Analysis of Inland Mode Choice Decision for Imported Waterborne Cargo from New York & New Jersey Ports

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Abstract

Accessibility to ports and their residential and industrial vicinities are constrained by truck congestion, whereby the truck share of transporting export/import shipments in comparison to alternative modes is quite significant. Despite port surrounding areas at least recognizing what is occurring to their accessibility and economic performance, the academic world has not yet taken much notice. Previous studies on mode choice and modal competition mainly focused on intercity movement of domestic trade, but scarce empirical studies have addressed additional choices for inland traffic of export and import waterborne freight fully dedicated to containerized trade. This study is intended to fill this gap by investigating the mode choice for inland movement of non-containerized imported waterborne shipments from the New York & New Jersey port complex. A logit mode choice model for truck and rail is estimated using 2194 non-containerized shipment samples from the Commodity Flow Survey 2007 database. These shipments were imported from EU and Asia and dispatched to the respective inland destinations via both modes available. According to results, mode choice is primarily affected by the difference between the two modes' freight rates and transit times. In the model it was identified that commodities imported from the EU, even though homogenous, have a higher chance of being shipped by rail. In the current study, marginal effects and elasticities were employed to investigate the average level of changes in mode probability as a result of certain modifications in explanatory variables.

Keywords: Freight transport, Mode choice, Logit model, Freight elasticity

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1. Introduction

In 2007, US ports accounted for 1.3 billion tons of inland freight transport demand. While ports are the most congested international trade gates, trucks are responsible for 90% of movement to/from the ports. In the movement of US domestic freight, the rail system accounted for 40% of total ton miles and 16% of total tons, while for inland transportation of waterborne export and import freight the rail share reduced to 13.3% and 8.1% of total ton miles and tons, respectively (FRA, 2010). Clearly, there is a considerable difference between intercity and export/import waterborne freight mode choice. While for the US economy international water shipping is the dominant means of transport for domestically consumed goods (Nealer et al., 2011), trucks are the prominent mode of movement (92% of tons). The dominance of trucks and discrepancy between the truck and rail shares has created two problems. First, since most US ports are neighbored by residential and industrial regions, accessibility to the ports is significantly restricted. Second, congested roads with access to and from ports have outperformed ports by increasing truck travel time (OECD, 2009). Thus, these issues have produced an urgency to find solutions to problems related to port-access roads and accessibility from residential and industrial neighborhoods. Recently, this type of crisis has been addressed by Feo-Valero et al. (2011) regarding Spain, Ravibabu (2012) for India, Truschkin and Elbert (2013) for Germany and (Bryan et al., 2007; Fan et al., 2012; FRA, 2013) with respect to the US.

Environmentalists are mainly concerned with the problem of high truck traffic volumes releasing emissions through low-income neighborhoods (Giuliano and O’Brien, 2007), while logisticians view it from the perspective of port performance and highway congestion (Berechman, 2009). To alleviate the congestion related to port activities two distinct solutions have been proposed: port gateway pricing and using alternative modes of transport (De Borger and De Bruyne, 2011; Feo-Valero et al., 2011; Ravibabu, 2012; Yuen et al., 2008). The latter is known as modal split (the third part of a 4-step transport demand modeling). Since major US ports are connected to rail networks, there is obvious interest in shifting portions of the truck demand toward the rail system (FRA, 2013). Therefore, the scope of this study is to model a mode choice for the inland movement of imported waterborne freight.

In this research, the mode choice for inland movement of imported waterborne freight from the New York - New Jersey (NY-NJ) port complex to US mainland destinations is examined. NY-NJ has been selected because it is located by the most populated urban areas in the US, with highly congested roads and insufficient land for further road development. The standard logit model will be applied to data revealed for NY-NJ to identify influential decision variables of mode choice for inland movement of non-containerized imported waterborne freight. To the best of our knowledge, only two empirical studies have been done about inland movement of containerized waterborne freight. Feo-Valero et al. (2011) studied mode choice for inland movement of Spanish containerized waterborne trade (export/import) with stated preference data; Indian containerized export was analyzed by Ravibabu (2012) using revealed data. The former study analyzed the role of maritime frequency in inland mode choice waterborne trade while the second did not study a variable related to the content of waterborne trade.

Thus, there is opportunity for further analysis of non-containerized trade with regards to waterborne specifications[1].

If total logistic cost is a determinant to mode choice (Blauwens et al., 2006), where maritime distance affects total logistic cost of waterborne freight must have influenced inland mode choice for such freight. Or, whenever imported freight originates from farther away and with higher maritime cost, the travelled nautical distance must impose import shipment via lower-cost transport modes for the subsequent part of their inland journey. It should be pointed out that longer distances are often, but not always, associated with higher cost. Accordingly, the intention of this study is not only to attempt to model an inland mode choice of imported non-containerized waterborne freight but also to investigate the role of maritime distance on inland mode choice. To demonstrate the model's sensitivity to short-range policies, the marginal effect and elasticities of decision variables are calculated. They have been applied to show how demand from one mode shifts to another mode as a result of changes in the decision variables. The remainder of this study is structured as follows. The next section presents a review of freight mode choice and movement of waterborne freight with focus on the US freight context (Section 2). This is followed by an outline of the logit model and data description in Section 3, while the estimation and results are presented in Sections 4. The study ends with conclusions and recommendations for future studies.

2. Review of freight mode choice literature

Freight mode choice modeling is quite modest in comparison to its passenger counterpart. This is mainly due to the unavailability of suitable data besides costly data gathering activities (Abdelwahab and Sargious, 1992; Brooks et al., 2012; Samimi et al., 2011). Early studies on freight modal split had been based on cost comparison with no regard to non-cost factors (Cunningham, 1982). It was a dominant approach and is now used for intercity mode choice analysis of the dominant US freight market-coal industry (Satar and Peoples, 2010). Freight mode choice modeling with concern to other factors in North America dates back to the early studies of Domencich and McFadden (1975) who introduced the logit model for urban modal split based on the Random Utility Model (RUM). Consequently, transport mode choice modeling was based on RUM and has become a leading theoretical framework.

North American studies on freight mode choice primarily focused on intercity commodity movement. Among earlier intercity studies, Wilson et al. (1988) developed a logit mode choice model with stated preference (SP) data for manufacturing commodities, in which the characteristics of transport system, carriers, shippers and shipments were examined. Picard and Gaudry (1998) introduced a Box-Cox logit model for rail and trucks with the 1979 Canadian Domestic Flow. A joint model of mode choice and shipment size was developed by Abdelwahab and Sargious (1992), who examined the Commodity Flow Survey (CFS) 1977 for manufacturing commodities. More recently, Puckett et al. (2011) applied a generalized mixed logit model to assess the launching of a new transport mode on the eastern coast of North America. In a behavioral freight mode choice for American shippers, Samimi et al. (2011) applied two logit and probit models to assess the effect of increasing fuel price on mode choice for intercity freight movement. The mentioned studies are mostly devoted to intercity movement of commodities with domestic establishments but not on foreign trade with

[1] Origin, sea traveled days and nautical distance, type of contract, maritime cost, custom and port dues, special maintenance in port, warehousing cost and special processing are other specifications.

maritime leg, while domestically consumed goods in the US are dependent on international maritime transportation. Port connectivity levels to its vicinity have been elucidated by Rodrigue and Guan (2009), whereas a modal split pattern and shippers' (forwarders) behavior handling and facilitating inland movement of waterborne commodities has not been studied yet.

While freight mode choice in the context of America is mostly focused on intercity movement, there are few studies on Europe dedicated to inland movement of export/import waterborne freight to and from ports. García-Menéndez et al. (2004) examined modal attributes with a conditional logit model to identify influential mode choice variables for Spanish exporters from Valencia to EU destinations. They found that sea transport is extremely sensitive to the variations in expenses in response to changes in other transport modes. Essentially, they examined five classes of export commodities with single transport leg (coming from sea or intending to start a sea trip). The inventory theory was applied by Blauwens et al. (2006) to study the effectiveness of policy measurement on the shift of containerized trade from trucks to rail and waterways. They investigated German containers imported from the US through the port of Antwerp and deduced that to obtain a significant modal shift a combination of policies should be employed.

A combination of Swedish and Norwegian domestic and export freight was simulated by De Jong and Ben-Akiva (2007) to understand the role of distribution and consolidation centers[2] on shipment size. They discovered that distribution and consolidation centers are determinant decision variables of shipment size, which in turn affects the choice of mode. Indian containerized export in the Delhi-Mumbai corridor was examined by Ravibabu (2012) for three modes with a nested logit model, and it was found that containerized break bulk by truck and rail predicts the mode choice behavior better than break bulk by truck. The estimated model did not include any variable to characterize the maritime transport leg. For the Australian market, Brooks et al. (2012) studied road, rail and coastal shipping for all ranges of domestic cargo with mixed and multinomial logit models to assess the mode switching potentially occurring if a regulatory policy with respect to the carbon pricing of transport options is imposed in future. They applied the same variables as in previous intercity studies; however, their sample consisted of shippers settled in the vicinities of ports, but who did not engage in foreign trade. A counterpart to this study for North America was conducted by Puckett et al. (2011). The reviewed works differ from the current study, as this is dedicated to inland movement of non-containerized waterborne foreign trade.

Inland movement of Spanish containerized trade (Valencia-Madrid corridor) was studied by Feo-Valero et al. (2011). They applied a mixed logit model with stated preference technique to indentify the critical issues that public measures are aimed at to foster rail transport connecting ports and their hinterlands. The researchers applied transit time as a continuous variable in hours, while significant measurement of transit time for long distances like the US is a discrete variable in days (Abdelwahab and Sargious, 1992). Their study is the first to apply frequency of maritime services to inland mode choice for export/import waterborne freight. It was found that if the frequency of maritime services to the port of Valencia increases, then the probability of rail haulage decreases to the benefit of trucks. However, this variable confirmed a 10%

[2] Based on their definition, consolidation centers are locations where goods are transshipped (and possibly stored), with small loads getting in and larger loads getting out. Distribution centers are locations where goods are transshipped (and possibly stored), with large loads getting in and small loads getting out. Both consolidation and distribution centers exist not only in road transport, but also in ports, airports or rail terminals.

confidence level, but our concern is that a significant percentage of rail traffic from the port to the hinterland and vice-versa in the studied corridor is under the ocean carriers' control -- an uncommon matter in the US freight system.

The role of forwarders in port selection along with their arrangements with shipping lines from South-east Asian and Norwegian forwarders was researched by Tongzon (2009) and Saeed (2013) respectively. However, it remains unclear how these arrangements may influence inland mode choice and the preferences of shippers (forwarders). The effect of total inland logistic cost on inland mode choice for German containerized import was assessed by Blauwens et al. (2006) using an inventory theoretical approach. Since their study was based on cost analysis, only the inland section of the container journey was regarded but not the maritime leg. Furthermore, their finding is not applicable to waterborne freight arriving from various origins over different nautical distances. De Jong and Ben-Akiva (2007) investigated the logistic element's (freight consolidation center) function on shipment size and the effect of shipment size on intercity mode choice for Swedish and Norwegian domestic and export freight. The theoretical relationship between shipment size and mode choice, and the role of consolidation centers were strongly confirmed. Based on their definition of consolidation and distribution centers, a port for export freight denotes a consolidation center (as their results only included consolidation centers), while for imported freight a port is a distribution center. As such, their port results are applicable for ports considered consolidation centers, but not distribution centers.

The findings of Blauwens et al. (2006); De Jong and Ben-Akiva (2007) and Feo-Valero et al. (2011) provide sufficient evidence and theoretical justification to examine the role that maritime distance plays in mode choice for the inland leg of imported waterborne freight; on the other hand, there are no studies regarding inland mode choice of imported waterborne freight in the North American context. Thus, the intention in this study is to follow along these lines by examining the effect of maritime distance on inland mode choice of waterborne freight, and theoretically utilize Domencich and McFadden (1975) RUM for discrete choice.

A number of different decision variables for diverse commodities have been examined through intercity mode choice studies. The variables studied can be categorized in three main classes: those related to commodity, mode and other variables (such specifications are associated to economic and market structures, and institutions) (Table 1). In the present work, value, weight, density and value-density as commodity attributes, along with freight rate and transit time as modal attributes will be examined. Given that this study is devoted to imported waterborne freight, an additional decision variable (i.e. maritime distance) to characterize such freight will be investigated. Selected studies considering data, models and commodity groups are presented in Table 1.

Table 1: Specification of freight mode choice studies

Author, commodity, Model, Country	**Studied Modes**	**Commodity attributes**	**Mode attributes**	**Other attributes**	**Waterborne commodities included**
(Ravibabu, 2012)-containerized trade, Nested logit, India	Break bulk by truck, containerized by truck and rail	value, density, suitability for containerization, post export benefits	costs, transit time, reliability, loss and damage %, terminal frequency of service	Consignmen t (urgent or with LC), firm size	YES-Export revealed data
(Brooks et al., 2012)-all cargo range-mixed and multinomial logit, Australia	Truck , rail and coastal shipping		Frequency, transit time, distance, direction, reliability, price		NO
(Feo-Valero et al., 2011)-containerized trade-mixed logit, Spain	Rail and truck	weight, volume of container, value,	transit time, cost, reliability, frequency, road haulage quota	Frequency of maritime service	YES-Export and Import SP data
(García-Menéndez et al., 2004), wood &furniture, ceramics, textile, agro-industry-conditional logit, Spain	Road, Sea	Frequency	Cost, transit time, damage, delay, distance,		NO
(De Jong and Ben-Akiva, 2007), mineral and building material, petroleum, metal, chemical, machinery and equipments, multinomial logit with inventory total cost simulation, Sweden and Norway	Road, rail, water, air	Value density, shipment size, modal cost, capital cost during transit,	Access level, loss and damage rate, distance, transit time	Company size, total logistic cost, capital cost of inventory, location of consolidation center	YES-Export revealed data
(Holgui'n-Veras et al., 2011), general cargo, game and inventory theories, US	Truck, van, combined rail and road	Production and delivery rate, shipment size,	Transport cost, per vehicle cost, number of required vehicle,	Shipper's and carrier's total operating cost	NO
(Samimi et al., 2011)-Not specified,	Rail and	weight, value,	Distance, modes cost	Decision	NO

Author, commodity, Model, Country	**Studied Modes**	**Commodity attributes**	**Mode attributes**	**Other attributes**	**Waterborne commodities included**
logit and probit, US	truck	same decision, perishability, warehouse required,	and time, truck-cost index, rail-cost index, access, , potential intermodal	maker	
(Jiang et al., 1999)-five group of commodities-nested and multinomial logit, US	Road, rail and combined	Type, value, packaging	frequency, distance, origin, destination	firms attributes; nature, structure, location, size, MIS	NO
(Wilson et al., 1988)-wheat-supply and demand functions, US	Rail, truck	Rail and truck shipment size	cost, mode availability		NO
(Abdelwahab and Sargious, 1992)-manufacturing commodities-probit model, US	Rail, Truck	Shipment size, density, value, status, ton-mile	cost, transit time, reliability of mode, loss & damage %,		NO

3. Model and Data

Theoretically, in order to maximize utility an individual opts to choose an alternative. The concept has been proved by McFadden and applied to passenger mode choice by Domencich and McFadden (1975). Random utility *(U)* for freight mode choice can be defined with observed *(V)* and random *(η)* components as:

$$U = V(s, x) + \eta(s, x) \qquad (1)$$

where:

x is a vector of measurable attributes characterizing an alternative (mode),

s is a set of commodity attributes.

In the binary choice model an alternative (mode) with higher utility is preferred by the decision maker. Owing to their random components, these utility values are stochastic, and the events of $U(x, s, \eta)$ will be probabilistic (Domencich and McFadden, 1975). The probability of choosing alternative i over j can be formulated as:

$$P_i = prob\left[U_i > U_j\right] = prob\left[\left(\eta_j - \eta_i\right) < \left(V_i - V_j\right)\right] \qquad (2)$$

The above probabilistic form will yield a family of probability functions that are not only dependent on their observed *(V'*s*)* component, but also on the difference between their random parameter distributions across the population (Small and Winston, 1999). One assumption on distribution $(\eta j - \eta i)$ is to suppose that its cumulative distribution function (CDF) follows a logistic function and its linear form is a logit model. Then the logit model is:

$$Logistic\ probability\ function: p_i = \frac{\exp(-\alpha-\beta_1 x_1-\cdots-\beta_k x_k)}{1+\exp(-\alpha-\beta_1 x_1-\sum_{n=2}^{N}\beta_n x_n)} \qquad (3)$$

$$\text{Logit model}: \log\left(\frac{p_i}{1-p_i}\right) = \alpha + \beta_1 x_1 + \sum_{n=2}^{N}\beta_n x_n \qquad (4)$$

where:

p_1 is the probability of the desired outcome,

x_1 is the price of mode i relative to that of the other mode (or other common characters),

x_n other exogenous factors affecting mode choice,

β is the parameter of the logistic probability function (and α is constant):

Estimated linear logit models can be classified as models that apply the ratio (p_i/p_m) of the price[3] of the *i*th mode to the base mode (m), and models that apply the difference between (p_i - p_m) the price of the *i*th mode to the base mode (Oum, 1979). As the elasticities of choice are not dependent on the base mode choice, the second approach is favored (Oum, 1979) and this study adheres to it.

Variable selection for the logit model remains a case of dispute. Forward selection, backward elimination and stepwise selection approaches are commonly used. Some researchers prefer to select variables purposefully -- a method that has been explained by Hosmer et al. (2013) in detail. The variables presented in Table 2 examined for a suitable logit model are value, weight, density and value density as commodity attributes, and freight rate and transit time difference as modal attributes.

[3] Price or other modal attributes that are common can be addressed in a ratio or difference approach. Normally, both characters can be applied in the model.

To fit a logit model, various goodness-of-fit (GOF) criteria have been created. Likelihood ratio index (McFadden's-R^2), McKelvey and Zavoina's pseudo-R^2, Cox & Snell Nagelkerke/Cragg & Uhler's R^2 are all entropy-based criteria, which compare the null model with a full model (model with predictors). To assess the predictability power of the logit model, count R^2, specificity and sensitivity are created. Count R^2 converts the continuous predicted probabilities into binary outcome variables and reports a ratio of the number of correctly specified to the total number of observations. Sensitivity measures the proportion of outcomes of interest that were accurately identified while specificity measures the proportion of correctly identified outcomes that are not of interest. Count R^2, sensitivity, and specificity report different values for diverse cutoff points. Sensitivity and specificity can be illustrated as a graph known as a receiver operating characteristics (ROC) curve. The theoretical range of all mentioned criteria is 0-1. The Akaike information criterion (AIC) gives a relative measure of lost information when a new variable is added to the current model; if the new variable is associated to the model less information will be lost.

Data for this study was sampled from the Commodity Flow Survey (CFS) 2007 by selecting waterborne imported shipments from NY-NJ to destinations within the US where trucks and rail are available. Certain important commodity or modal attributes are not publicly available in CFS, for which reason they have been calculated based on previous studies. Truck and rail transit times were calculated according to Picard and Gaudry (1998). Freight rates for inland shipping were determined based on average revenue per ton-mile in 2007 (16.52 cents for rail and 29.9 cents for trucks) (FRA, 2010). Strategic Freight Transport Analysis (SFTA) provides shipment density in tons per truck/railcar and value density in $US per ton of shipments in Standard Transportation Commodity Codes (STCC), which has been converted into Standard Classification of Transported Goods (SCTG) based on Brinckerhoff (2009) to match CFS data.

Table 2: Variable Specification

Attributes	Decision variable	Measurement
Commodity	Value	$US-$10^6$
	Weight	Ton-10^3
	Commodity Class	SCTG, 41 Class
	Density	Ton/Truck or trailer
	Value-density	$/ton
Mode	Freight rate	$-$10^6$
	Transit time	Day
Others	Import Origin	EU, Asia
	Distance (maritime)	Mile (nautical mile)
	Destination	27 states

A 2003 Cambridge Systematic Analysis showed that roughly 7% and 75% of all shipments in metric tons from the NY-NJ ports to inland destinations moved by rail and truck, respectively (Corzine and Kolluri, 2007). If rail and truck shipments were aggregated in metric tons, the rail share would be 8.2%. For imported shipments from NY-NJ in the CFS database, the rail share from the rail and truck aggregation would be 7.19% for all destinations. The dataset of the current study contains 2194 observations for both rail and trucks. The rail portion in this dataset is 10.93%. The data prepared for this study and the measurements are presented in Table 2, while regional data structure is given in Table 3.

Table 3: Data Structure

Origin	Truck	Rail	Total
EU	786	111	897
Asia & Oceania	1168	129	1297
Total	1954	240	2194
%	89.07	10.93	100

The purposeful method is applied for variable selection. First, a model with all variables is presented, and then maritime distance as a decision variable is added to the first model. The model demonstrating superior fit based on various GOFs will be selected for further analysis. To show the role of maritime distance among other covariates, its contribution for various percentiles of all covariates will be depicted. Model sensitivity to some changes in decision variables presents marginal effects and elasticities.

4. Estimation

Inland mode choice modeling for imported waterborne freight is the main focus of this study. Based on the evidence from the literature review, this research assumes that maritime distance to NY-NJ is a determinant decision variable for further inland journeying of imported freight from NY-NJ to various destinations. In other words, the events of one transportation mode affect the other modes, as far as multimodal transport is concerned. To model a discrete dependent variable of mode choice, the logit model was applied to the described data. The models provided in Table 4 illustrate the probability of choosing trucks versus rail.

Table 4: Logit model for inland movement of imported waterborne cargo

Mode (Truck=1, Rail=0)	Model (1)		Model (2)		VIF
	Coef.	P>|z|	Coef.	P>|z|	
Value (+)	0.2040	0.001	0.2135	0.000	1.75
Weight (-)	0.3540	0.1*	0.3641	0.098*	2.07
Density (-)	-0.0255	0.000	-0.0255	0.000	1.06
Value-density (+)	.0002	0.002	0.0001	0.002	1.07
Distance (-)	-.0004	0.002	-0.0004	0.004	1.57

Freight rate difference (-)	-1.2085	0.035	-1.2553	0.029	1.99
Transit time difference (+)	-0.4020	0.012	-.3676	0.022	1.48
Nautical distance (?)	---	---	.0001	0.018	1.01
Cons.	3.848	0.000	3.3495	0.000	
Total No. Observation	2194		2194		
GOF	*Model (1)*		*Model (2)*	*Difference*	
Log-Lik. Intercept only	-757.449		-757.449	0	
Log-lik. full model	-526.924		-524.113	2.811	
LR-full model (df)	(7) 461		(8) 466	5.621(1)	
Prob>LR	0.000		0.000	0.018	
McFadden's R2	0.3043		0.3081	0.004	
McFadden Adj. R2	0.294		0.296	0.002	
McKelvey & Zavoina's R2	0.972		0.974	0.002	
Akaike I.C. (AIC)	0.488		0.486	-0.002	
Count R2 (cutoff=0.5, 0.9)	0.881-0.9508		0.881-0.9558	0-0.005	
Sensitivity% (cutoff=0.5, 0.9)	97.08-96.53		97.08-96.83	0-0.3	
Specificity %(cutoff=0.5, 0.9)	15-82.92		15- 85.42	0-2.5	
Area under ROC curve	0.9253		0.9260	0.0007	
*Significant at 10%,					
Truck share in sample = 89.07%, Rail share in sample = 10.93%					

All GOFs for the second model indicate a slightly enhanced fit as a result of adding a new variable to the base model. The variance inflation factor (VIF), which is a criterion of standard error or controlling multi-collinearity between the explanatory variables, is less than 10 in this study such that multi-collinearity is unlikely to pose a problem in the models. McFadden adjusted R^2, which penalized the model when the added variable did not include more information, signifying that the second model explains the mode choice slightly better. The extent of information added to the model evaluated by AIC and the difference between the AICs of both models suggests that the second model lost less information. Count R^2, sensitivity and specificity of the models show that both models offer the same predictability for a cut-off point of 0.5, while at a cut-off point of 0.9 (which is close to the modal sample share) the second model provides superior predictability. Both McFadden R^2 and Mckelvey-Zavonia R^2 improved slightly in the second model. All criteria validate the role of maritime distance as a determinant decision variable in inland mode choice for imported waterborne freight. Although this confirmation is not very strong, it is acceptable. The remaining analysis of the current study is based on the results obtained from the second model.

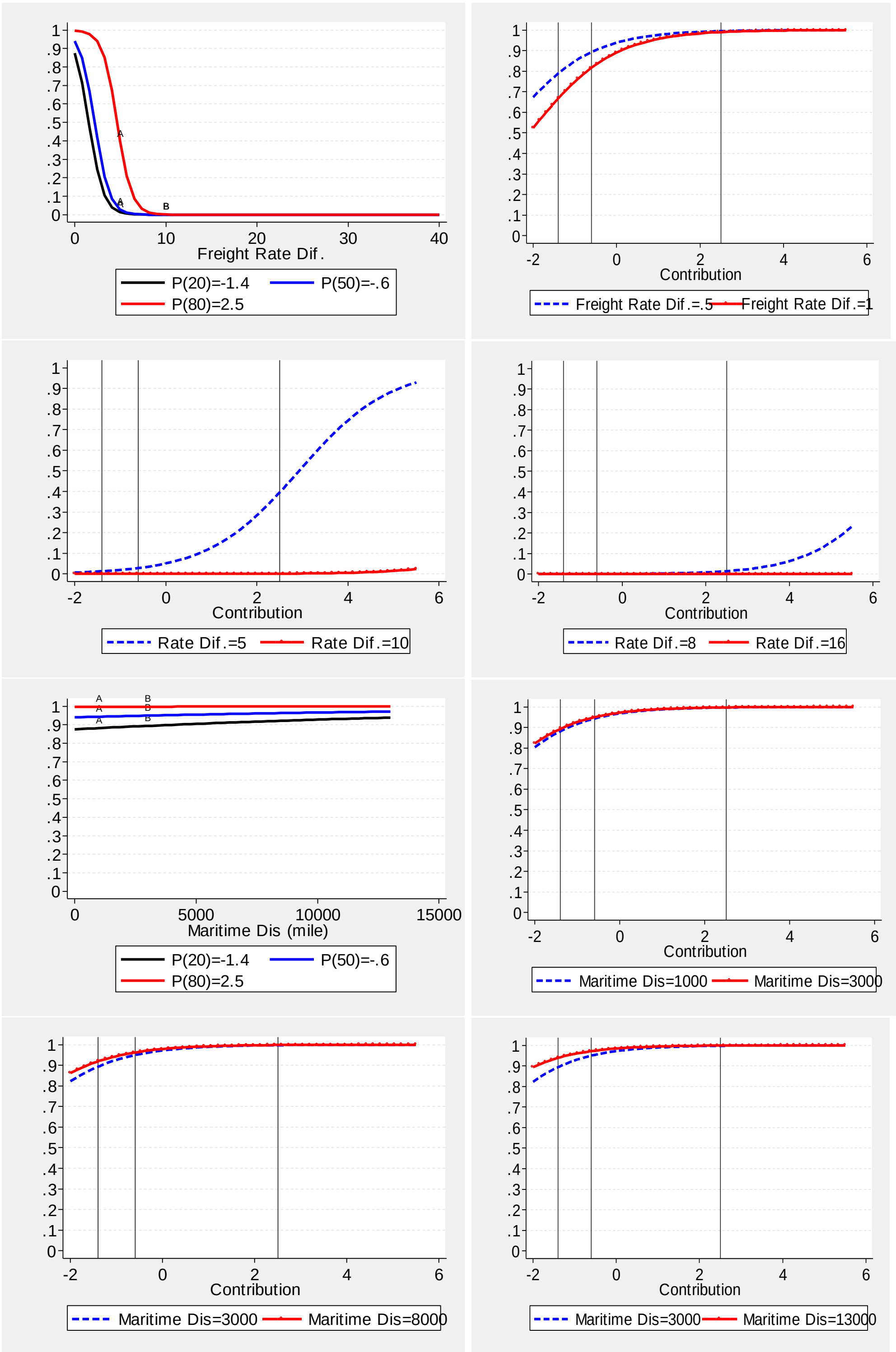
The truck log-odd (and probability) will increase by positive and decrease by negative coefficients. For both models attained, signs are strongly supported by previous studies except for shipment weight and transit time differences. Normally, in domestic freight movement with greater shipment sizes and longer transit time, rail is favored to trucks. Here, these variables show an inverse behavior to domestic freight movement. Where the sample shows that 56% of shipments are in a high-weight class (100 tons and above) and less than 5% moved by rail (sample rail share is 10.93%), a positive sign is expected. Since transit time is a function of distance, a descriptive analysis of observations shows that for a 700-1000 mile distance range, rail gains more share than its sample's share, while for trucks this occurs over distances of more than 1500 miles. Here, unlike intercity freight movement for which rail serves for long distances, waterborne freight is transported by rail over medium distances. In view of medium distance ranges, the disparity between the two transit modes' time is not considerable. This model displays that inland mode choice for imported waterborne freight is more highly affected by the difference between the two modes' freight rate, difference in the transit times of the two modes and shipment weight.

5. Analysis

The logit model for different ranges of an explanatory variable exhibits distinct behavior. However, all variables contribute to the log-odd and probability of dependent variables, but the amount of contribution for each variable in its different levels is unclear (Bruin, 2006). For instance, the effects of 100% increase in freight rate difference for lower values produce different log-odd and probability than for higher values. If an index is created by all variables (continuous variables or covariates), it is possible to investigate the contribution of each variable among the other covariates. To illustrate how various ranges of freight rate difference contribute to the probability of mode choice, this variable has been examined at three bounds (percentiles)[4]. The mean of this variable is 0.5 and its effect on the probability of mode choice is examined for various ranges (changes from 0.5-1, 5-10 and 8-16) (Fig 1). This variable at lower values (changes from 0.5 to 1) is more effective for a lower percentile of covariate contribution, while at higher values its contribution for lower percentiles is eliminated and essentially affects higher percentiles. Then, the level and pattern of this variable's effect on the probability of mode choice varies across covariate contribution percentiles. It can be concluded that this variable at a higher level considerably affects the probability of mode choice, but only for elevated percentiles of covariate contributions. Analyzing the contribution of maritime distance on the changes in mode choice probability shows that it affects the lower bounds of covariate contribution even with its higher values (Fig 1). If maritime distance increased considerably, the probability of mode would change to the detriment of the rail system. When maritime distance changes from 3000 to 13000, the contribution of this variable to the total probability of mode choice for lower percentiles will be around 10%.

[4] To draw this analysis, first an index (covariates contribution) with an equation based on all coefficients and their corresponding variable has been created. Then, the value of this index for all observations calculated, the percentiles are based on the index. For further details reference can be made to Bruin, J., 2006. Command to compute new test. Statistical Consulting Group, UCLA.

Fig 1: contribution of freight rate difference and maritime distance to the probability of mode choice



Logically, and based on the literature, freight imported over longer nautical distances with greater maritime cost must be of greater interest to be shipped by a cheaper inland mode for the remainder of the journey than the same freight over shorter distances with lower cost. This logical statement is rejected when maritime distance in the model gains a positive sign. Thus, the question arising is whether there is any statistically significant difference between the specifications of imported commodities from EU and Asia, or if the imported commodities from the two regions differ. To investigate this question, commodities imported from the two regions have been examined based on their specifications (Table 4). There is no considerable difference (at p-value=0.05) in the specification of imported commodities if the travelled maritime distance from EU and Asia to NY-NJ is drastically different.

Table 4: Independency of imported commodities

Origin	Value	Weight	Mode of SCTG	Distance	Freight rate difference
EU	11.3	3.86	32, 24, 26, 28	1140	0.37
Asia	11.96	3.2	32, 24, 26, 28	1123	0.38
T-test		*Pr(|T|>|t|)*		*t-statistics (df=2193)*	
SCTG		1		0	
Value		0.0996		1.6476	
Weight		0.4262		0.7959	
Density		0.3831		0.8723	
Freight rates difference		0.8920		-0.1358	
Distance		0.6732		0.4218	
Nautical distance		Pearson chi2(2) = 2.2e+03		Pr = 0.000	
Ton-mile		0.8920		-0.1358	
SCTG 32= Base metal in primary or semi-finished form and in finished shape, SCTG 24= Plastic and rubber, products, SCTG 26= Wood, SCTG 28= Paper or paperboard articles					

The probability of shipment by rail is higher for freight traveling longer nautical distances while the shipment is homogenous. However, the model in this case is silent, possibly for two reasons: a difference between values of homogenous commodities at import origin or some concession for EU-imported commodities. If the former is true, Asian commodities may follow the current pattern whenever this value difference exists. In that case, a mode choice model that includes the difference between values of commodities at origin and destination will explain the choice behavior more suitably.

Since the logit model coefficients are odd or log-odd numbers, their interpretation is not intuitive. To gain more insight into the logit model, it may be relevant to know how the probability of one mode modifies in response to changes in one predictor. Marginal effect provides an approximation to the amount of changes in probability of the dependent variable associated with one unit changes in the explanatory variable. Elasticity is the amount of changes in the probability of mode choice associated with

1% changes in the explanatory variable. For example, a 1% increase in maritime distance will, on average, increase the probability of truck use by 0.0439%. Or, its marginal effect indicates that with an increase of 1 nautical mile in maritime distance to NY-NJ, the probability of truck use rises by 3.79e-06. The absolute values of elasticity and marginal effects for both nautical and inland distances are not equal, but similar. While a 1% increase of inland distance will decrease the truck probability by -0.0525%, maritime distance will augment this probability by 0.0439%. Their elasticity signifies that they alter the probability of mode choice in similar but inverse directions (Table 5).

Table 5: Marginal effect and elasticity analysis of the mode choice

Decision variable	Marginal effect-d(y)/d(x)	P>|z|	Elasticity	P>|z|
Value	.0148274	0.000	.0191912	0.000
Weight	.0252863	0.099*	.0128227	0.019
Density	-.001774	0.000	-.225935	0.000
Value-density	9.84e-06	0.002	.0154343	0.000
Distance	-.0000245	0.004	-.0525101	0.008
Freight rate difference	-.0871658	0.029	-.0104521	0.018
Transit time difference	-.0255232	0.022	-.0846038	0.027
Maritime distance	3.79e-06	0.017	.0439021	0.012

*significant at 10%

Since some Asian economies are passing through the last stage of a developing country status to that of a developed country, their product will be more sophisticated and probably with higher value. The relevant elasticity in the model shows that with 1% increase in commodity value, the probability of truck to rail will increase by 0.019 to the detriment of rail system. This higher tendency of high-valued commodities to be transported by truck while Asian merchandise has less probability of being transported by rail and are becoming more valuable than before will make Asian products in the US market vulnerable. This can only be avoided if they start using inland rail transport so as to save total logistic cost like their European competitors. Suppose 10% increase in the value of Asian commodities while the value of EU imported commodities assumed to be fixed, the calculated elasticity for value of imported commodities will increase from 0.0192 to 0.0198. While same increase in the values of EU observations will decrease elasticity from 0.0192 to 0.0186, it shows that commodities imported from EU in response to their value are more elastic than Asian commodities. Such a condition in short run may happened as a result of exchange rate fluctuations in origin or destination or any increase in maritime costs from Asia to the US ports.

6. Conclusion

In the US inland freight system, trucks are the dominant mode of inland movement. There exists a considerable gap between the truck share of moving domestic freight and waterborne freight import. This truck domination has led to truck-dependent port activities, consequently creating congestion of trucks with limited accessibility levels to ports and their neighborhood. Recent studies have identified two approaches to mitigating the truck congestion issue related to port activities. The first approach proposes a pricing system when departing from the port's gate at various hours of the day, which is also known as gate congestion pricing. The second method suggests moving freight via alternative modes, a method called mode choice. This study was designed to investigate mode choice for imported waterborne freight. To achieve this goal, 2194 waterborne imported observations were made from CFS-2007 for NY-NJ using the logit model. Value, weight, inland distance, density and value density as commodity specifications, and distance, difference between truck and rail freight rates and transit times as modal specifications were deployed to examine the mode choice for non-containerized imported waterborne freight. A model with all of these variables was initially developed, after which maritime distance as a new decision variable was added to the model to gain a positive, statistically significant coefficient. Upon comparing both models, the second was selected for further analysis.

In this present study it was found that the logit of mode choice is highly sensitive to differences among the two modes' freight rates. From the commodity specifications, weight, followed by shipment value are determinants to mode choice. Although all coefficients gained appropriate sign in line with previous intercity freight studies, weight gained opposite sign. Normally, intercity freight movement experiences larger shipment sizes transport by rail. For this study, the opposite sign for weight is related to shipment weight for rail observations. Among the modal specifications, the difference between rail and truck transit time gained reverse sign compared to prior studies. This occurred because imported waterborne freight over medium distance ranges moved by rail.

In this study the role of maritime distance in inland mode choice was confirmed. For higher maritime distances, the truck has higher probability than rail regarding ship-imported waterborne freight. While imported waterborne freight from Asia and EU were homogenous, commodities imported from Asia (greater nautical distances) in comparison to EU (shorter nautical distances) have lower chances of being shipped by rail. It is a wonder then why importers of Asian commodities do not attempt to utilize cheaper modes for inland merchandise journeys. One reason could be related to the differences in prices of Asian commodities at origin and destination, but this gap should be sufficient to make up for the cost of low rail utilization. If this is indeed the reason, and as the price of production factors in both regions are getting closer, in the long run Asian commodities will have lost their price advantage on the US market. Thus, Asian exporters need to find ways to decrease the total logistic cost of their merchants before they lose considerable market share.

It was generally found in this study that the inland mode choice for imported waterborne freight differs from intercity freight movement. It may be deduced that although inland shippers and freight forwarders are in a similar business, they make distinctive mode choice decisions.

To expand on this study, additional specific attributes for export and import commodities are required. Besides, it is necessary to analyze mode choice behavior for various commodity groups in a range of ports to identify the differences in mode choice behavior for export and import commodities. This research focused on import commodities with two modes only. Thus, a comprehensive study shall include a multinomial model for various groups of export and import commodities.

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