Understanding Waterway Investments

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NETS:
Navigation Economic Technologies Program

A program designed to advance the ACE expertise by developing state of the art tools and techniques for economic modeling and analysis.

- Four basic standards
  - Grounded in Reality
  - Intuitive and transparent
  - Verifiable
  - Transportable

NETS-Research

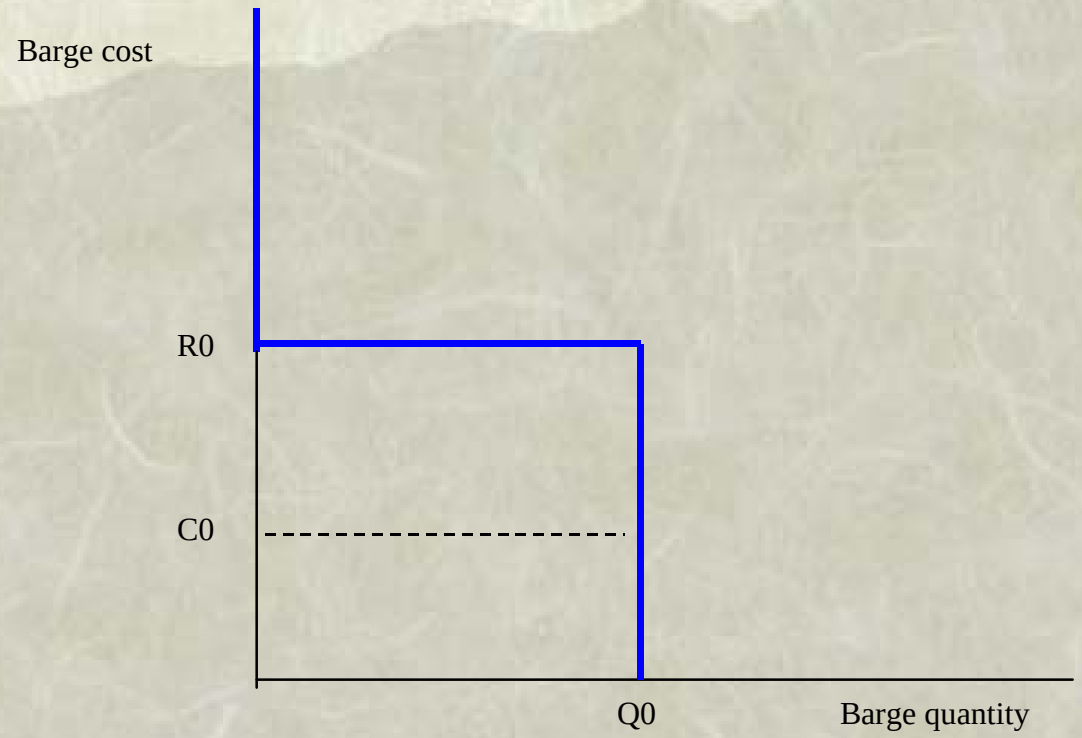
- The basic research is being conducted by a set of academic economists along with a variety of ACE and other waterway experts.
- The research is being reviewed by ACE and Academic outside reviewers.
- There are lots of studies that are going-on under NETS. These include:
  - Demand studies (Kenneth Train, Kenneth Boyer) Kenneth Casavant, Mark Burton, Eric Jessup)
  - Supply studies (Gene Griffin and Jill Hough)
  - Forecasting studies (Mark Thoma, William Wilson)
  - Spatial Equilibrium (Simon Anderson)
  - International Trade and Transportation (Bruce Blonigen)

Mid-American Grain Study
by
Kenneth Train and Wesley Wilson

*"**Price responsiveness 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)

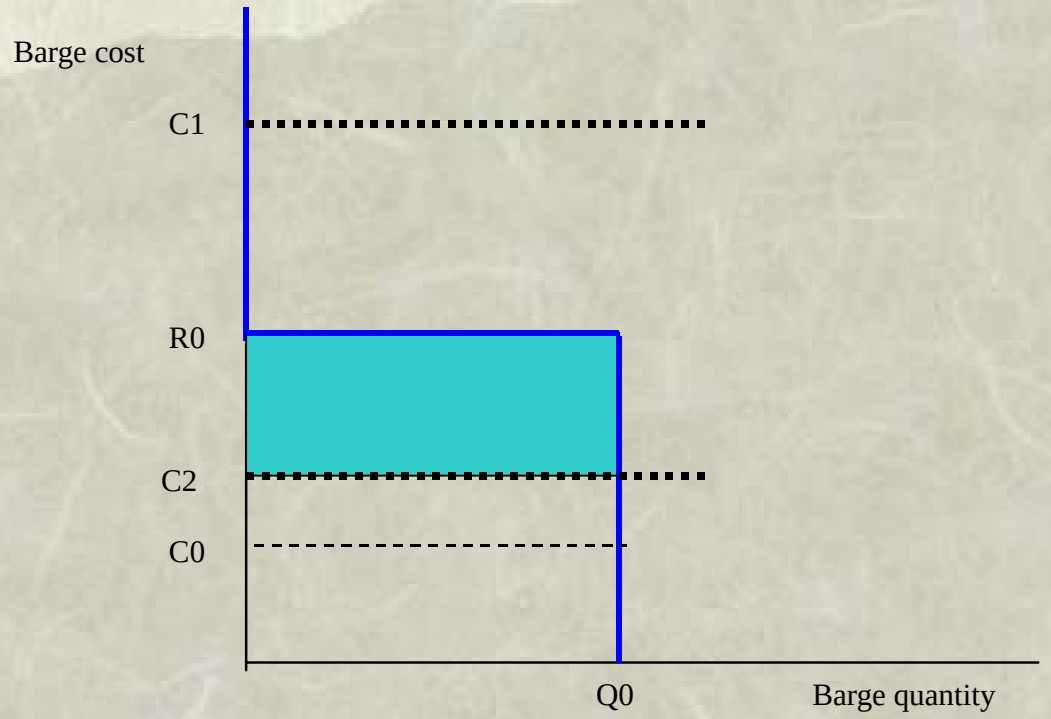
National Research Council (2004)

Demand Curve in the Tow Cost Model

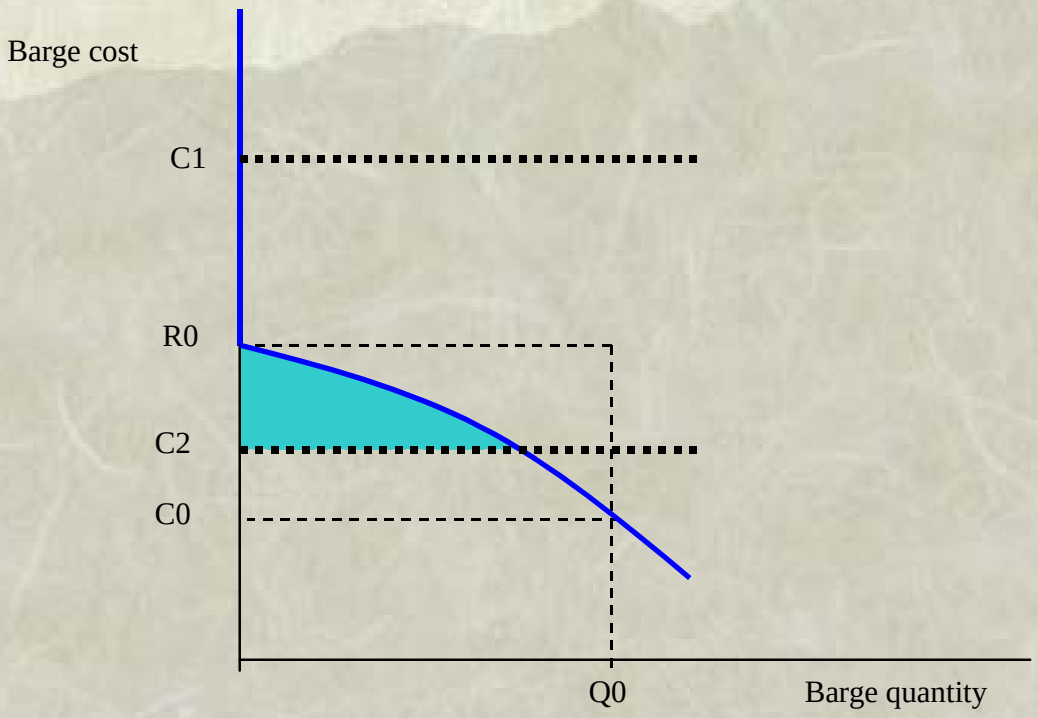


Demand curve in Essence

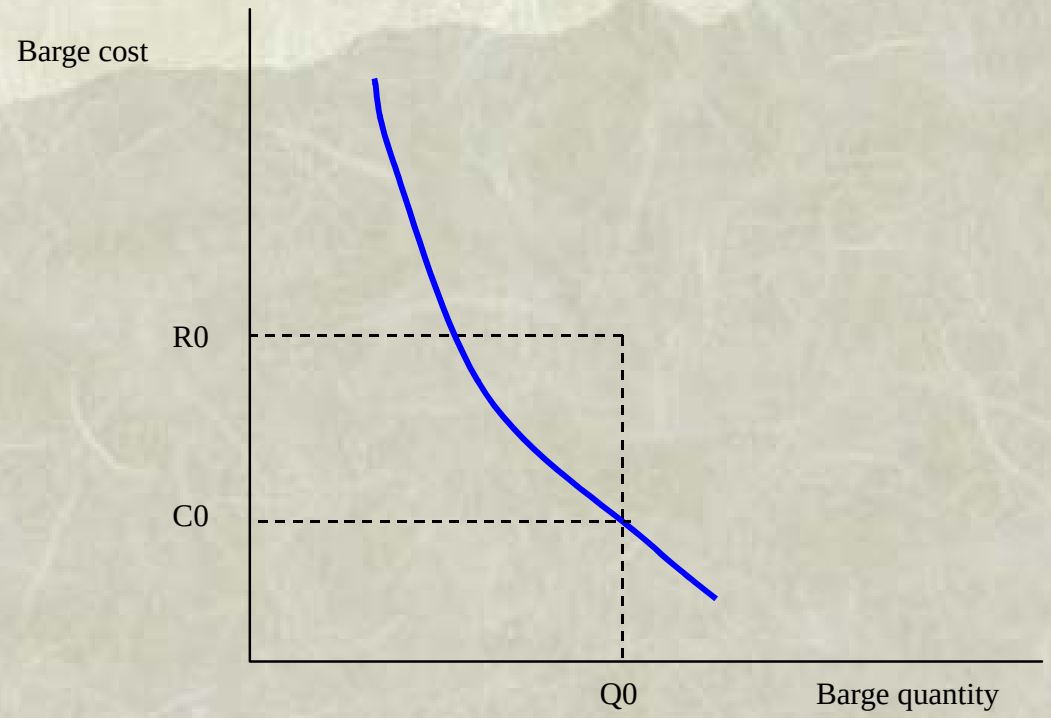
Benefits in TCM/EQ



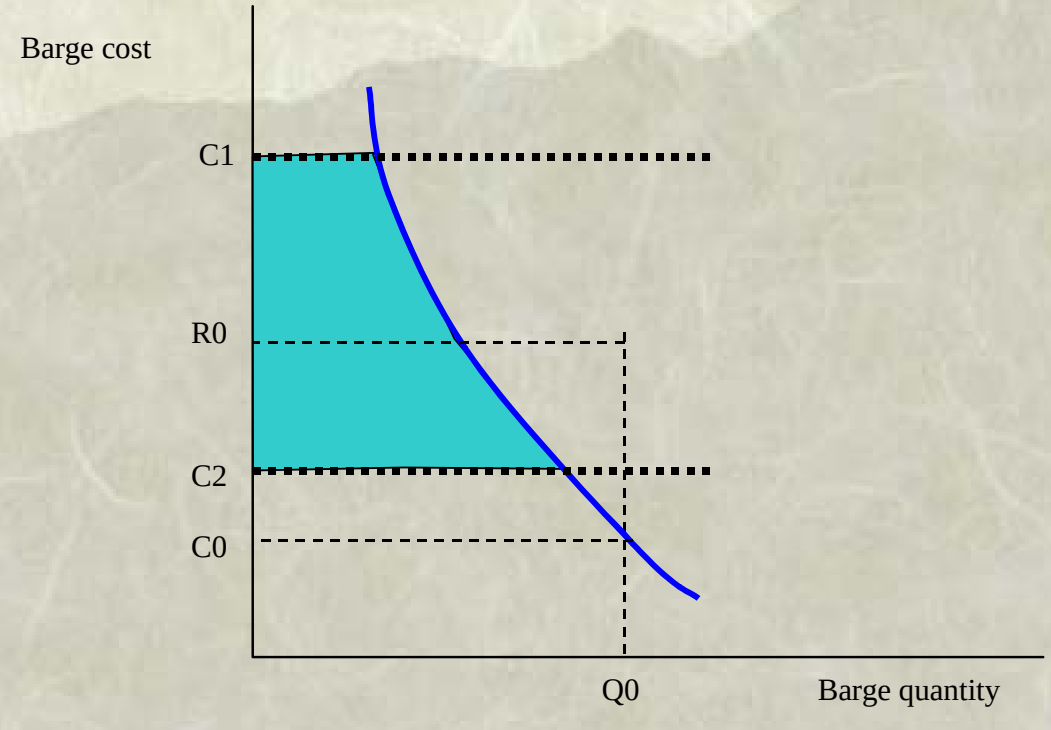
Benefits in Essence



Demand curve from survey model



Benefits from survey model



Survey

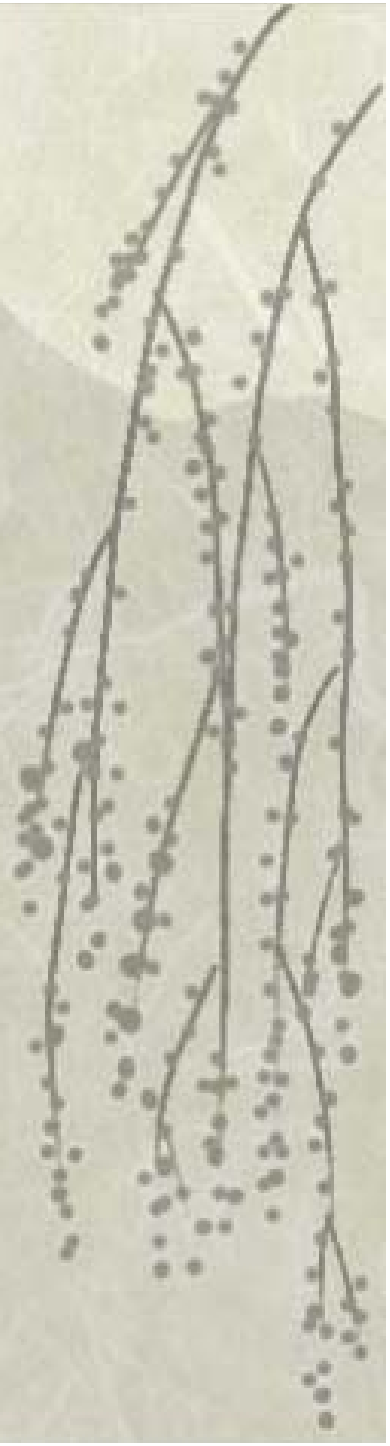
- Center for Business and Economic Research at Marshall University implemented the survey.
- Midwest Agricultural Shippers located both on and off the waterway.
- Shipper list from USDA and trade associations.
- 369 observations drawn primarily from States located on or neighboring states on the Mississippi and Illinois Waterway.

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

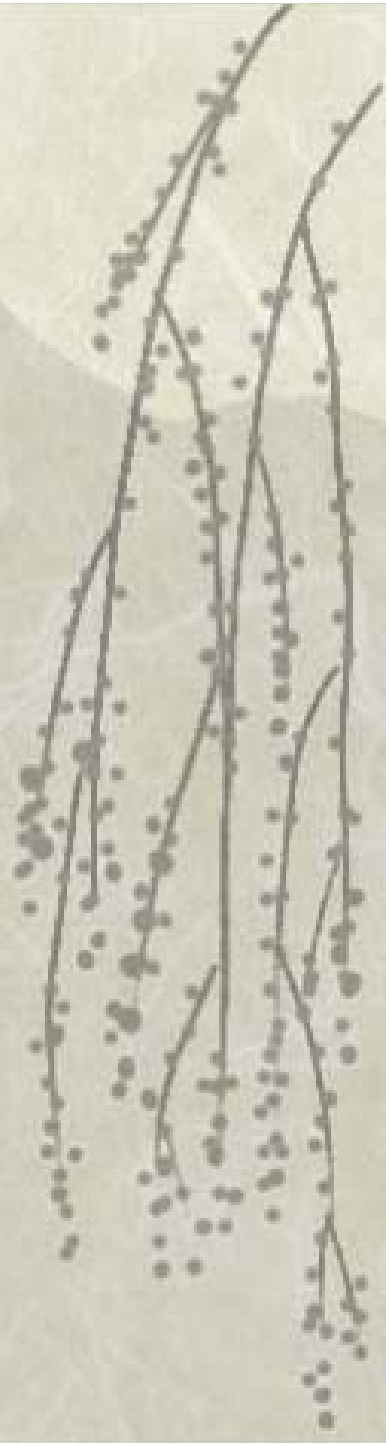
Commodity Shipped

Corn	59.35 %
Soybeans	7.05
Wheat	14.63
Other	19.97

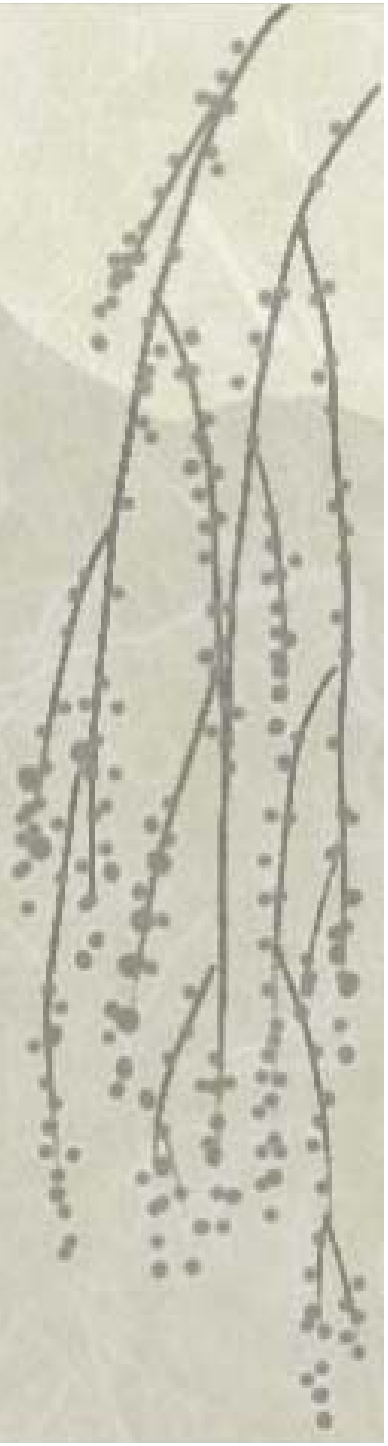


Components of demand

- O/D and mode of shipments
- Volume of shipments
- Location of facilities



Mode and O/D



Strategy

- Current models focus on switching and the least cost alternative mode.
- Our model focuses on switching to next-best alternative, including alternative modes and alternative O/D.

Survey Information
Revealed Choices

- Shippers queried on their last shipment made:
  - Mode(s)
  - Origin and destination (O/D)
  - Rates, transit times, shipment sizes, and distances
- Shippers asked to identify their next best alternative (what they would do if they couldn't do what they did)
  - Mode(s)
  - Origin and destination (O/D)
  - Rates, transit times, shipment sizes, and distances

Next-Best Alternative

Mode switch, same O/D	57.7%
Different O/D	15.6
Shutdown	26.8

Survey Information
Stated Preference

Each shipper was given a randomly drawn increase in rates and transit times, and asked if they would switch from their original choice or not.

Estimation

- Combines revealed and stated preference results.
- Shippers' choices are consistent with profit maximization.
- Profit function for the revealed and stated preference data share parameters.
- Profit function for cost and time prompts share parameters.
- Estimation is by simulation.
- Results give the estimated distribution of switching rates

Utility from last shipment: $U_1 = V(c_1 , t_1 , x_1 \mid \beta) + \varepsilon_1$,

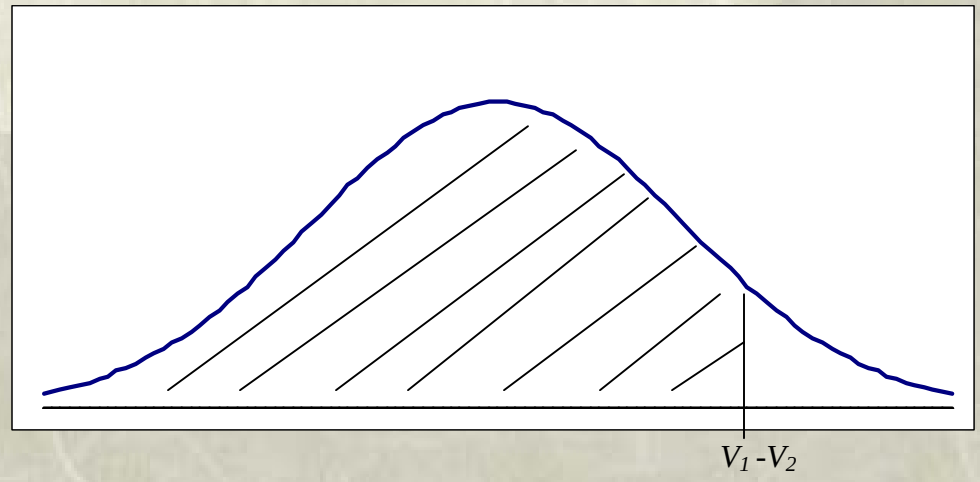
Utility from next-best alternative: $U_2 = V(c_2 , t_2 , x_2 \mid \beta) + \varepsilon_2$

$$\text{Prob}(U_1 > U_2)$$

$$= \text{Prob}(V_1 + \varepsilon_1 > V_2 + \varepsilon_2)$$

$$= \text{Prob}(e < V_1 - V_2)$$

Probability of RP choice



$$r(\beta) = \frac{e^{V_1}}{e^{V_1} + e^{V_2}}.$$

Utility from last shipment under cost prompt:

$$U_{1,CP} = V(c_1 (1+cp/100), t_1, x_1 \mid \beta) + \varepsilon_1$$

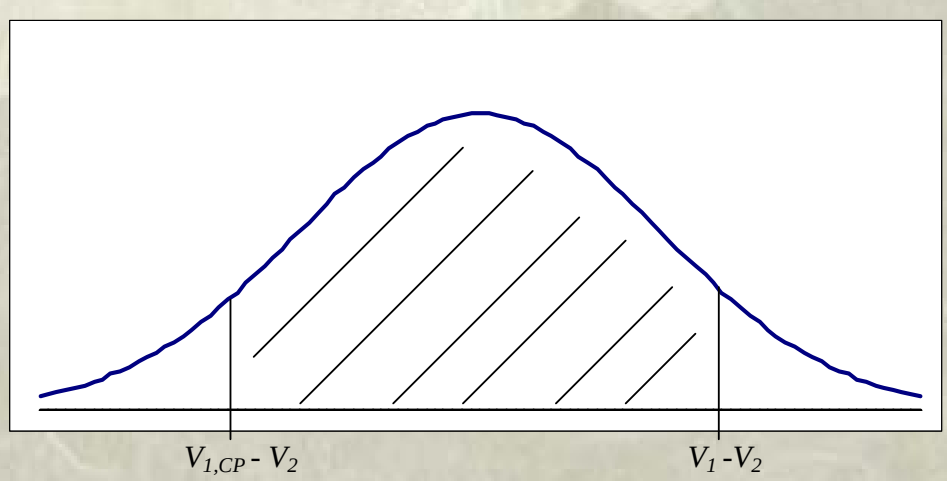
Suppose person says “I would switch”.

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

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

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

Probability of RP and SP cost choices



$$r(\beta) = \frac{e^{V_1}}{e^{V_1} + e^{V_2}} - \frac{e^{V_{1,CP}}}{e^{V_{1,CP}} + e^{V_2}}.$$

Utility of the last shipment under time prompt:

$$U_{1,TP} = V(c_1 , t_1 (1+tp/100), x_1 \mid \beta) + \varepsilon_1$$

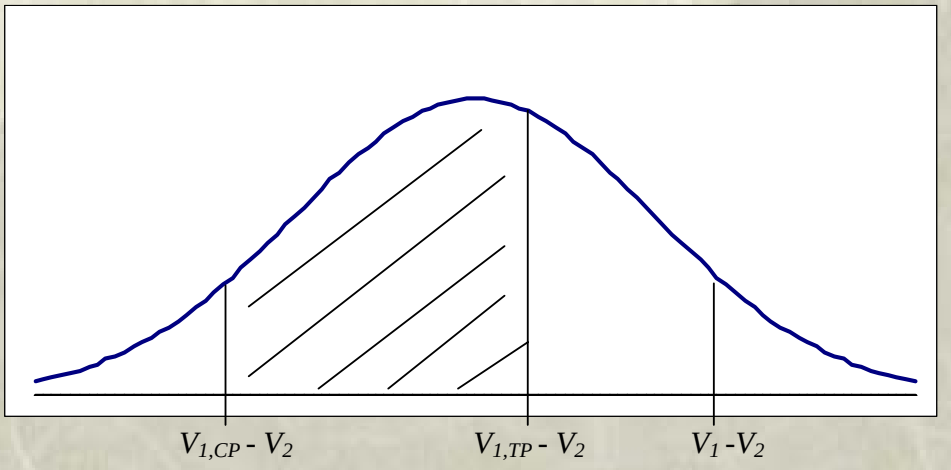
Suppose person says “I would not switch”.

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

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

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

Prob of RP and SP cost and time choices



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

Probability, integrated over distribution of decision parameters

$$P = \int r(\beta) \; f(\beta \mid \theta) \; d\beta$$

Model of Shippers' Choice between Two Best Alternatives

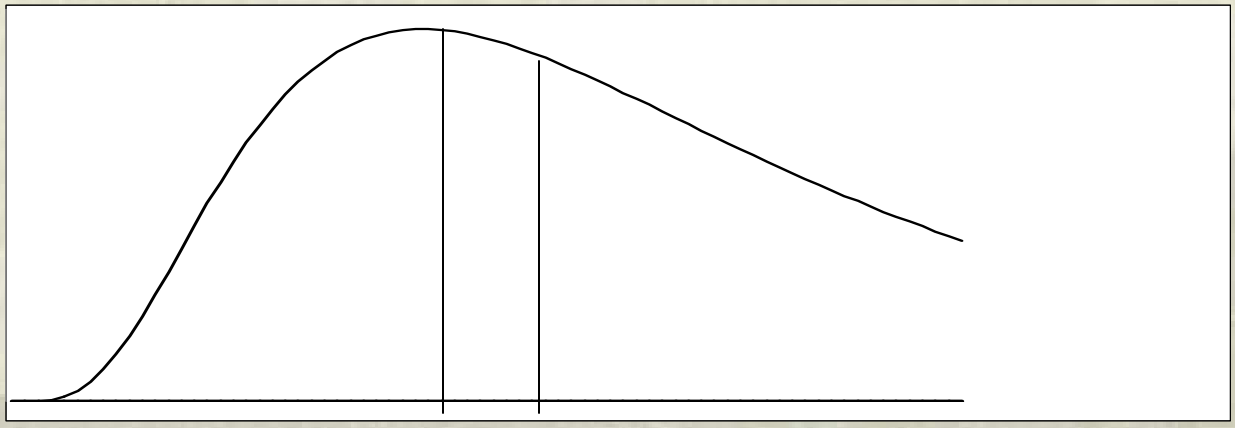
Parameters	Estimates	Std. err.	T-statistic
Median cost coefficient	-3.2436	0.3750	8.649
Mean cost coefficient	-3.9629	0.5061	7.830
Median time coefficient	-1.7942	0.1649	10.882
Mean time coefficient	-1.9232	0.1841	10.446
Rail dummy	3.7036	0.3313	11.179
Barge dummy	4.7048	1.0167	4.627
Time coefficient factor (not c/w/s)	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

Summary of Results

- Average Cost Coefficient is –3.96 and average time is –1.92. "Loosely speaking" rates are more important than time.
- Rail and Barge dummies reflect the choice made (truck is the base). Rail and barge are each preferred to truck *given all else is the same.*
- Time is more important for non-wheat/corn/soybean shipments
- Shipment distance (enters only if an O/D switch) is positive – shipping greater distances increases profits.
- Large increases in rates or time still have a large fraction of shippers not switching (38% for rates, 55% for time)---CAPTIVE SHIPPERS

Estimated Distributions of Cost and Time Parameters



Median=3.24 Mean=3.96

Cost

Median=1.79 Mean=1.92

TIME

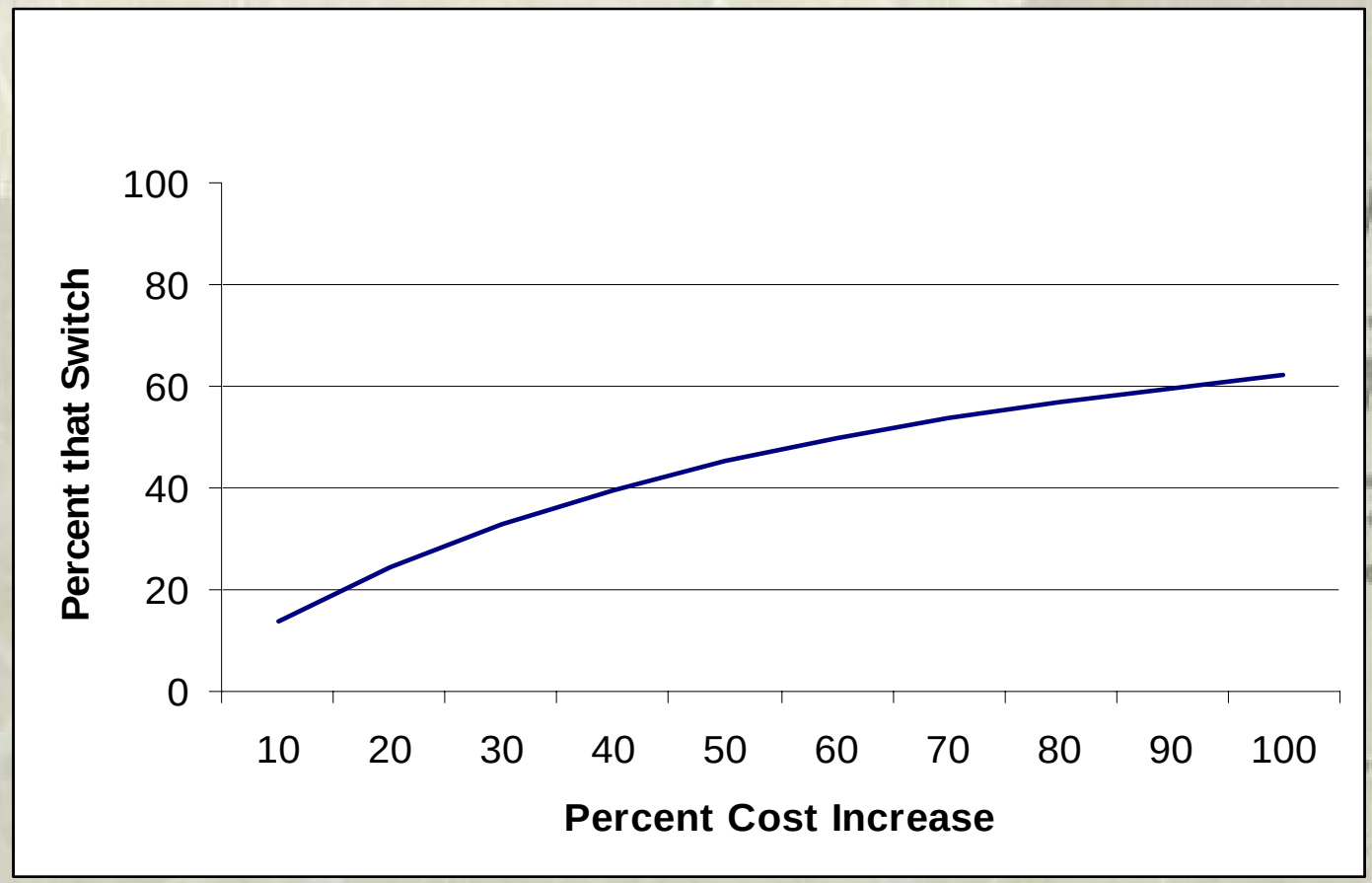
Other Specifications

- Interactions of commodities and rates.
- Interactions of commodities and time.
- Whether the shipper had immediate access to barge and rail facilities.
- Shipment size.
- Level of percentage increase in cost and time necessary to switch.

Share of surveyed shippers forecasted to switch to their next-best alternative if their transportation rates rise

% Cost Increase	% 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

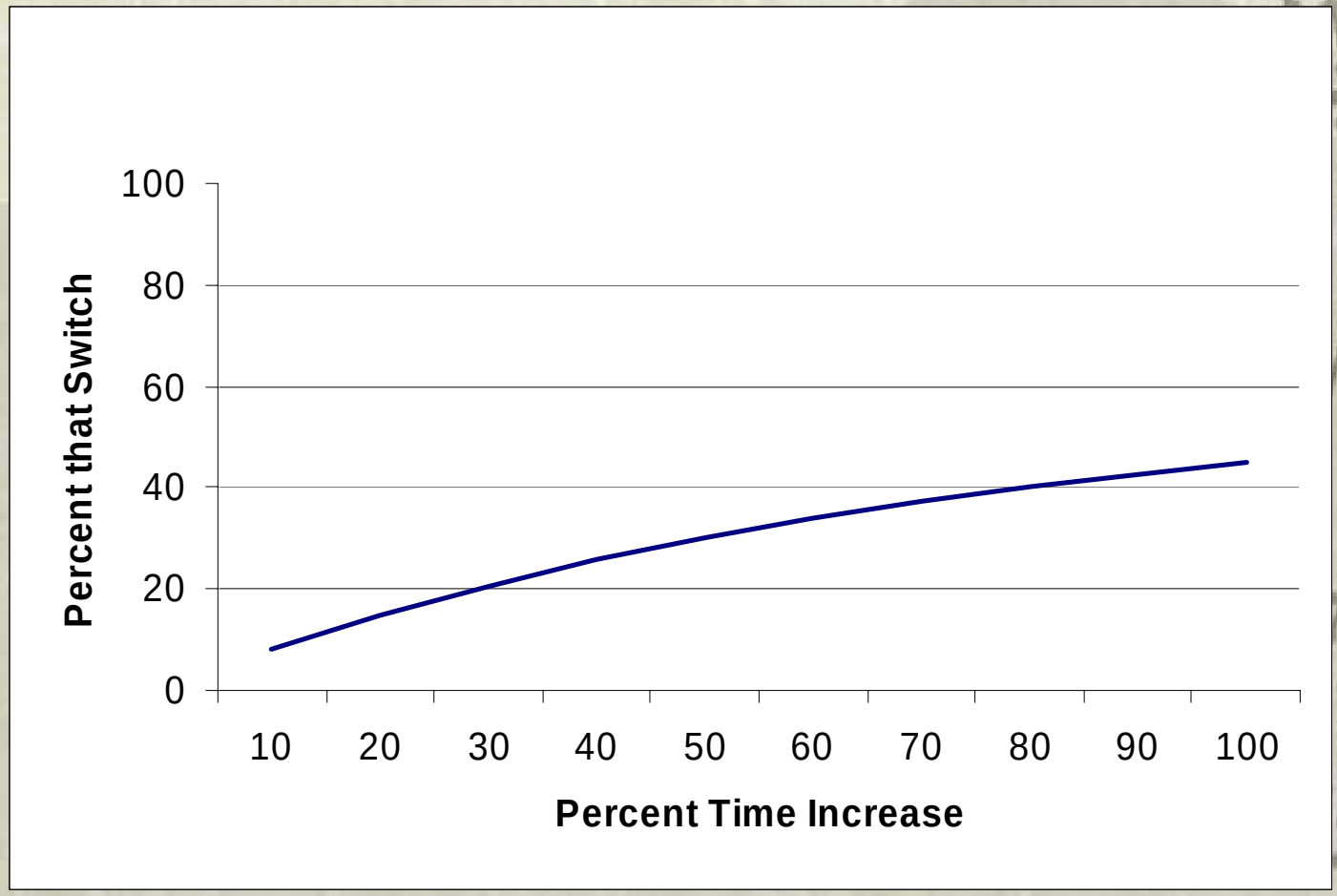
Forecasted Switch Rates



Share forecasted to switch to their next-best alternative if their transit times rise

% time increase	% 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

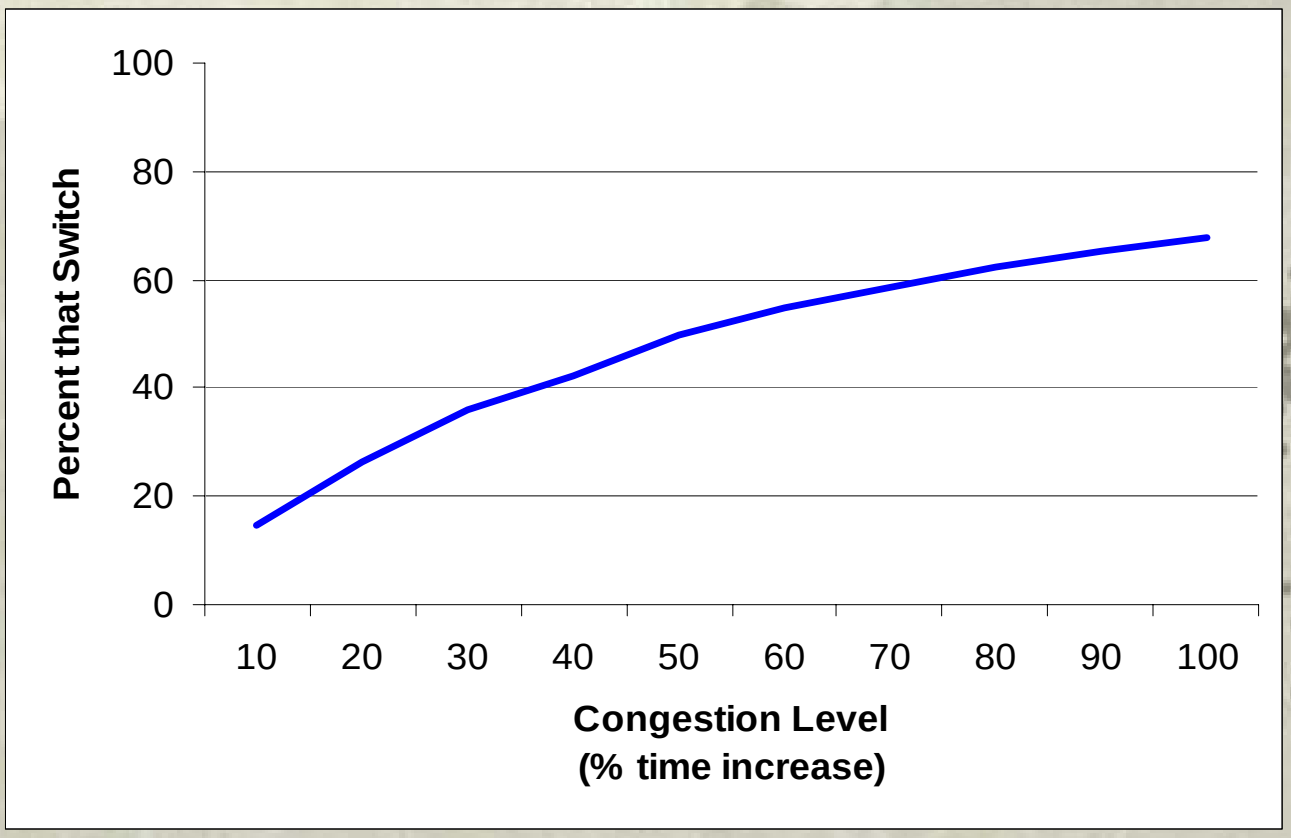
Forecasted Switch Rates



Share forecasted to switch to their next-best alternative if congestion rises

Percent time increase	Percent cost 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

Forecasted Switch Rates



Shipment Volumes

Stated preference questions related to annual shipment volumes:

If rates (time) increased by XX percent, would your annual shipment volumes decrease? If yes, by what percent?

Possibilities:

- No
- Yes and the percentage of decrease.

Estimation

- We model the proportion reduction in shipment volume from a rate or time increase.
- The range of the dependent variable is 0 to 1.
- We use a two-limit tobit model. Estimation of the model ignoring truncation gives biased results.
- Model:

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

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

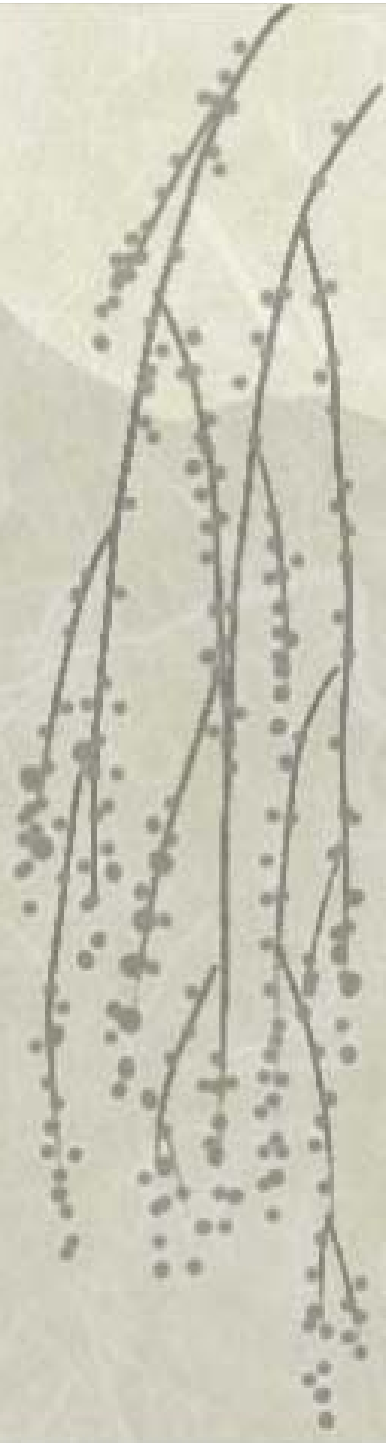
Results-Rates

Variable	Estimates	Std. Err.	T-Statistic
Cost increase	.8813	.1646	5.35
Transportation costs 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

Other Specifications

- Commodity type
- Importance of rates in location decision
- Cost increase interacted with all variables
- Ignore truncation-all estimates smaller in magnitude (as expected)



Results-Time

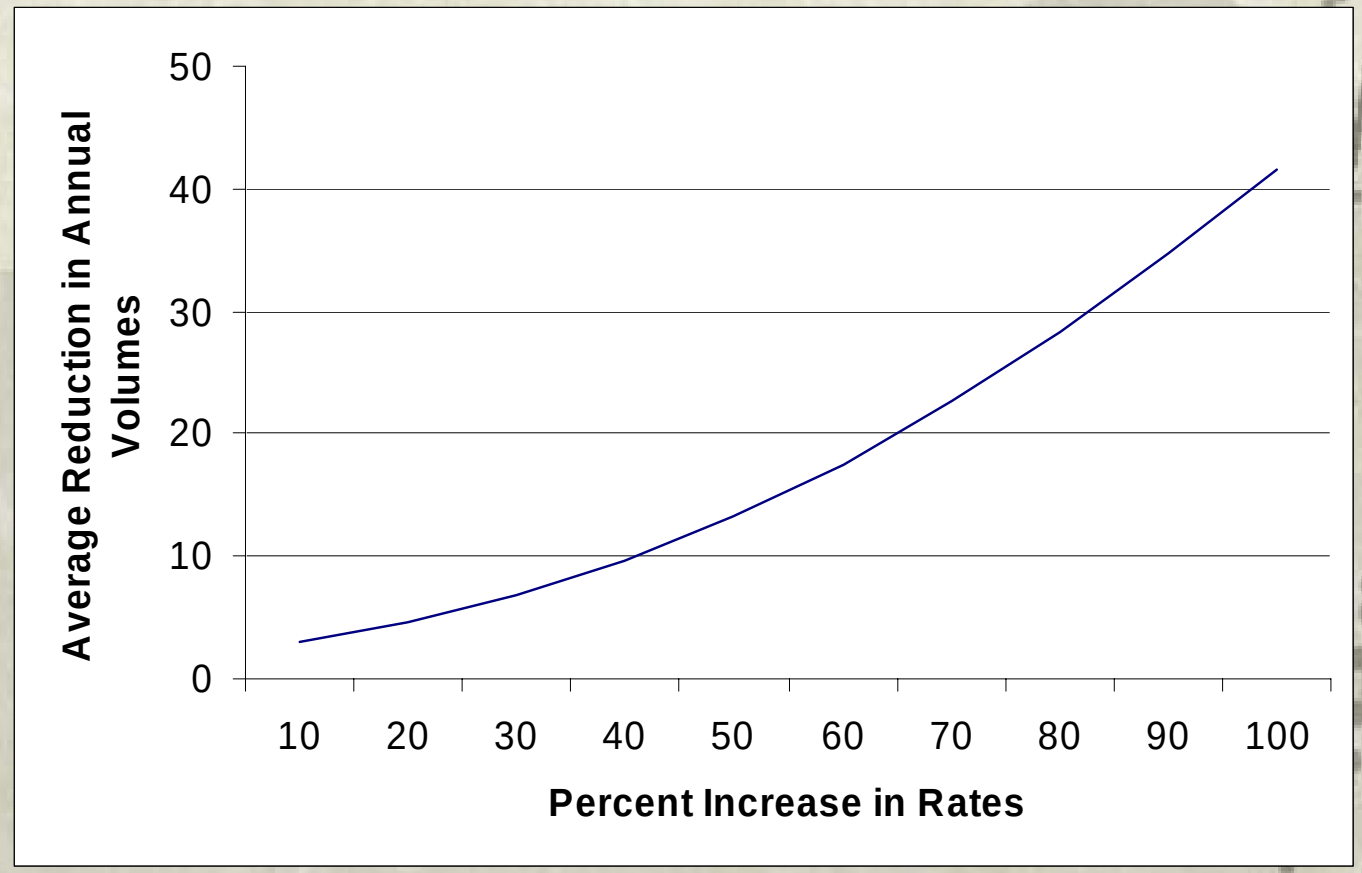
Variable	Estimates	Std. Err.	T-Statistic
Cost increase	.7580	.1638	4.63
Transportation costs as a share of product value	1.259	.3210	3.92
Years at current location	-.00182	.00080	2.29
Rail	.06615	.0503	1.31
Constant	-.5414	.0990	5.47
Standard deviation of ε	*.3682*	*.0280*	

Number of observation: 352
Mean log-likelihood at convergence: -0.4697

Forecasted impact of rates increases

Percent cost 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

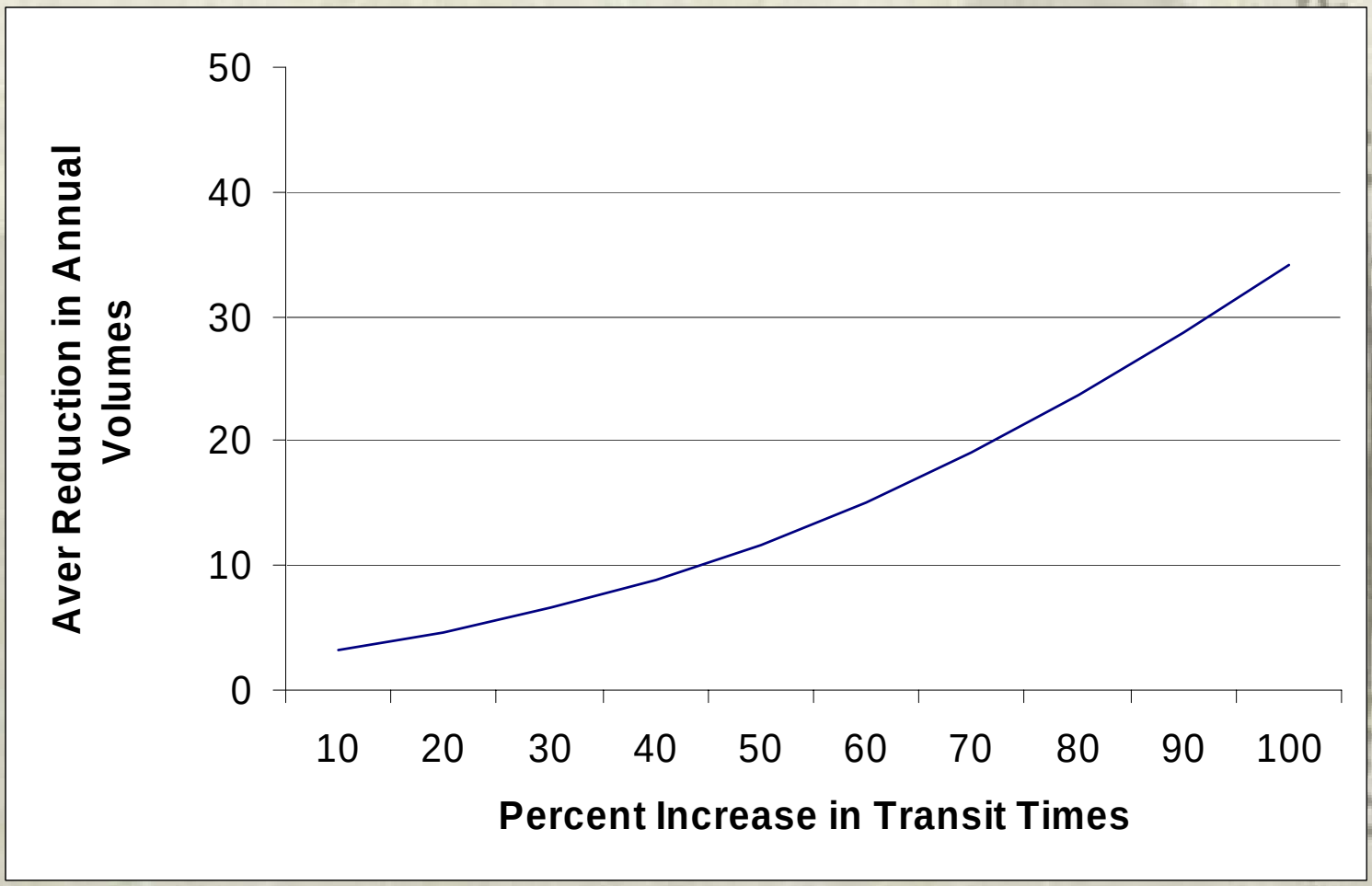
Forecasts-Rates and Volumes



Forecasted impact of time increases

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

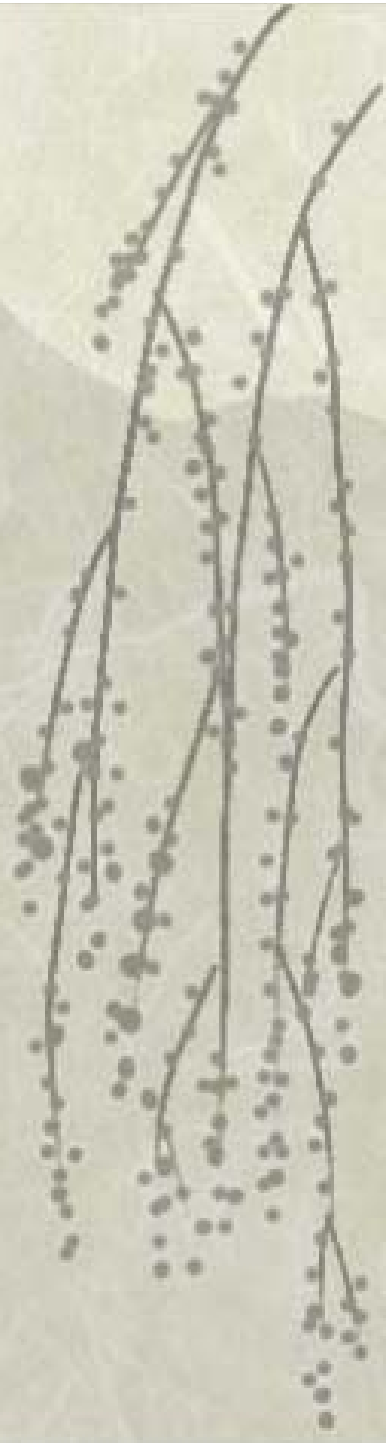
Forecasts-Time and Volumes



Facility location

Longevity of Locations

0-10 years	6.9 %
11-20	8.1
21-50	38.6
51-100	41.1
>100	5.3



Importance of Location Decisions

1 very important	64.54 %
2	12.19
3 somewhat important	11.91
4	4.16
5 not important	7.20

Percent of Rate Decrease to Induce a Location Change

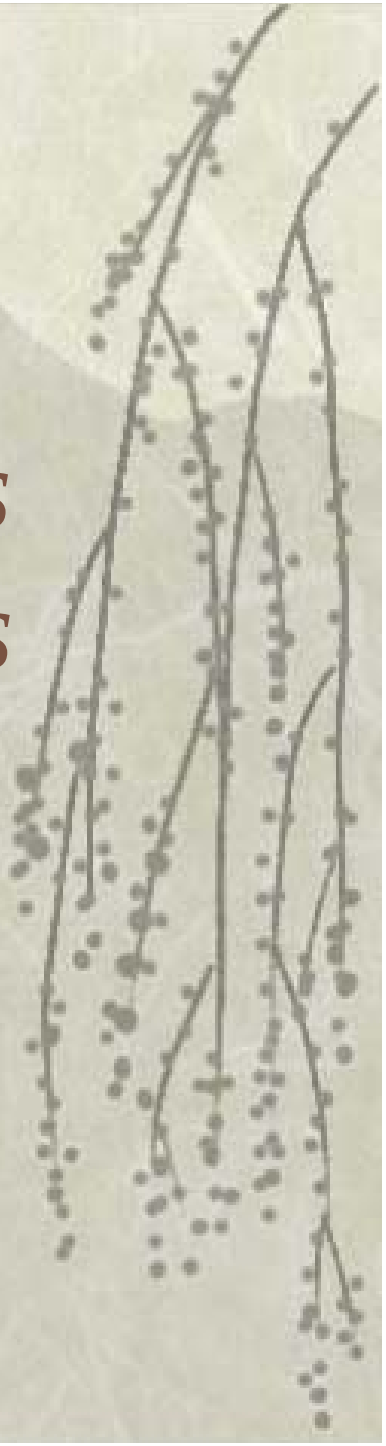
Percent of Rate Decrease	%
1-20	6.07
21-40	10.00
41-60	14.64
61-80	3.57
81-100	5.36
Won’t switch at any decrease	60.36

Location Choice for New Startups

Shippers told they were a start up business. Given a choice between locations with lower (higher) logistics costs and higher (lower) investment costs.

- 76% of shippers choose lower logistics costs and higher investment cost locations.
- 24% of shippers choose higher logistic costs and lower investment costs.

Summary of conclusions for all three components



Primary Findings

- Demand has mode/location and quantity decisions in the short-run and location decisions in the long run.
- Both rates and time affect shipper's demands.
- The elasticity of mode and O/D component of demand with respect to rates ranges from .62 to 1.38.
- The elasticity of mode and O/D component of demand with respect to time ranges from .45 to .8.
- A large share of shippers are captive and do not respond to rate and time changes (38 percent for rates, and 55 percent of for time)

Primary Findings (Con't.)

- Annual volumes do change in response to rate and time changes. Elasticities are smaller than the mode-O/D elasticities, and range in value from .23 to .41.
- Location of existing facilities is fairly insensitive to changes in costs and time (inelastic)
- Location of where to locate for new firms is highly sensitive to rates (elastic).

Upcoming

- Coal shipments on Ohio River
- More grain shipments on Upper Miss
- Non-grain shipments on Upper Miss
- Shipments on Columbia River