A Binary Probit Model to Analyse Freight Transportation Decision-Maker Perspectives for Container Shipping on the Northern Sea Route

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Abstract

The predicted decrease of ice presence in the Arctic Ocean may allow commercial container shipping to use the Northern Sea Route (NSR) throughout the year starting about 2050. This paper conducts a *stated preference* survey of freight transportation decision-makers in East Asia and Europe to understand their perspectives towards the use of the NSR to ship cargo. A binary probit model is used to investigate the correlation between the operational and behavioural characteristics of freight transportation decision-makers and their attitudes towards maritime freight carriers operating through the NSR. The survey results suggest that a significant percentage of users will not use the NSR, at least during the initial period of operations, if the NSR is considered for container transportation between East Asia and Europe. Some perceptible differences were observed between the responses of forwarding companies, and freight transportation decision-makers from other industries, with forwarding companies less likely to use the NSR if their current carriers offer it as an alternative. Freight transportation decision-makers with large volumes, having shipments from East Asian countries but not to them, and/or ship chemical commodities, were found to be less likely to use the NSR.

Keywords*: Northern Sea Route, binary probit model, container transportation, stated preference survey, freight transportation demand, maritime transportation*

Introduction

Using the Arctic Ocean for commercial shipping year round may be feasible starting about 2050 (Khon et al., 2010), based on changes in the ice cover of the Arctic region. Observations made by the National Snow and Ice Data Centre show that the average annual ice extent has decreased in the last twenty years by 1.25 million km^2, or 8% (Beitler, 2015). The Arctic Ocean is predicted to be open for commercial shipping on a regular basis during the summer season (from April to October) after 2020 (Khon et al., 2010). Currently, the operational period in the Arctic Ocean varies from 3 to 6 months (Beitler, 2015; Northern Sea Route Administration, 2015).

There are two routes in the Arctic Ocean: the Northwest Passage and the Northeast Passage. The Northwest Passage is a sea route along the northern coast of North America, via waterways through the Canadian Arctic Archipelago, which connects East Asian ports with the east coast ports of North America without the need to transit the Panama Canal. By contrast, the Northeast Passage traverses the Russian and Norwegian regions of the Arctic Ocean, and connects East Asian ports with European ports. The Northern Sea Route (NSR) is a part of the Northeast Passage, defined as a route from the Kara Gates Strait between the Barents Sea and the Kara Sea, along Siberia, to the Bering Strait (Northern Sea Route Administration, 2015). In this study, only the NSR part of the Northeast Passage is considered for two key reasons. First, due to its geographic characteristics, the Northwest Passage cannot be used by many types of vessels currently being operated, making the use of this route questionable for commercial shipping. Somanathan et al. (2009) showed that the sea route through the Panama Canal is preferable for cargo transportation between East Asian ports and ports on the east coast of the United States. Second, shipments between Europe and East Asia represent one of the largest container trade volumes in the world (Hampert, 2013). However, existing routes between East Asia and Europe experience congestion that can lead to delays and additional costs. In addition, the integration of container transportation with the global supply chain requires improvements to existing transportation procedures in terms of transit time and costs for container transportation users. These transportation procedures include, but are not limited to packaging, cargo handling, route and mode selections, warehousing, and communication with service providers. Hence, there is a need for the associated countries to explore different options to improve the existing maritime freight transportation system.

Currently, the main cargo types shipped through the NSR include liquid and dry bulk cargo (Kuptsov, 2014). Only a few container carriers have used the NSR on a trial basis, and none currently uses it on a regular basis. Lasserre and Pelletier (2011) conducted a survey of carrier companies to determine their attitudes towards sailing in the Arctic. Their survey results suggest that carriers in the container segment have lower interest in Arctic routes compared to carriers in the bulk, liquid, and general cargo segments. Nevertheless, several studies have suggested that using the NSR for container transportation is economically feasible. For example, Verny and Christophe (2009) compared the NSR with the sea route through the Suez Canal, Trans-Siberian rail transportation, air transportation, and a combination of maritime and air transportation, and found that the NSR was the cheapest option. By contrast, Liu et al. (2010) found that the NSR may not be profitable for freight carriers due to possible cost and operational uncertainties (e.g., vessel and cargo damage, uncertain insurance costs, icebreaker and pilot ship cost uncertainty, and weather uncertainty).

There are five main reasons for the increasing interest in using the NSR for freight transportation between East Asian ports and European ports as an alternative to the route through the Suez Canal: (i) the NSR provides mileage reduction (up to 30%), and thus can decrease transit time and fuel consumption depending on ice conditions; (ii) the NSR avoids regions with high piracy risks; (iii) the NSR avoids the Suez Canal fee, as well as possible congestion in the canal; (iv) the NSR could provide an alternative route between East Asian ports and Europe in the event of political instability in the Middle East; and (v) the Arctic Ocean has high potential for gas resources, with the first liquefied natural gas (LNG) plant now under construction in the Yamal Peninsula (Kara Sea) (EY's Global Oil & Gas Centre, 2015), with some studies predicting rapid transition to LNG fuel for marine transportation in the near future (Adamchak and Adede, 2013). Hence, vessels using the NSR can potentially have ready access to the cheaper LNG fuel along their route without additional transportation costs.

Existing studies on the feasibility and economic efficiency of the NSR have accounted for the first three factors, but do not consider the fourth and fifth factors. This is because it is difficult to quantify the impact of political instability in the Middle East. In terms of the fifth factor, the use of LNG fuel requires substantial changes in the shipbuilding industry and, further, LNG has not yet been broadly used in container vessels.

Despite the potential benefits of using the NSR, there are also several disadvantages. First, bureaucracy and unclear pricing policy for icebreaker and pilotage make it difficult to estimate the economic efficiency of using the NSR (Ho and Rajaratnam, 2010). Second, an absence of safe ports and weather uncertainty within the NSR make conditions less safe for commercial shipping (Ragner, 2000). Third, the NSR is currently available for commercial shipping only in certain seasons. Depending on ice conditions, shipping may start in April and continue until October, but the actual start date is always subject to weather and ice conditions. This makes scheduling for carriers challenging, as container services are typically planned 3-6 months in advance (American Bureau of Shipping. Navigating the Northern Sea Route adviser, 2014). Fourth, unclear insurance policies for vessels traveling in the NSR and cargo transported through the NSR add uncertainty to the economic efficiency estimation and feasibility studies of the NSR (American Bureau of Shipping. Navigating the Northern Sea Route adviser, 2014). Fifth, depending on weather conditions, certain vessel types can be restricted to operate on this route due to the geographical features of the route and the size of the biggest icebreaker used for a particular convoy (Marsh & McLennan Companies, 2015). Most of the aforementioned disadvantages are related to uncertainty. Hence, accounting for them complicates the efficiency estimation.

Previous studies related to the feasibility and the economic efficiency analysis of the NSR have not considered potential changes in future demand, or have not considered demand at all. Such approaches may not be reasonable, as container transportation is highly competitive (Lee and Meng, 2015), and hence, demand can vary significantly with small changes in freight rates, transit time, routing, location of transhipments, safety statistics, etc. (Chao and Chen, 2015). Use of the NSR for services between East Asia and Europe could entail changes in any of these parameters. Hence, the demand for container transportation between East Asia and Europe through the NSR is difficult to predict.

To understand the roles of some of the aforementioned issues in the NSR context, this study seeks to: (i) understand freight transportation decision-maker perspectives toward container transportation through the NSR; and (ii) identify possible reasons for demand changes in container transportation if a carrier decides to use the NSR for transportation between East Asia and Europe. A stated preference survey of potential users of container transportation services through the NSR is conducted to understand their perspectives towards the use of the NSR. These potential users are the freight transportation decision-makers, and include

forwarding companies, and sellers and buyers of shipped cargoes. Depending on the sales contract terms, either seller or buyer acts as shipper for the maritime segment of container transportation, and hence, is responsible for carrier and transportation procedure selection. For a seller or buyer to be selected as a survey participant, it must currently have container flows between East Asia and Europe, and must be responsible for carrier and transportation procedure selection. Forwarding companies act on behalf of sellers and/or buyers, and can also act as a shipper on their behalf. Forwarding companies can provide the following services to sellers and/or buyers: communication with truckers, clearance agents, maritime carriers, railway services, financial and freight insurance institutions, etc. (Panayides, 2006). For a forwarding company to be selected as a survey participant here, it needs to be involved in the maritime segment of container transportation between East Asia and Europe. Based on a seller's or buyer's awareness of, willingness, and capability to control the transportation procedure selection, the final decision related to transportation could be made by the forwarding company, or by seller or buyer itself. Hence, to better understand possible demand changes, forwarding companies are considered separately in this study.

A binary probit model is used to analyse the correlation between the operational and behavioural characteristics of freight transportation decision-makers, and their intent to use the NSR if their current carriers offer it as an alternative.

Methodology

We evaluate the intent of freight transportation decision-makers to use the NSR if their current carriers offer it as an alternative. To do so, the response to the following question with binary choice is considered as the dependent variable: If your container carrier announces that it will start using the NSR as an alternative, will you consider using it, at least for the initial period of operation (one season, or longer)? A binary probit model (Washington et al., 2011) is used to determine the probability of the intent to use the NSR. To measure the expected changes in the dependent variable due to changes in a certain explanatory variable, the marginal effects were computed.

The binary probit model assumes that the observed dependent variable Y can be 1 if and only if its underlying continuous latent variable Y^* takes on a positive value (Washington et al., 2011):

$$Y = \begin{cases} 1, if\ Y^* > 0 \\ 0, otherwise \end{cases} \qquad (1)$$

where

$$Y^* = X\beta + \varepsilon, \text{with } \varepsilon \sim \mathcal{N}(0,1) \qquad (2)$$

where Y denotes the respondents' intent to use the NSR if their current carriers offer it as an alternative. X denotes the vector of explanatory variables. β is a vector of estimable parameters for the latent variable Y^*. ε is an error term, and is assumed to be normally distributed with zero mean and a variance of one. By denoting the two outcomes as 1 and 2, the cumulative probability of outcome 1 occurring for observation n can be written as follows (Washington et al., 2011):

$$P_n(1) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{(\beta_1 X_{1n} - \beta_2 X_{2n})/\sigma} e^{-\frac{1}{2}w^2} dw \qquad (3)$$

where σ is a standard deviation used to rescale the normally distributed random variables into the standard normal distribution. Denoting the cumulative distribution function of the standard normal distribution by $\Phi(\cdot)$, the cumulative probability for the binary case can be written as follows:

$$P_n(1) = \Phi\left(\frac{\beta_1 X_{1n} - \beta_2 X_{2n}}{\sigma}\right) \qquad (4)$$

To fit the binary probit model, β is estimated using the maximum likelihood method. Without loss of generality, the log likelihood function can be used in the estimation, as the log transformation does not affect the ordering. In the binary case, the log likelihood function is:

$$LL = \sum_{n=1}^{N} \left(\delta_{1n} LN\Phi\left(\frac{\beta_1 X_{1n} - \beta_2 X_{2n}}{\sigma}\right) + (1 - \delta_{1n}) LN\Phi\left(\frac{\beta_1 X_{1n} - \beta_2 X_{2n}}{\sigma}\right)\right) \qquad (5)$$

where N is the total number of observations, and δ_{in} is defined as being equal to 1 if the observed discrete outcome for observation n is i, and 0 otherwise.

Data collection and descriptive results

Data was collected from June 2014 to March 2015 using anonymous online surveys (The NSR Survey in English, Chinese, and Russian languages). Potential users of container transportation services through the NSR, operating container flows between Europe and East Asia, were recruited to complete surveys. The recruiting process was conducted through e-mail and phone calls. Information about potential respondents was collected through several open source websites (Alibaba Group Holding Limited, Prodexpo 2014, China import and export fair,

International exhibition for transport and logistic services and technologies: TRANSRUSSIA). About 1,500 potential respondents were contacted for the survey. 204 valid responses were obtained, for an overall response rate of 13.6%.

In our survey, a respondent was required to be aware of all international container shipments of his/her company, and influence decisions related to transportation and carrier selection. Hence, depending on company size, the logistics department head or president of the company was chosen as a respondent. The respondent was asked to consider only those shipments where his/her company was responsible for decisions related to transportation and carrier selection.

They survey considered several business sectors that use commercial container shipping, including forwarding, commerce and trading, building and construction, manufacturing, and agriculture. Commerce and trading includes retail, fashion, "just-in-time" cargo, etc. The survey goal was to capture perspectives of these respondent groups, carrying different cargo types, towards the NSR.

A respondent was asked three sets of questions: (i) the company's operational characteristics, (ii) questions to assess the company's awareness and expectations of the NSR, and (iii) the company's attitude towards the NSR. The first set of questions included information about the type of company by industry, the types of commodities it shipped, origins and destinations of the shipments, annual volume of shipping, and the location of its headquarters. The first set of questions also asked respondents to evaluate the importance of different parameters (freight rates, transit time, routing, previous work experience with the carrier, safety statistics, numbers of transhipment ports, location of latest transhipment, terminal employed at the port, and routing) when they select their carriers. The second set of questions asked if the respondent was aware that carriers have already started to use the NSR on a trial basis. To understand a company's expectations of the NSR option, the respondent was also asked about possible changes related to container transportation (changes in transit time, freight rates, vessel and commodity safety, and reliability) if the NSR was used. The third set of questions asked if the respondent's company would consider using the NSR if their current carriers offer it as an alternative for container transportation between East Asia and Europe. If respondents answered "no", they were asked to indicate what factors would persuade them to do so, with the following options specified: lower freight rates, shorter transit time, sufficient reliability, or none.

Among the 204 valid responses, 97 were forwarding companies and the rest were freight transportation decision-maker respondents from other industries (commerce and trading, building and construction, manufacturing, and agriculture) as illustrated in Table 1. Though forwarding companies constituted just 47.5% of the respondents, they accounted for 86.7% of the total volume (twenty-foot equivalent unit - TEU).

Companies that work in commerce and trading were the second largest group (40.7%). The other three groups constituted only small percentages of the respondent group: 5.9% of the companies were associated with building and construction, and 2.9% each with manufacturing and agriculture. The main reason for the distribution reflected in Table 1 is that the global supply chain is the main customer for container transportation service.

Table 1: Type of company by industry.

Industry type	**Numbers of respondents**	**Volume (in TEUs)**		
		East Asia to Europe trade	Europe to East Asia trade	Total
Forwarding	47.5%	258,088	150,566	408,654
Commerce and trading	40.7%	44,959	10,352	55,311
Building and construction	5.9%	2,782	103	2,885
Manufacturing	2.9%	235	10	245
Agriculture	2.9%	1,550	2,150	3,700
Total	100.0%	307,614	163,181	470,795

The cargo types shipped by respondents are shown in Table 2; multiple answers were allowed for this question for each respondent. Consumer and industrial goods were the main cargo types shipped by the respondents.

The descriptive statistics for the annual volume shipped by respondents are presented in Table 3. The annual volume of companies from the transportation sector (forwarding) is higher, although there were fewer participants from that sector.

The headquarters of the companies of most of the respondents are in Europe, and the most frequent direction of shipment is from East Asia to Europe, as indicated in Table 4.

Table 2: Commodity types shipped by respondents (multiple answers are allowed).

Commodity type	Numbers of respondents
Consumer goods	65.7%
Industrial goods	59.8%
Equipment	43.6%
Chemical goods	34.8%
Seasonal goods	25.5%
Food and beverage	19.1%
Refrigerated goods	17.6%

Table 3: Annual volume statistics.

Parameter	Company type	Total	Mean
Approximate annual volume in TEUs from East Asia to Europe	Forwarding companies	258,088	2,661
	Others	49,526	462
Approximate annual volume in TEUs from Europe to East Asia	Forwarding companies	150,566	1,552
	Others	12,615	118

Table 4: Locations of headquarters of the companies, and origin and destination of shipments.

Region	Locations of headquarters	Origin	Destination
Europe	179	114	197
East Asia	19	195	54
South Asia	4	78	20
Middle East and North Africa	2	51	15
Southeast Asia	-	102	27
North and South America	-	35	28
Australia and New Zealand	-	31	6

Participants were asked to rate the importance of different factors that influence their decision to choose a carrier, on a scale of 1 to 5, where 1 indicates a factor that is not considered and 5 indicates that a factor has the highest importance. As illustrated in Fig.1, the freight rate is the most important factor (4.8 out of 5) influencing transportation decisions, followed by transit time (4.0 out of 5) and previous positive work experience with the current carrier (3.9 out of 5).

Transit time and previous work experience are rated slightly lower by forwarding companies compared to respondents from other industries. The loading/discharging terminal is more important for forwarding companies, as the operational plan of the forwarding company depends primarily on the deployed terminal. Safety statistics are rated slightly higher by respondents that are not forwarding companies (average rates are 2.8 and 3.1 out of 5 for forwarding companies and respondents from other industries, respectively).

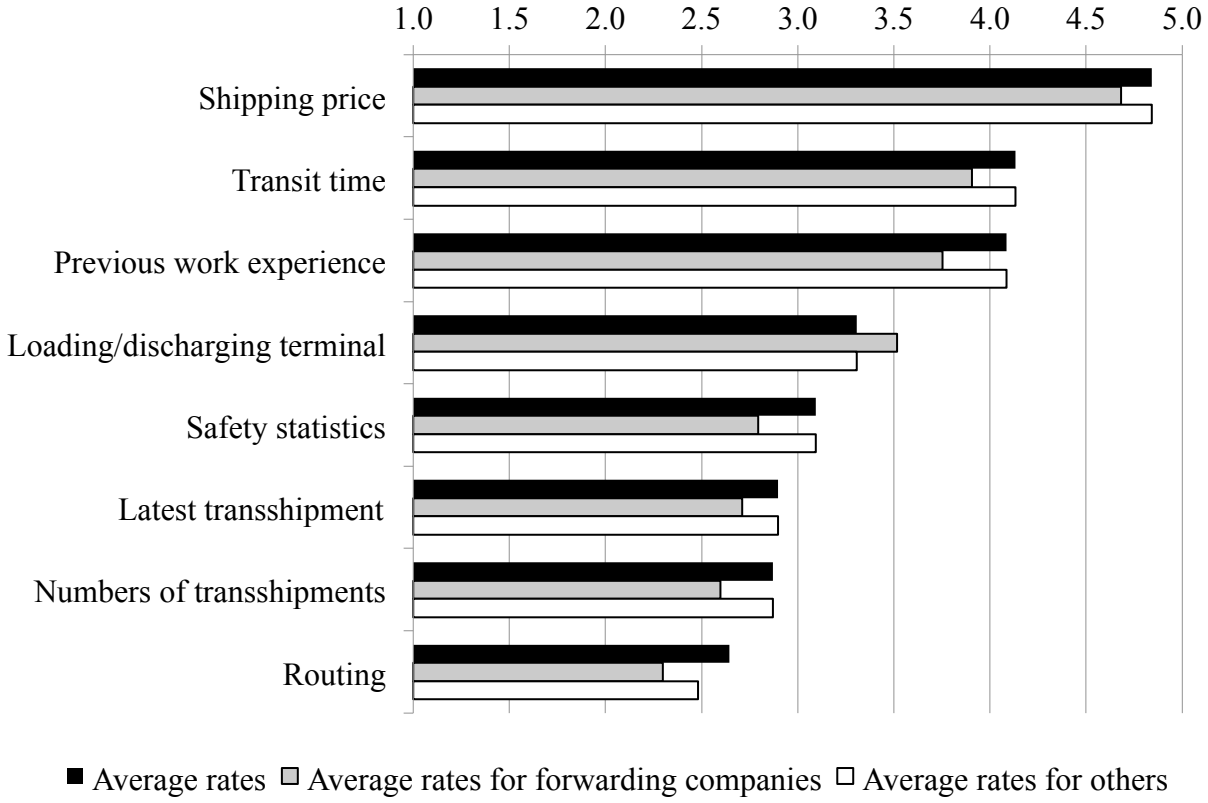

Figure 1: Respondents' ranking of the importance of factors that influence transportation decisions (scale is from 1 – "factor not considered at all" to 5 – "the most important factor").

Table 5 illustrates responses related to: (i) whether respondents would consider using the NSR if their current carriers offer it as an alternative, and (ii) respondent awareness of the use of the NSR by carriers in general. 41.2% of the respondents indicated that they would not use the NSR. This suggests that a significant percentage of users will not use the NSR, at least during the initial period of operations, if the NSR is considered for container transportation between East Asia and Europe. This can have a significant impact on the economic efficiency of using the

NSR for container transportation. Future studies related to the economic efficiency of the NSR should account for possible demand decreases on these routes.

A key characteristic observed in Table 5 is the significant difference in the response of forwarding companies and respondents from other industries. While the latter mostly would consider using the NSR, a significant majority of the forwarding companies would not. This clear differentiation in their responses is because forwarding companies typically operate in a highly competitive space (Guo and Peeta, 2015; Guo et al., 2016), and are hence sensitive to changes. To reduce the risk of losing clients, they are more likely to avoid any deviations from well-established transportation procedures. 39.2% of the respondents were aware that some carriers have already started to use the NSR on a trial basis. There was no significant difference in this awareness between forwarding companies and respondents from other industries.

Table 5: Responses related to intention to use the NSR and awareness of the use of the NSR by carriers.

Response	**Will respondent consider using the NSR?**			**Is respondent aware that carriers have started using the NSR?**		
	Total (n = 204)	Forwarding companies (n = 97)	Others (n = 107)	Total (n = 204)	Forwarding companies (n = 97)	Others (n = 107)
Yes	58.8%	26.8%	87.9%	39.2%	37.1%	41.1%
No	41.2%	73.2%	12.1%	60.8%	62.9%	58.9%

Table 6 illustrates the respondents' assessment of the impacts of the use of NSR on various operational factors. 36.3% of the respondents felt that none of the specified factors would be adversely impacted by the use of the NSR, and 27.5% of them felt that none of the specified factors would be improved. However, in both contexts, there are some differences in the responses of forwarding companies and respondents from other industries. These differences can be explained by possible differences in experience related to container transportation. Typically, forwarding companies have more diverse experiences as they work with different shippers and consignees with varying requirements. Reduced commodity safety is the main concern of both types of respondents, as 23.7% and 29.9% of them, respectively, indicate that commodity safety would be reduced if the NSR is used. Only 4.4% of the respondents indicate that commodity

safety would improve if the NSR is used. Almost one-fifth of the respondents feel that reliability would decline if the NSR is used, while just 2.1% of the respondents feel that reliability would improve. 18.6% of the respondents felt that transit time would increase. This could be because some routes through the NSR are not competitive, for example, between southern ports in East Asia and Mediterranean ports in Europe. However, 46.1% of the respondents indicated that transit time would decrease; the positive sentiment is more pronounced for forwarding companies. As forwarding companies usually work with several commodity flows, they are more likely to have shipments between ports that will have higher transit time savings if the NSR is used. In particular, shipments between ports in northern East Asia and northern Europe will entail higher transit time savings if the NSR is used, compared to shipments between ports in southern East Asia and southern Europe. Hence, the diversity of commodity flows leads to more forwarding companies expressing optimism that transit time will decrease if the NSR is used. Reduced vessel safety is indicated as a possible impact by 14.2% of the respondents. 12.7% of the respondents feel that freight rates would increase if the NSR is used; by contrast, 41.7% of the respondents feel that freight rates would decrease.

Table 6: Responses related to the impacts of the use of the NSR (multiple answers are allowed).

Factor	**What will become worse?**			**What will become better?**		
	Total (n = 204)	Forwarding companies (n = 97)	Others (n = 107)	Total (n = 204)	Forwarding companies (n = 97)	Others (n = 107)
Commodity safety	27.0%	23.7%	29.9%	4.4%	5.2%	3.7%
Reliability	19.1%	15.5%	22.4%	2.0%	2.1%	1.9%
Transit time	18.6%	17.5%	19.6%	46.1%	54.6%	38.3%
Vessel safety	14.2%	16.5%	12.1%	3.4%	5.2%	1.9%
Freight rates	12.7%	9.3%	15.9%	41.7%	42.3%	41.1%
None	36.3%	45.4%	28.0%	27.5%	19.6%	34.6%

If a respondent answered that he/she would not consider using the NSR, the respondent was also asked to indicate what factors would persuade him/her to do so. Multiple answers were allowed from among the following specified options: lower freight rates, shorter transit time,

sufficient reliability, or none. The results are shown in Table 7. 84 respondents indicate that they would not consider using the NSR, of which 71 correspond to forwarding companies and 13 correspond to respondents from other industries. The results indicate that lower freight rates, shorter transit time, and sufficient reliability are factors that could persuade freight transportation decision-makers to use the NSR. Shorter transit time and sufficient reliability are less pronounced as factors for forwarding companies compared to respondents from other industries. This can be explained in terms of the difference in risk aversion between these two groups of respondents. New transportation procedures can change the economic efficiency of business, by either improving it or making it worse. By contrast, forwarding companies are more risk averse due to the highly competitive space they operate in. Hence, the additional risk associated with using the NSR is higher for forwarding companies compared to respondents from other industries. The survey responses suggest that carriers should consider lowering freight rates, reducing transit times, and enhancing reliability to mitigate the potential demand reduction if they start to use the NSR. To do so, carriers need to communicate with related agencies and shipbuilding companies to resolve safety and operational issues associated with the NSR operation.

Table 7: Factors that could persuade freight transportation decision-makers to use the NSR (multiple answers are allowed).

Factor	**Numbers of respondents**			**Volume in TEUs**		
	Total (n = 84)	Forwarding companies (n = 71)	Others (n = 13)	Total (n = 84)	Forwarding companies (n = 71)	Others (n = 13)
Lower freight rates	51.2%	49.3%	61.5%	175,555	170,880	4,675
Shorter transit time	48.8%	43.7%	76.9%	124,125	111,175	12,950
Sufficient reliability	29.8%	25.4%	53.8%	75,010	69,920	5,090
None	21.4%	22.5%	15.4%	56,740	56,210	530

To better understand freight transportation decision-makers' attitudes and analyse possible reasons for demand changes, the binary probit modelling approach was adopted. The model estimation results are discussed in the next section.

Estimation results

Results from an estimated binary probit model are presented in Table 8, with the dependent variable being whether the respondent would consider using the NSR if their current carriers offer it as an alternative. Six operational and behavioural characteristics of freight transportation decision-makers were found to be statistically significant ($p < 0.05$).

The results suggest that forwarding companies are 60.6% less likely than respondents from other industries to consider using the NSR if their current carriers offer it as an alternative. Due to the high competition among forwarding companies, they must avoid any possible risk of losing clients. Hence, to ameliorate possible decreases in demand, carriers should pay more attention to generating positive attitudes of forwarding companies toward the NSR option.

Table 8: Binary probit model parameter estimates.

Parameter Description	**Parameter estimate**	**t-statistic**	**Marginal effect**
Constant	-1.505	-4.300	-
Indicator for respondent working in forwarding company	1.313	5.000	60.6%
Indicator for respondent with annual volume more than 1,000 TEUs	0.763	2.735	33.5%
Indicator for respondent that has shipments from East Asian countries, but have no shipments to East Asian countries	0.430	2.549	30.7%
Indicator for respondent that ships chemical commodities	0.611	2.523	22.1%
Indicator that respondent considers “transit time” as a non-important factor	-1.115	-2.388	-7.6%
Indicator that respondent considers “previous work experience” as an important factor	-0.343	-2.503	-22.1%
Log Likelihood at zero		-138.209	
Log Likelihood at convergence		-83.227	
$\boldsymbol{\rho^2}$		0.398	
Number of observations		204	

Freight transportation decision-makers with annual volumes of more than 1,000 TEUs, are less likely to consider using the NSR. A possible reason is that companies with large volumes cannot change their transportation procedures easily (e.g., changing cargo insurance or adjusting cargo packaging).

Freight transportation decision-makers that have shipments from East Asia, but not to East Asia, are 30.7% less likely to use the NSR. Since a majority of the respondents' companies are located in Europe (87.7%), they are more likely to be buyers of these shipments or act on behalf of the buyers (if respondent is a forwarding company). Hence, they are more sensitive to possible transit time changes and other uncertainties during maritime transportation, as those uncertainties can impact their operations. Use of the NSR to ship cargo can increase the uncertainty in transit time and reduce cargo and vessel safety due to weather and ice conditions. To reduce the impacts of these factors, freight transportation decision-makers may prefer to avoid using the NSR if their current carriers offer it as an alternative until there is sufficient clarity on the performance of the NSR.

Freight transportation decision-makers that ship chemicals are 22.1% less likely to use the NSR if their current carriers offer it as an alternative. This is possibly because chemicals usually require additional negotiations at every step of transportation (in the port of loading, in transhipment ports, in port of discharging, etc.). Any changes or uncertainties arising from the use of the NSR would therefore require additional preparations, which could cost time and money. Hence, companies that carry chemical cargo are more likely to continue using services similar to those that they currently use.

Freight transportation decision-makers that do not consider transit time as an important factor when choosing a carrier are 7.6% more likely to use the NSR. Using the NSR can potentially increase transit time variability due to weather uncertainty; thus, freight transportation decision-makers that assign less importance to the transit time as a factor are more likely to use the NSR if their current carriers offer it as an alternative. Freight transportation decision-makers who consider previous work experience as an important factor are 22.1% more likely to use the NSR. If they have prior positive work experiences with their current carrier, they are likely to use the NSR if their current carriers offer it as an alternative.

Concluding comments

The NSR provides a shorter route between East Asian and European ports compared to the current maritime route through the Suez Canal. The predicted further decrease of ice presence in the Arctic Ocean in the near future may allow commercial shipping to use the NSR throughout the year. While several studies have suggested that using the NSR for container transportation is feasible and economically efficient, they assume that carriers would elicit similar demand levels for transportation through the NSR as through the Suez Canal. This study finds that this assumption is not valid, at least during the initial period of operations. While carriers have started to explore the Arctic Ocean as a possible option for future operations, potential users may have specific concerns that need to be understood, so that the decision-makers can take appropriate actions to foster the use of the NSR.

As illustrated in Table 8, four operational characteristics (forwarding companies, volume, companies with shipments from East Asian countries but not to them, and companies shipping chemicals) and two behavioural characteristics (considering "transit time" as a non-important factor, and considering "previous work experience" as an important factor) have strong, statistically significant, correlations with the intent to use the NSR. The main findings of this paper can be summarized as follows. First, carriers may experience a demand decrease if they start using the NSR, at least during the initial period of operation. Second, carriers are more likely to lose clients that: (i) are forwarding companies, (ii) transport annual volumes of more than 1,000 TEUs, (iii) have shipments from East Asian countries but not to them, or (iv) ship chemical commodities. Third, as illustrated in Table 7, lower freight rates, shorter transit time, and sufficient reliability could persuade freight transportation decision-makers to use the NSR. Fourth, forwarding companies and respondents from other industries display perceptible differences in attitudes in some specific contexts under the NSR option due to differences in the roles they entail. For example, forwarding companies typically operate in a highly competitive space, and are hence more sensitive to the vagaries of the NSR operational characteristics.

Based on the insights from this study, decision-makers can take appropriate actions and effectively allocate their resources to design and operate freight transportation services in the NSR. To ensure that the NSR option is a meaningful alternative to the current maritime routes, decision-makers of carrier companies need to communicate with related agencies and shipbuilding companies to resolve safety and operational issues associated with the NSR operation.

Additional studies are needed to explore the following issues: (i) identifying optimal pricing policy for icebreaker and pilotage convoys; (ii) identifying optimal configuration of safety and navigational infrastructure in the Arctic Ocean; (iii) accounting for weather uncertainty; (iv) identifying insurance policies for transportation in the Arctic Ocean; and (v) identifying optimal vessel parameters (size, ice class, fuel type). Using shipping vessels with ice class could decrease icebreaker fees and dependence on weather conditions. However, container vessels with ice class do not currently exist. Planning and building of vessels with ice class could substantially increase construction costs. However, possible benefits of using container vessels with ice class may outweigh the increase in construction cost.

Future research directions are to collect additional data to infer on freight transportation decision-makers' familiarity with the NSR, and to explore possible connection between familiarity and readiness to use this route.

References

Adamchak, F., Adede, A. (2013) LNG as marine fuel. *IGT International Liquefied Natural Gas Conference Proceedings* 1: 321-328.

Alibaba Group Holding limited. (2016) Available at: www.alibaba.com. Accessed 20 May 2016.

American Bureau of Shipping. Navigating the Northern Sea Route adviser. (2014) Available at: http://ww2.eagle.org/content/dam/eagle/publications/2014/NSR_Advisory.pdf. Accessed 20 May 2016.

Beitler, J. (2015) May in decline. National Snow and Ice Data Centre, June 2015. Available at: http://nsidc.org/arcticseaicenews/category/analysis/. Accessed December 1, 2015.

Chao, S.-L., Chen, B.-C. (2015) Effects of Switching Costs on Customer Loyalty in the Shipping Industry. *Maritime Economics and Logistics* 17(3): 341-358.

China import and export fair. (2016) Available at: http://www.cantonfair.org.cn/en/. Accessed 20 May 2016.

EY's Global Oil & Gas Centre. Arctic Oil and Gas. (2016) Ernst & Young Global Limited. Available at: http://www.ey.com/Publication/vwLUAssets/ey_global_oil_and_gas_capabilities/$FILE/global_oil_and_gas_capabilities.pdf. Accessed 20 May 2016.

Hampert, M. (2013) The Future of Arctic Shipping: a New Silk Road for China? The Arctic

Institute, Centre for Circumpolar Security Studies. Available at: http://www.thearcticinstitute.org/2013/11/the-future-of-arctic-shipping-new-silk.html. Accessed 20 May 2016.

Ho, J. (2010) The Implications of Arctic Sea Ice Decline on Shipping. *Marine Policy* 34(3): 713-715.

Guo, Y. and Peeta, S. (2015) Rail-Truck Multimodal Freight Collaboration: Truck Freight Carrier Perspectives in the United States. *Journal of Transportation Engineering* 141(11): 1-11.

Guo, Y., Peeta, S., Mannering, F.L. (2016) Rail-Truck Multimodal Freight Collaboration: a Statistical Analysis of Freight-Shipper Perspectives. *Transportation Planning and Technology* 39(5): 484-506.

International Exhibition for Transport and Logistic Services and Technologies: TRANSRUSSIA. (2015) Available at: http://www.transrussia.ru/en-GB. Accessed 20 May 2016.

Khon, V.C., Mokhov, I.I., Latif, M., Semenov, V.A., Park, W. (2010) Perspectives of Northern Sea Route and Northwest Passage in the Twenty-First Century. *Climatic Change* 100(3/4): 757-769.

Kuptsov, N. (2014) Northern Sea Route: Perspectives for Bulk Carriers and Liquid Tankers. *Applied Mechanics and Materials* 587-589: 1986-1992.

Lasserre, F., Pelletier, S. (2011) Polar Super Seaways? Maritime Transport in the Arctic: an Analysis of Shipowners' Intentions. *Journal of Transportation Geography* 19(6): 1465-1473.

Lee, C.-Y., Meng, Q. (2015) Handbook of Ocean Container Transportation Logistics. Springer.

Liu, M., Kronbak, J. (2010) The Potential Economic Viability of Using the Northern Sea Route (NSR) as an Alternative Route Between Asia and Europe. J*ournal of Transport Geography* 18(3): 434-445.

Marsh & McLennan Companies. Arctic Shipping: Navigating the Risk and Opportunities. (2014) Available at: https://www.marsh.com/us/insights/arctic-shipping-navigating-risks-opportunities.html. Accessed 20 May 2016.

Northern Sea Route Administration. (2016) Northern Sea Route Information Office. Available at: http://www.arctic-lio.com/nsr_transits. Accessed 20 May 2016.

Panayides, P.M. (2006) Maritime Logistics and Global Supply Chains: Towards a Research

Agenda. *Maritime Economics and Logistics* 8: 3-18.

Prodexpo 2014: 21st International Exhibition for Food, Beverages and Food Raw Materials. (2014) Available at: http://www.prod-expo.ru/en/. Accessed 20 May 2016.

Ragner, C.L. (2000). Northern Sea Route Cargo Flows and Infrastructure – Present State and Future Potential. Fridtjof Nansen Institute Report. Available at: http://www.fni.no/pdf/FNI-R1300.pdf. Accessed 20 May 2016.

Somanathan, S., Flynn, P., Szymanski, J. (2009) The Northwest Passage: a Simulation. *Transportation Research Part A: Policy and Practice* 43(2): 127-136.

The NSR Survey in English and Chinese Languages. (2015) Available at: https://purdue.qualtrics.com/SE/?SID=SV_e9ihQ2tB2CUehDL. Accessed 20 May 2016.

The NSR Survey in English and Russian Languages. (2015) Available at: https://purdue.qualtrics.com/SE/?SID=SV_1X1KfKDA34q9mlL. Accessed 20 May 2016.

Verny, J., Grigentin, C. (2009) Container Shipping on the Northern Sea Route. *International Journal of Production Economics* 122(1): 107-117.

Washington, S.P., Karlaftis, M.G., Mannering, F.L. (2011) Statistical and Econometric Methods for Transportation Data Analysis, 2nd Ed. Chapman & Hall/CRC, Boca Raton.