Modeling Values of Time to Support Freight Decision-Making: Results from a Stated Preference Survey in New York

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ABSTRACT

This paper makes major contributions to improve the understanding of the determinants of freight travel choice behavior. It models current patterns in freight modal choice across the Hudson moving into the greater New York Metropolitan area and presents a range of willingness to pay for new ferry and rail options.

Two types of stated preference experiments were administered. First, respondents were asked to choose between two routes on their current mode with different levels of service and cost attributes to develop a baseline understanding of choice behavior. Second, complex stated preference surveys targeting mode choice were designed to model demand for future modes.

This research indicates that a single value of time that is often used in demand models to describe freight movement is unrealistic. In fact, value of time varies by the commodity being shipped, the cost of making the shipments, travel distance and travel time.

Key Words: Stated Preference Survey, Cross-Harbor, New York, Shippers, Receivers, Carriers, Choice Modeling, Value of Time, VoT

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1. BACKGROUND

Port, rail, and air freight facilities needed to sustain New York City have developed largely to the west of the Hudson River. This freight hub is connected with New York over a limited number of crossings by truck and poorly connected rail service[1]. Nearly 118 million tons of freight crossed the Hudson River in 2007 with less than 2 percent using non-highway modes[2] resulting in heavy traffic on the George Washington and the Verrazano Narrows Bridges that carry between 195,000 and 300,000 vehicles each day (*1*).

Freight forecasts[3] for the year 2035 predict an additional growth of 40 percent in freight traffic in the region. Should non-highway modes remain underdeveloped; this increased volume will result in crippling congestion on the crossings.

Several studies that have been commissioned to study the worsening traffic conditions in the New York area focused primarily on time-of-day pricing for passenger vehicles (2), (3). The current study focuses on freight alternatives including: (a) **two improved water-based** crossings for transporting rail cars and trucks and (b) **two new rail-based tunnel** crossings that are either rail only or multimodal. Additionally, **transportation demand strategies** that target efficient highway usage were also studied.

A market assessment to quantify demand under various operating scenarios is critical because of the capital investments required (4). Discrete choice models using stated choice experiments were selected as the preferred method to perform the demand analysis [(5), (6) and (7)] and understand the relative importance of factors affecting freight choice.

This paper presents mode and route choice modeling results using the stated preference experiments. The most critical finding is the variation in the value of time estimates for different commodity group and mode combinations and their central role in supporting freight policy decision making.

2. SAMPLING FRAME AND SURVEY DESIGN

A total of 854 establishments were recruited to collect experiments from 57,444 establishments listed in the Freight Generator database[4] which served as the sampling frame. A few criteria were applied to streamline recruitment of the most relevant firms and decision makers. First, establishments that did not move Cross-Hudson shipments were dropped as all the alternatives under evaluation are river crossing options. Second, establishments that moved small packages (<200 lbs) were dropped. Third, given that the stated goal of the study is to move

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[1] There are no freight rail crossings over the Hudson in the greater New York Metropolitan region. Freight rail crosses the Hudson at Albany to connect regions on either side of the Hudson.

[2,3] Current freight movements and future freight forecasts were generated by Global Insights as part of their Transearch database.

[4] The "Freight Generator" database is provided by Global Insights and serves as a companion file to the Transearch Freight Flow database. For this study, establishments operating in a 54-county region in New York, New Jersey and Connecticut were included in the Freight Generator database.

trucks off the existing crossings, the survey focused on current truck users and the results were used to quantify truck decision-making and diversion.

Focus groups, telephone surveys and surveys in-person interviews were carried out[5] to identify decision-makers, understand the relevance of network levels of service and to streamline the questionnaire. Key findings include that shippers, receivers and carriers contribute equally to freight decision-making; cost, travel time and on-time reliability affect decisions; respondents value their participation at $100 per hour and prefer to be recruited over the phone for short surveys. These findings are in line with earlier studies on freight decision making [(2), (7), and (8)].

To limit questionnaire length, each respondent was presented with six experiments customized based on information collected about a reference trip during the recruit. One set of questions focused on service and cost trade-offs between two competing hypothetical truck routes to study the impact of transportation demand strategies. Another set presented respondents with three modal choices with varying levels of service to study their modal preferences.

3. CHOICE MODELING

Reported shipment costs for the reference trip varied from $125 to $7,500 while travel times varied from less than an hour to nearly 11 days. On average, trips took about a day and cost nearly $900[6] suggesting that the more expensive and slower trips were relatively uncommon. Simple outlier analysis was performed to eliminate experiments that had short travel times (<5 hrs) and high transportation costs (>$10,000), or long travel times (>500 hrs) and very low transportation cost (<$100). Specifications were finalized based on joint analysis of the practical and statistical significance of model parameters.

3.1 Truck Route Choice Models

Respondents were shown two truck route variations and were asked to make trade-offs based on on-time reliability, travel times and transportation costs. A binomial logit model was estimated using these data. Table 1 presents the results. The models are partially segmented and provide variable cost and travel time sensitivities by commodity.

Overall, high reliability routes (>90%) were preferred over medium reliability (85-90%) routes, which were in turn were preferred over low (<85%) reliability routes. Both the coefficients were statistically significant at the 95% confidence level. This result is logical and consistent with the findings of a study in Indonesia *(9).*

As expected, higher transportation costs and travel times negatively impact route choice [(4) and (8)]. Further, both variables impact behavior in a non-linear fashion as borne out by the statistical significance of the spline variables that are classified by commodity type. The spline coefficients suggest that long, expensive shipments are less interested in unit savings in cost and

[5] Establishments were recruited from a variety of industries and of varying sizes to receive feed-back from a variety of establishments. Recruitment to each style of interviewing was made on the basis of privacy concerns and the ease of participation for each establishment.

[6] These mean values for shipment delivery time and cost were used to identify the break-points in a non-linear (spline) choice model estimation.

time. This is a critical observation which suggests that shippers making long trips must be presented with larger travel time (or cost) savings to influence behavior to the same extent as short trips.

Table 1 Baseline Sensitivities for Travel Time, Cost and Reliability (Logit Model)

	Coefficient Description	**Value**	**T-Stat**
On-Time Reliability	Low Reliability (<85% on-time)	-0.758	-4.4
	Medium Reliability (85-90% on-time)	-0.275	-1.4
Shipment Cost	Cost Agricultural Goods	-0.0108	-4.4
	Cost Metal and Mining Goods	-0.0095	-5
	Cost Construction Goods	-0.0086	-7
	Cost Chemical Goods	-0.0092	-6
	Cost Wood and Paper Goods	-0.0109	-5.6
	Cost Electronics Goods	-0.0099	-5.2
	Cost Transportation and Utility Goods	-0.0060	-4.1
	Cost Wholesale and Retail Goods	-0.0068	-7
	Cost Spline (Applied if Cost > $900)	0.0053	5.7
Travel Time	Time (hrs)	-0.320	-5.6
	Time Spline 1 (Applied if TT > 12 hrs) Agricultural Goods	0.237	3.6
	Time Spline 1 (Applied if TT > 12 hrs) Metal and Mining Goods	0.173	3.1
	Time Spline 1 (Applied if TT > 12 hrs) Construction Goods	0.166	3.2
	Time Spline 1 (Applied if TT > 12 hrs) Chemical Goods	0.146	2.4
	Time Spline 1 (Applied if TT > 12 hrs) Wood and Paper Goods	0.156	2.8
	Time Spline 1 (Applied if TT > 12 hrs) Electronics Goods	0.135	1.7
	Time Spline 1 (Applied if TT > 12 hrs) Transportation and Utility Goods	0.205	3.8
	Time Spline 1 (Applied if TT > 12 hrs) Wholesale and Retail Goods	0.174	3.6
	Time Spline 2 (Applied if Travel Time > 25 hours)	0.109	2.6
	Pseudo R^2 (0)	**0.415**	
	Pseudo R^2 (c)	**0.324**	
	Number of Observations	**716**	

3.2 Multi-Modal Choice Models

In these experiments, respondents evaluated both existing and new proposed freight models. Short haul respondents whose typical trip was shorter than 400 miles evaluated truck, truck-on-ferry and truck-on-rail options. Long haul respondents evaluated all five modes in the survey. Table 2 presents the estimation results. Truck was preferred in nearly 70% of the experiments with truck-on-rail being selected 19% of the time. Truck was still the preferred option (62%) for long haul experiments, followed by truck on rail (15%). Rail tunnel and rail float were selected 4 and 9 percent of the time respectively. These preferences are clearly reflected in the alternative specific constants for each mode. As before, the models are partially segmented using commodity classes and provide the analyst with a means to measure diversion from truck under different operating scenarios.

Final model specifications include on-time reliability categories, cost and travel time categories classified by commodity type and mode of travel. Travel times, costs and reliability coefficients all exhibit the same pattern observed with the route choice coefficients. Again, the non-linear impact of travel times and costs on freight behavior is reinforced by the statistical significance of the spline parameters. For mid-range trips (400-700 miles), the utility is mostly impacted by the alternate specific constants which are significantly more negative for rail modes than truck modes. This indicates a lower preference towards hauling freight on non-truck alternatives for trips that take less than 24 hours. This finding is consistent with the findings from the focus groups and a study carried out by FHWA *(10)*.

Table 2 Stated Preference Model Estimates for Mode Choice (Logit Model)

	Coefficient Description	**Value**	**T-Stat**
Alternative Specific Constants[7]	Truck Ferry Constant (No DC)	-1.53	-10.2
	Truck on Rail Constant (No DC)	-1.69	-9.5
	Rail Constant (No DC)	-4.69	-4.4
	Rail Float Constant (No DC)	-4.23	-5.1
On-Time Reliability	Low Reliability (<85%)	-1.03	-6.0
	Medium Reliability (85-90%)	-0.341	-3.1
Shipment Cost (Commodity & Mode Specific)	Cost Agricultural Goods	-0.0028	-3.1
	Cost Metal and Mining Goods	-0.0035	-3.9
	Cost Construction Goods	-0.0033	-5.7
	Cost Chemical Goods	-0.0045	-6.6
	Cost Wood and Paper Goods	-0.0036	-5.2
	Cost Electronics Goods	-0.0034	-5.7
	Cost Transportation and Utility Goods	-0.0026	-3.7
	Cost Wholesale and Retail Goods	-0.0036	-7.5
	Cost Spline for Truck (applied if Cost > $900)	0.0013	4.5
	Cost Spline for Truck Ferry (applied if Cost > $900)	0.0015	4.5
	Cost Spline for Truck on Rail (applied if Cost > $900)	0.0014	4.3
Travel Time (Mode Specific)	Time – Truck (hrs)	-0.138	-6.1
	Time - Truck Ferry (hrs)	-0.143	-5.5
	Time - Truck on Rail (hrs)	-0.119	-4.9
	Time - Rail (hrs)	-0.0122	-2.2
	Time - Rail Float (hrs)	-0.0122	-2.2
	Travel Time Spline for Truck (applied for TT > 24 hrs)	0.127	5.4
	Travel Time Spline for Truck Ferry (applied for TT > 24 hrs)	0.131	4.7
	Travel Time Spline for Truck on Rail (applied for TT > 24 hrs)	0.109	4.3
	Pseudo R^2 (0)	**0.345**	
	Pseudo R^2 (c)	**0.149**	
.	**Number of observations**	**1,093**	

[7] Truck is treated as the base for these models.

Table 3 Value of Time by Commodity Type & Levels of Service

Value of Time (per hr)	Cost<$900 Time>=25 hrs (1)	Cost<$900 Time 12-25 hr (2)	Cost<$900 Time<=12 hrs (3)	Cost>=$900 Time>=25 hrs (4)	Cost>=$900 Time 12–25 hr (5)	Cost>=$900 Time<= 12 hrs (6)
Agricultural	-	$7.69	$29.63	-	$15.09	$58.18
Metal and Mining	-	$15.47	$33.68	$9.05	$35.00	$76.19
Construction	$5.23	$17.91	$37.21	$13.64	$46.67	$96.97
Chemical	$7.07	$18.91	$34.78	$16.67	$44.62	$82.05
Wood and Paper	$5.05	$15.05	$29.36	$9.82	$29.29	$57.14
Electronic	$7.68	$18.69	$32.32	$16.52	$40.22	$69.57
Transportation and Utility (TU)	-	$19.17	$53.33	$8.57	$164.29	$457.14
Wholesale and Retail	$5.44	$21.47	$47.06	$24.67	$97.33	$213.33

4.2 Mode Choice Values of Time

Results indicate that VoT vary by commodity type, mode, travel time and cost. Table 4 presents the VoT calculated using the mode choice models. This improves granularity as VoTs are further broken down by mode. It must be noted that patterns described in the route choice VoT also exist in the mode choice VoT. Three interesting observations were made by the study team.

- First, the mode choice VoT[8] is tempered at the upper end when compared to the route choice VoT. This is probably indicative of the added complexity of these experiments (3 vs. 2 options, different modes vs. truck only).
- Second, all truck-based alternatives have comparable VoT to the base truck option suggesting that respondents perceive the truck improvements as variations of the base truck option.
- Rail options were only presented to long haul respondents. The results indicate that the VoT for rail is comparable to the VoT for long haul truck options. These results are comparable to a BTS report on freight shipments by transportation mode *(11)*. Given that rail trips invariable take longer than truck, shippers are looking for a suitably discounted rail service in order to switch.

From a policy perspective, the study clearly indicates that shippers moving different commodities across different distances are willing to pay vastly different service charges for infrastructure improvements. Depending on the type of movements that are most common to the region, a surcharge that appeals to a majority of shippers may be selected to maximize the return on investment and provide the most benefits to the region.

[8] The one exception to the rule is the perishable (agriculture) commodity, where the VoT estimated by the mode choice far exceeds the route choice VoT. This reinforces the belief that the route choice VoT for agricultural shippers may be misleading.

Table 4 Value of Time By Commodity Type, Levels of Service & Mode

Value of Time ($/hr)	Service Attributes	Agriculture	Metal and Mining	Construction	Chemical	Wood and Paper	Electronics	Transportation and Utility	Wholesale and Retail
Truck	**Cost>=$900 Time<24 hrs**	$92.00	$62.70	$69.00	$43.10	$60.00	$65.70	$106.20	$60.00
	Cost<$900 Time<24 hrs	$49.30	$39.40	$41.80	$30.70	$38.30	$40.60	$53.10	$38.30
	Cost>=$900 Time>=24 hrs	$7.30	$5.00	$5.50	$3.40	$4.80	$5.20	$8.50	$4.80
	Cost<$900 Time>=24 hrs	$3.90	$3.10	$3.30	$2.40	$3.10	$3.20	$4.20	$3.10
Truck Ferry	**Cost>=$900 Time<24 hrs**	$85.00	$56.70	$62.60	$38.40	$54.10	$59.50	$99.20	$54.10
	Cost<$900 Time<24 hrs	$42.50	$34.00	$36.10	$26.40	$33.10	$35.00	$45.80	$33.10
	Cost>=$900 Time>24 hrs	$7.10	$4.80	$5.30	$3.20	$4.50	$5.00	$8.30	$4.50
	Cost<$900 Time>24 hrs	$3.60	$2.90	$3.00	$2.20	$2.80	$2.90	$3.80	$2.80
Truck on Rail	**Cost>=$900 Time<=24 hrs**	$110.00	$71.50	$79.40	$47.70	$68.10	$75.30	$130.00	$68.10
	Cost<$900 Time<=24 hrs	$51.10	$40.90	$43.30	$31.80	$39.70	$42.10	$55.00	$39.70
	Cost>=$900 Time>24 hrs	$9.20	$6.00	$6.70	$4.00	$5.70	$6.30	$10.90	$5.70
	Cost<$900 and Time>24 hrs	$4.30	$3.40	$3.60	$2.70	$3.30	$3.50	$4.60	$3.30
Rail & Rail Float	**All Costs and Times**	$4.40	$3.50	$3.70	$2.70	$3.40	$3.60	$4.70	$3.40

5. CONCLUSIONS

The Route and mode choice models clearly indicate that a single value of time often used in demand models to describe freight movement is an extreme simplification. Our research indicates that values of time vary by distance, shipment cost and commodity. Results suggest that shippers who move high value commodity goods over short distances are more likely to embrace policy options such as pricing in return for improved travel times.

The model suggests that short haul shippers would choose highway alternatives that could generate a one-hour savings in travel time for a toll of up to $30 over current toll rates in the New York region. However, most long and short haul shippers are likely to switch to less congested and circuitous routes that take 1-2 hours longer if a new $60 toll were imposed on the most congested and direct routes. While unlikely, a variable toll by commodity could be enforced to impact congestion and freight behavior at a finer level.

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