow for the possibility that a currently third best alternative could improve to an extent that makes it the best or second best alternative.

16. The current methods (TCM/EQ and Essence) consider only whether barge shipments are diverted. Under the assumptions embedded in these models, a decrease in time or cost will have no impact on barge traffic; only on the benefits to existing barge shippers.

17. Predictions using the new model will indicate some probability of barge and the second alternative for all 1900 cases. This appears to be more realistic except that the prior selection based on choice of barge seems likely to bias the results in unknown ways.

18. The benefit estimation would appear to be biased in an unknown way due to considering only existing barge shipments in the prediction sample.

Impact of Cost and Time on Annual Shipment Volume

The questions to which shipper's responded describe an average increase in time or cost. The distribution of the time or cost increase across modes and destinations is not specified. The model, a doubly truncated Tobit model is reasonable for the case at hand although other models (such as a binary logit share model) could be used. This importance of using the Tobit model (or an alternative model that takes account of limits in percent change is highlighted by the differences in the parameter estimates for the cost model based on data, which is or is not truncated.

The estimated Tobit volume response to cost model has reasonable results. The inclusion of cost relative to product value is desirable. The inclusion of a barge dummy variable is useful but considering its lack of significance, replacement by the fraction of shipments or tons by barge should be considered.

Essentially, the same comments apply to the volume response to time model. In this case, it would be desirable to test a fraction of shipments or tons by rail as a substitute for the rail dummy variable. [Note the labeling error on the first variable.]

The predicted responses to changes in time and cost appear to be reasonable. Comparison to the elasticity of mode changes is consistent with expectations.

V. Technical Review by Reviewer 3

Summary and Assessment

Kenneth Train and Wesley Wilson (TW) have developed and applied an econometric methodology to analyze agricultural shippers' demand for freight transportation modes. The demand models will be used to assess the costs and benefits of potential projects to improve the nation's waterways. In my view, this study represents a marked improvement over previous methodologies used by the Army Corps. The theoretical foundations of the methodology are clearly and nicely illustrated on an original body of data. The study provides an excellent foundation for refinements that will have a significant impact on the project evaluations by the Army Corps. I have no major criticisms. My comments have two purposes. First, it is my understanding that there will be some follow-up studies based on the TW study; hopefully, my comments will be of some use for these studies. Second, my comments may be helpful to the authors if they wish to publish their research in an academic journal. I will organize my comments by various sections.

Sample/Data

The survey focuses on the last shipment that was made. I understand that TW wanted to make sure that the shipments in the sample were representative. As an alternative, one could ask directly for a *representative* shipment. I am not sure this would be an improvement, but it may be worth considering for future surveys.

In terms of the data themselves, it would be interesting to try to validate some of the responses for the next best alternatives. For example, in question 12 are the barge, rail, and truck rates consistent with what people say when they actually use these modes? It also might be helpful to ask private truck users whether thy have a backhaul that they could transport. This could dramatically lower the cost of using private trucking. Finally, in table 6 I thought the rail rates seemed a bit high (I thought they would be closer to 2 cents per ton-mile like estimates for other commodities) and that the "comparative advantage" of truck is reversed for agricultural commodities. That is, rail is thought to be attractive for shorter hauls because truck has a major service time advantage.

Generally, the discussion about the reasonableness of the data should explicitly focus on whether there are any obvious implications for bias. Of course, the data may not be completely consistent with a random sample, but the point to stress is whether one has any reason to believe that the key coefficients will be biased in a particular way.

Theory/Specification

It would be useful for TW to provide a general discussion of shipping behavior. Who makes the decision the shipper or receiver? How does the decision making fit within the context of the firm? What theoretical models are appropriate? The literature contains freight demand models based on expected utility maximization, profit maximization based on inventory behavior, cost minimization, and so on. Some discussion of the previous literature would be helpful.

The key methodological innovation is combining RP choices with SP data on the next best alternative. I think it might help if TW use a multinomial RP model as a starting point and argue why their approach makes a reasonable compromise between data availability and realistic choice behavior.

It would also be worthwhile to at least mention the value of using a joint discrete/continuous model to estimate mode, shipment size, and shipment frequency. Thus, one could analyze how transport rates and time affect shipment volume (shipment size times frequency) accounting for modal substitution.

The basic specifications were sound. One key variable that was not in the model is a measure of service time reliability. Service time reliability is particularly important in this context because there is concern about congestion. Traffic congestion affects the mean and some measure of the dispersion of travel time. TW asked questions about delay in their survey (questions 6 & 7) but did not discuss the problems with these responses. In any case, TW should mention the potential importance of this variable and future surveys should try to include questions that measure service reliability.

The other variable that previous researchers have used in their freight demand models is the value of the commodity. For example, high valued commodities tend to be shipped by truck and low valued commodities tend to be shipped by rail. TW might report the range of commodity value in their data and if the range is sufficiently wide it might be possible to interact commodity value with other explanatory variables.

Interpretations of Results

1. On page 28, TW suggest that the dummies may reflect a scale effect. I would suggest what might be going on is that shippers may experience unanticipated

demand that requires them to make large shipments. Thus, rail and barge are preferred because they have the capacity to address problems that may arise when demand is unexpectedly large.

2. At the bottom of the page, estimates may vary for different commodities because of their susceptibility to damage and spoilage.

3. On page 29, it would be helpful to provide some actual data that shows that delivered prices are higher for longer distance trips.

Calculations

1. It would be useful to present elasticities that account for tonnage shipped.

2. I generally like to focus on generic coefficients for modal attributes. TW could test, however, whether time and cost coefficients vary by mode. I don't see why the cost coefficients would vary, but there may be variation in the time coefficients.

3. Finally, the time and cost coefficients should be combined to estimate the value of shipment time. Then this value can be divided by shipment value to determine shippers' implicit discount rate. This parameter would be quite useful and verify the plausibility of the model.

APPENDIX C

AUTHORS' REPLIES TO REVIEWERS' COMMENTS

We are very grateful for the thorough and insightful reviews. We have revised the report and performed additional empirical analyses as suggested by the reviewers. In this appendix, we address each of the reviewers' suggestions and describe how we revised the report and/or investigated the issue that was raised. In our descriptions below, we identify the statement to which we are responding by giving the section and item number of the statement within Appendix B. Our responses are therefore most usefully read in conjunction with Appendix B, rather than as a self-contained document. We respond only to the reviewers' suggestions for changes and/or additional analysis. We do not respond to their general comments, since their specific suggestions arise from their general comments.

<u>Appendix B, Section III, Reviewer 1, point 1</u>: We tested whether model parameters are different for shippers who have only one mode available (truck) and those who have multiple mode options. No significant differences were found. It seems that two countervaling forces are operating with respect to this distinction. First, shippers with no mode options are likely to be less able to respond to changes in rates and times than shippers with multiple mode option, as Reviewer 1 suggests. Also, however, shippers who use truck tend to be more readily able to switch destinations than shippers who use rail or barge. The net result, at least as evidence by our data, is that these two tendencies balance out, such that there is no significant difference.

A note is useful with respect to these tests and all the other tests that we report below. If the sample size were larger, then tests of differences would be more powerful. The IWR plans to undertake another, more extensive survey that will allow more powerful testing of these issues.

<u>Appendix B, Section III, Reviewer 1, point 2</u>: We revised the report to provide more information on the shipper selection process. We omitted the questionable statements that the reviewer identified. The script that the surveyers used when contacting shippers is now included in Appendix A.

We think that it is important to state that we feel that the most important limitation of the current study is the small sample size and the possibility that it is not representative. We have no reason to believe that any particular bias has been introduced. However, we would be more confident with a larger and more demonstrably representative sample. This, we understand, is the goal of the IWR in its plans for another, more extensive survey.

<u>Appendix B, Section III, Reviewer 2, first major issue</u>: We tested whether model parameters are different for shippers whose alternative is a different destination from

those whose alternative is the same destination but a different mode. No significant differences were found.

Appendix B, Section III, Reviewer 2, second major issue: We agree that it would be useful to verify that the stated responses of the shippers conform to what they actually do when facing a rise in rates and times. As the reviewer points out, this verification cannot be performed with the existing data and would require monitoring of shippers' actions over time when rates and/or times change.

Appendix B, Section III, Reviewer 2, first additional issue: We provide information about this issue in our response to "Appendix B, Section III, Reviewer 1, point 1" above, since Reviewer 1 raised the issue also.

Appendix B, Section III, Reviewer 2, second additional issue: We did not explicitly investigate whether grain producers will switch elevators, and we are not able to do so with our existing data. The surveyed shippers' answers to the questions about reductions in total volumes shipped in response to changes in rates and time (and therefore our model of volume reductions) would take this effect into account, to the extent that the shipper was able to anticipate this effect. However, a survey of grain producers would be useful in investigating the issue explicitly. We agree that it is an important issue.

Appendix B, Section IV, Reviewer 1, point 1: We changed the word "costs" to "rates" throughout the report, since, as the reviewer noted, costs include items such as inventory costs that are not included in rates. We used the word "rates" rather than "charges" since "rates" is the more common term.

Appendix B, Section IV, Reviewer 1, points 2-7: We have made all of these editorial corrections and changes in the report.

Appendix B, Section IV, Reviewer 1, point 10: We have added this reason for the result that carrying more tons is preferable, holding rates and time constant.

Appendix B, Section IV, Reviewer 1, point 11: We have provided a better and more complete explanation of this adjustment parameter.

Appendix B, Section IV, Reviewer 1, point 12: The purpose of the regression was to assess the impact of transportation times on rates, including time differences due to distance. If distance were included as a separate variable, then the time coefficient would only capture part of the relationship between time and rates.

Appendix B, Section IV, Reviewer 1, point 14: This sentence has been changed to avoid the misleading implication.

Appendix B, Section IV, Reviewer 1, point 15: The description of volumes now states immediately that the volumes are for all modes and O/Ds.

Appendix B, Section IV, Reviewer 1, points 16, 17: The corrections have been made.

Appendix B, Section IV, Reviewer 1, point 18: All of the tables that contain model estimation results have been amended to include significance levels.

Appendix B, Section IV, Reviewer 1, points 20-23: The corrections have been made.

Appendix B, Section IV, Reviewer 2, point 1: See discussion of "Appendix B, Section III, Reviewer 1, point 1" above.

Appendix B, Section IV, Reviewer 2, point 2: As stated above in relation to "Appendix B, Section III, Reviewer 1, point 2", we are also concerned about the small size of the sample.

Appendix B, Section IV, Reviewer 2, point 3: We have added the number of respondents by mode to Table 6.

Appendix B, Section IV, Reviewer 2, point 4: The shipment origin is the elevator location in most cases, but need not be. A shipper at an elevator can arrange for a shipment from a location other than the elevator to some destination.

Appendix B, Section IV, Reviewer 2, point 5: See discussion of "Appendix B, Section III, Reviewer 1, point 2" above.

Appendix B, Section IV, Reviewer 2, point 6: We agree with this concern, that the stated preference questions are in respect to rate and time increases, with no analysis of decreases. This aspect of the questions is consistent with the ACE planning models: the time and cost on the river is forecast to rise over time under base conditions, and then waterway improvement are examined that reduce the amount of rise (i.e., that reduce rates and times relative to the future base conditions but are higher than under present-day conditions.) Nevertheless, we agree that it would be useful to examine responses to rate and time decreases.

Appendix B, Section IV, Reviewer 2, point 7: True. Unfortunately, this reliance is unavoidable unless large changes in rates and times can be observed in the real-world conditions.

Appendix B, Section IV, Reviewer 2, point 8: Table 6 contains tonnage information by mode. We do not report tonnage by O/D and commodity aggregated over mode (i.e., in Tables 3-5) because the mode differences are so great that data on tonnage aggregated over mode and yet disaggregated by commodity and O/D are not meaningfully interpretable.

Appendix B, Section IV, Reviewer 2, point 9: We changed the phrase "essentially captive" to "rate/time insensitive," as suggested.

Appendix B, Section IV, Reviewer 2, point 11a: See discussion of "Appendix B, Section III, Reviewer 2, first major issue" above.

Appendix B, Section IV, Reviewer 2, point 11b and c: We tested whether the barge dummy, rail dummy or rate coefficient differ for the two commodity groups. No significant differences were found.

Appendix B, Section IV, Reviewer 2, point 11d: We tested whether the time coefficient differed over other commody types, mode, or whether the shipper faced one or multiple mode options. No significant differences were found.

Appendix B, Section IV, Reviewer 2, point 11e: The rate and time variables enter the model in log terms. Dividing the variables by the value of the commodity would have no impact on the estimated coefficients (since $ln(c_i/v)=ln(c_i)-ln(v)$ such that $ln(v)$ enters each alternative and hence does not affect the difference between alternatives, where c_i is the rate or time for alternative i and v is the value of the commodity.) The models can therefore be equivalently viewed as having rates and/or times normalized for commodity value.

However, the reviewer's point indicates a concern about whether the responsiveness of shippers is related to the magnitude of transportation rates and time relative to the value of their commodity. The survey includes information for each shipper on the shipper's logistics costs as a percent of the value of the commodity. We tested whether the cost or time coefficients vary with this attribute of shippers. We found no significant relation.

Appendix B, Section IV, Reviewer 2, point 11f: The only generic variable that we have on the destination of the shipment is a dummy for whether the shipment is to the river. We tested whether model parameters differed on the basis of this variable and found no significant differences.

Appendix B, Section IV, Reviewer 2, point 12: We tested for differences in model parameters with respect to whether the shipper has rail/barge facilities available and distance to rail/barge facilities. No significant differences were found.

Appendix B, Section IV, Reviewer 2, point 13: We tested for differences in model parameters with respect to whether the shipper used barge for the last or alternative shipment. No significant differences were found. Note that this test is different from the tests of mode-specific rate and time coefficients, discussed below in relation to "Appendix B, Section V, Reviewer 3, Calculations, point 2."

Appendix B, Section IV, Reviewer 2, point 14: We tried an inertia variable for the stated preference choices but were not able to obtain convergence when it was included. We think that this lack of empirical indentification reflects the comparatively small independent variation in rates and times in the revealed preference data. We did not attempt to estimate a separate scale factor for the stated preference choices relative to the revealed preference choices. The stated preference questions, and the model that is used for estimation, is different from those in which different scale factors are traditionally estimated. In the traditional setup, a respondent is presented with several hypothetical options and asked to choose among them. The variance of quixotic factors that affect the respondents' choices can easily differ from the variance of unobserved factors in the real world, implying a different scale factor. In our setup, the respondent is comparing the last shipment under a change in time or rates with the best alternative. Both of the alternatives are real-world alternatives, and the only hypothetical change is in an observed variable (rates or times). The unobserved portion of utility is definitionally the same in this kind of stated-preference choice as in the revealed-preference choice. A separate scale factor therefore does not have the same justification as in the traditional stated preference setups.

Appendix B, Section IV, Reviewer 2, point 14: We added this explanation in the report.

Appendix B, Section IV, Reviewer 2, point 18: This potential bias is avoided by forecasting the impact of changes on barge shippers *conditional* on these shippers having chosen barge. This is an aspect of implementation of the model into the ACE planning tools for benefit calculation.

Appendix B, Section IV, Reviewer 2, second and third paragraphs under Impact of Cost and Time…: We tried entering the percent of tons shipped by barge and rail, but these variables were less significant that the barge and rail dummies.

Appendix B, Section V, Reviewer 3, second paragraph under Sample/Data: The rate and time data that respondents provided for their next-best alterative were compared to the rate and time data for the last shipment, and no obvious inconsistencies were found. The survey did not ask truckers about backhaul, and we agree that this information would be useful for future analysis.

Appendix B, Section V, Reviewer 3, third paragraph under Theory/Specification: A full model of shipment generation (frequency and tonnage), O/D and mode, with all alternatives specified, would clearly be the best approach in theory (ie, without considering constraints on data, funds, and time.) As we understand, IWR and ACE are considering starting the process to develop such a model. We constructed our analysis to be consistent with the current ACE planning models, so that our results could be incorporated into those models and provide an improvement in methodology without a full over-haul of the model systems.

Appendix B, Section V, Reviewer 3, fourth paragraph under Theory/Specification: We did not include reliability because the survey did not ask for information on the reliability of the last shipment. We have added the needed questions to the survey instrument, for use in future surveys.

Appendix B, Section V, Reviewer 3, fourth paragraph under Theory/Specification: See the discussion above in relation to "Appendix B, Section IV, Reviewer 2, point 11e."

Appendix B, Section V, Reviewer 3, Interpretation of Results, points 1 and 2: We have added these alternative interpretations to the report.

Appendix B, Section V, Reviewer 3, Interpretation of Results, point 3: Unfortunately, we do not have such data. We retained the explanation, however, since it seems reasonable.

Appendix B, Section V, Reviewer 3, Calculations, point 1: Elasticities are higher for shippers with low tonnage than for those with higher tonnage. Table C1 below gives the arc rate elasticities for two groups of shippers, those with tonnage above the median tonnage and those at or below the median. These figure are equivalent (i.e. were calculated the same) to those in Table 9, except that Table 9 is for all surveyed shippers and those below are for the two groups separately. Elasticities with respect to time follow the same pattern, with high-tonnage shippers being less elastic than low-tonnage shippers. These differences in elasticities reflect the fact that elasticities vary with respect to all the factors that enter the models. Because of this fact, the elasticistices given in the report need to be used with caution since they are not necessarily useful indications of elasticities for subgroups of shippers. For any subgroup, the model can be used to calculate elasticities that are appropriate for that subgroup.

Table C1.—Arc elasticity for switching to best alternative if their transportation rates rise.

Percent rate increase	Shippers with above-median tonnage	Shippers with median or below-median tonnage
10	0.93	1.75
20	0.84	1.54
30	0.77	1.37
40	0.71	1.22
50	0.66	1.10
60	0.61	1.01
70	0.57	0.92
80	0.54	0.85
90	0.51	0.79
100	0.48	0.73

Appendix B, Section V, Reviewer 3, Calculations, point 2: We tested whether the cost and time coefficients differ by mode. No significant differences were found.

Appendix B, Section V, Reviewer 3, Calculations, point 3: The estimated distribution of time and cost coefficients imply that the median ratio of the time coefficient to the rate coefficient is 0.60. This implies that, at the median, a 10% increase in transportation time is considered to the equivalent to (i.e., as onerous as) a 6% increase in rates. It is not clear to us how this estimate combined with commodity value would provide information about implicit discount rates.

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The centerpiece of these efforts will be a suite of simulation models. This suite will include:

- A model for forecasting international and domestic traffic flows and how they may be affected by project improvements.
- A regional traffic routing model that will identify the annual quantities of commodities coming from various origin points and the routes used to satisfy forecasted demand at each destination.
- A microscopic event model that will generate routes for individual shipments from commodity origin to destination in order to evaluate non-structural and reliability measures.

As these models and other tools are finalized they will be available on the NETS web site:

http://www.corpsnets.us/toolbox.cfm

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