Modelling the international Arctic Transport Corridor

N. Didenko[1], K. Kikkas[1] & K. Kunze[2]
[1]*St. Petersburg Polytechnic University, Russia*
[2]*University of Colorado, USA*

Abstract

The paper estimates the potential consequences of the development of the Arctic transport route taking into account the melting of polar ice and thus increased navigating time through the seas of the Arctic Ocean. The seas of the Arctic Ocean enable two ways from Europe to South-East Asia. The first one is the Northern Sea Route (the Northern Sea Corridor) around the Arctic coast of Russia and partially through the Pacific Ocean. This is the shortest seaway between Europe and South-East Asia. The second one is the Northwest Passage. It goes along the northern coast of North America through the Canadian Arctic Archipelago. The alternatives to the Northern Sea Route are either through the Suez Canal or via the Trans-Siberian Railway Road. The paper discusses a model of the international transport corridor thereby analyzing the factors that influence the endogenous variable of the model. The basis of the model is an autoregressive distributed lags model (ADL model). The models are estimated for the Northern Transport Corridor, Northwest Passage, Trans-Siberian Railway Road and Transport Corridor of the Suez Canal. While the volume of transported goods was taken as an endogenous variable in all the models, different exogenous variables were selected for each model using data for the period from 1990 to 2013. The paper comprises the results of the standard steps in the ADL model (test for autocorrelation of the endogenous and the exogenous variables; stationarity/non-stationarity analysis of the time series; regression analysis). Finally the paper provides the conclusions regarding the comparison of the Northern Transport Corridor to its alternatives.
Keywords: Arctic Transport Corridor, Northern Sea Route, empirical model of the Artic Transport Corridor, ADL model, autoregressive distributed lags, stationary series, ordinary least squares.

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1 Introduction

The transport capacity of the Arctic Region attracts the attention of the whole world, and especially the countries of the Arctic region. Arctic routes are interesting since it is possible to deliver the goods of the shortest sea route from Europe to Asia thereby shortening the trip from Asia to America at the expenses of cross-polar routes.

Many countries are interested in the development of the Arctic zone, since the Arctic is a strategically interesting region with huge hydrocarbon reserves. Industrial development of the Arctic should focus on the exploitation of hydrocarbon and biological resources, which will lead to the development of transport infrastructure and traffic flows of the Arctic Region.

The development of transport operations in the Arctic will require international cooperation in the transport sector, compliance with safety regulations of the areas, harmonization of legal legislations of the Arctic states, and development of next generation technologies to minimize the impact on the fragile ecosystem. In this case, the effective use of the main road of the Arctic – the Northern Sea Route, as well as trans-Arctic air areas will be possible only if there is a modern infrastructure and full communication and navigation systems.

Several studies have analyzed the effects of the economic potential of the transportation in the Arctic Zone.

Fadeev [1] considers that the technological complexity of transport operations in arctic climates and legal features of the laws of Arctic states determine the necessity of international cooperation in the transport sector. He analyzed the project "North airlift", that provides air routes from Asia to North America across the Arctic. In the first place flight routes can be used by the countries of Southeast Asia, The flight time, depending on the flight route is reduced by 2-5 hours.

"Northern Air Bridge" provides an integrated system of communication in the Arctic (in particular, by launching satellites in highly elliptical orbits and developing the necessary ground infrastructure) to provide air service between the airports of Krasnoyarsk (Russia) and Winnipeg (Canada).

Bayerz [2], and Rodrigue [3] analyzed the economic development of Canada's Arctic shelf adjacent. They postulate that relying on modern international law the country has a significant legal basis for the economic development of the adjacent Arctic shelf. The Northwest Passage is of great importance for Canada. Due to the melting of polar ice, the time of navigation has increased. In the case of the complete melting of the ice the strait will be comparable to the economic attractiveness of the Northern Sea Route (NSR) around the Arctic coast of Russia. The reason is that it significantly shortens the route from East Asia to Europe and the US East Coast and Canada (in comparison with the route through the Panama Canal).

Kozlovski. [4], Dudarev *et al*. [5], Lumiste and Prause [6] compare the Northern transport passage with the Trans-Siberian Transport Corridor and the Suez Canal. The authors believe that maritime transport in the Arctic is virtually uncontested and most effective way of delivery of equipment, energy, industrial

products, food, necessary for the functioning of clusters in Russia, located in the coastal zone of the Arctic seas.

Dodin [7] addresses the issue of education for sustainable development for the entire circumpolar Arctic, patterns of distribution of important natural resources, the state of the main traffic routes – the Northern Sea Route and Northwest Maritime Passage, as well as problems of indigenous peoples. For sustainable development in the Arctic, he proposes the establishment of a mechanism in the form of inter-state government program "Arctic-XXI century."

Konishev and Sergunin [8] analyzed the socio-economic, political, military-strategic and environmental interests of Russia in the Arctic. The authors conclude that these factors are long-term in nature and that the state and society should pay constant attention to them. Expanding the resource base is a priority for Russia in the Arctic zone to advance the economic development in these areas. At present, the Arctic zone provides 11% of national income in Russia, despite the fact that there is about 1.4 % of the population of the entire country. Mazur [9] considers the Arctic Zone as one of the key points of intersection of the various interests in the development of the global world. In the past five years the global importance of the Arctic has increased dramatically in geopolitical and geo-economic processes due to global climate change and the possibility of using natural resources and communications. The expert on environmental international cooperation Tennberg [10] thinks that the question on environmental issues has become a global problem.

In Proceedings of International Conference on "The Arctic Region Development and Cooperation", it was noted that the Arctic is an ideal region in terms of international cooperation and opportunities for complementary investments (Moscow [11]).

Effective development of the Russian Arctic is impossible without adequate transport provision in the region. A key role in its development is the Northern Sea Route (NSR). The NSR is the shortest waterway that connects the western and eastern parts of the country, as well as European and Asian ports. In the long run, this transport artery has all chances of becoming the shortest connection between the Asia-Pacific region and Europe.

2 Characteristics of the Northern Maritime Corridors

Currently, in the Arctic Ocean there are two sea routes (the Marine Traffic Corridors of the Arctic Ocean), the Northwest Passage and the Northern Sea Route. The Northwest Passage is along the northern coast of North America through the Canadian Arctic Archipelago. The Northern Sea Route is along the Russian coast. Figure 1 shows the map of the aforementioned sea routes [12].

The project Northern Maritime Corridor (NMC) began in 2002 with the support of the EU. Its implementation has shown the importance and success of the cooperation between the project participants from Russia and the Nordic countries. The project participants are representatives of ministries and departments, regional authorities, port authorities and representatives of private companies from eight European countries, including Norway, Russia, Iceland,

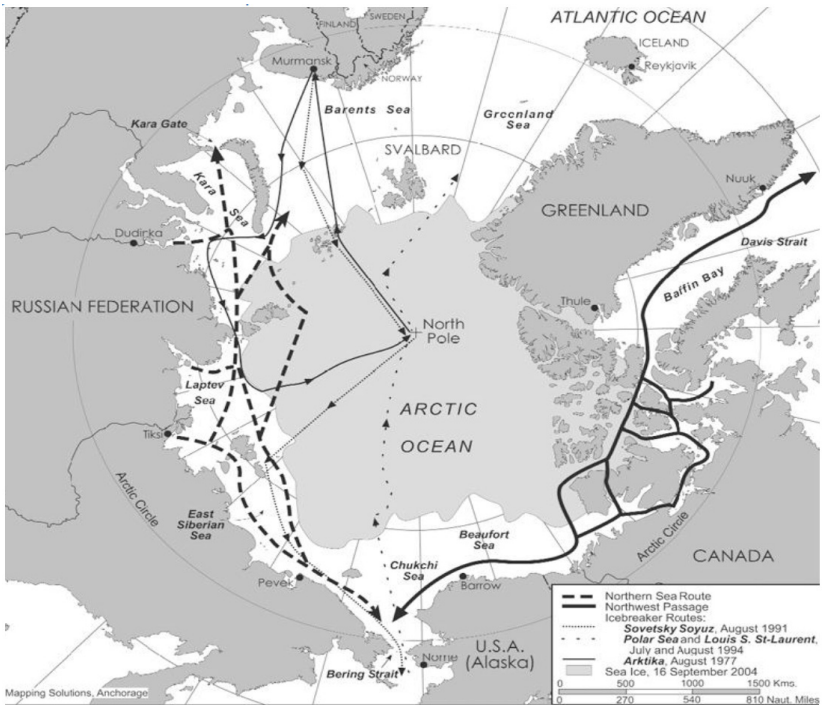

Figure 1: The Arctic Ocean with transportation corridors.

the Netherlands, Great Britain, and others. The main objective of the project is to create the most favorable conditions for the development of maritime and intermodal transportations, e.g. using different modes of transport through the northern ports of Norway and Russia, as well as the creation of an integrated transport system in northern Europe. This should help to increase the volume of maritime transport between European ports and the ports of northern Russia. In addition, one of the main driving factors is the development of oil and gas sector and the implementation of large projects in this area. Using Northern Maritime Corridor to transport oil and gas equipment is the main goal of the project. At the same time, the establishment of regular posts will attract the attention of forwarding agencies that are now supplying to Russia and from Russia through the ports of the Gulf of Finland.

The Northern Sea Route in Europe begins at Novaya Zemlya Straits (Cape of Desire), and ends in the Bering Strait, Asia. Transportation of goods along the Northern Sea Route can be performed in two shipping routes. The distance along the high latitude route is 2,200 nautical miles and along the coastal route 2,990 nautical miles.

Northwest Sea Passage, Trans-Siberian Railway Road, and South Sea way are considered as the most important alternatives to the Northern Sea Route and thus these alternatives are incorporated into the econometric analysis.

Northwest Sea Passage (SPP) is a network of several maritime routes through the Canadian Arctic Archipelago, consisting of about 19 thousands islands, lots of rocks and reefs [13, 14].

With the rapid climate change due to global warming shipping lines of the Arctic Ocean are becoming increasingly congested. In addition, the Northwest Sea Passage, connecting the Atlantic and Pacific oceans, reduces transport routes and thus saving time and money in the implementation of commercial trade. Melting ice of the Arctic Ocean reduces the dependence on the Panama and Suez Canals.

The Trans-Siberian Railway Road with a length of 9,288.2 kilometers, (historical name: Great Siberian Way) is a railroad through the Eurasian continent, connecting the European part of Russia that contains its largest industrial areas and the country's capital, with its median (Siberia) and eastern (Far East) areas, is the longest railway in the world. In 2002 it was fully electrified.

The key to South Sea Route is the Suez Canal. The legal status of the Suez Canal is currently governed by the Constantinople Convention relating to free passage through the Suez Canal. The most important principles of navigation through the canal, which have been established by the Convention of Constantinople is the freedom to use the canal by ships of all countries, the equality of all countries in the use of the canal, and the principle of neutrality, meaning the prohibition of the blockade of the Suez Canal.

3 Econometric model of the transport corridors

3.1 Auto regressive distributed lag model

The purpose of this paper is to develop model for the transport corridor in in order to assess the trends in endogenous variable depending on exogenous factors. The amount of commercial goods transported along the corridors is chosen as an endogenous variable. Three key performance indicators, gross domestic product of countries that use the corridor, the number of vehicles passing through the corridor, and the costs of transporting a cargo unit are included as exogenous factors in the model.

A feature of this model is that the volume of commercial goods transported along the corridor for the t-th year depends on the amount of commercial goods transported in previous periods. In addition, the volume of commercial goods transported along the corridor for the t-th period depends on the gross domestic product of countries that use the corridor, on the number of vehicles passing through the corridor, and on the costs of transporting a cargo unit in previous periods. Thus the desired dynamic relationship can be written as a function with different lags.

An autoregressive distributed lag model (ADL) includes the mentioned features and therefore was chosen for a formalized description of the economic representation of the transport corridors. ADL model is a time series model, in

which the current values depend on the number of past values of the series, and on the current and past values of other time series.

The ADL model has the form:

$$y_t = a_0 + \sum_{i=1}^{n} a_1 y_{t-i} + \sum_{j=0}^{q_1} b_j x_{t-i}^1 + \ldots + \sum_{j=0}^{qk} b_j x_{t-i}^k + E_t \qquad (1)$$

k – number of exogenous variables;
q – number of lags;
n – highest lag;
E_t – residues forming white noise process.

3.2 Data

Data on the Northern Sea Route, the Southern Sea route, the Trans-Siberian Railway Road, and the Northwest Passage were obtained from the World Bank database, the administration of the Northern Sea Route Russia, database of the Research Institute of Arctic and Antarctic regions of Russia, the Ministry of Economic Development and Trade of Russia, the Administration of the Suez Canal, administration of the Trans-Siberian Railway Road, and the Nordic Council.

3.3 Endogenous and exogenous variables used in the model

The endogenous variable is in all models the volume of transported goods. The exogenous variables are selected according to the strongest effect on the volume of goods transported and are most common in the literature of economics of transportation.

The preliminary analysis considers twenty socioeconomic variables for each corridor (including the aforementioned alternatives). After the preliminary analysis the number of indicators has been significantly reduced and for further analysis the following variables have been included in the model.

3.3.1 Northern Sea Route

Russia's GDP (x_t^1);

Number of vessels passing through the route (x_t^2);

Average cost of passage through the route (x_t^3);

3.3.2 Southern Sea Route

EU's GDP (x_t^1);

Number of vessels that have passed through the route (x_t^2);

Average cost of passage through the route (x_t^3).

3.3.3 Trans-Siberian Railway Road

Russia's GDP (x_t^1);

Number of containers passing through the Trans-Siberian Railway (x_t^2);

Average cost of transit through the Trans-Siberian Railway (x_t^3)

3.3.4 Northwest Passage

Canada's GDP (x_t^1);

Number of vessels passing through the passage (x_t^2);

Average cost of passage through the route (x_t^3).

3.4 Time series analysis

An important feature in the time-series analysis is the stationary process resulting in probabilistic properties that do not change over time. In the paper the analysis of stationary was performed using the Dickey-Fuller test. The Dickey-Fuller (DF-unit root test) is an algorithm for testing the statistical hypothesis of stationarity of the time series and its differences with rising order. The analysis showed that all-time series have the calculated value of t-statistics (-2.862497, -49.74669; -7.865434, -4.581936), which is less than the critical t-tests at the 5% significance level (-1.580936, -6.970114, -0.996234, -1.869742) implying that all-time series have a unit root. Therefore, the first differences form a stationary time series.

The autocorrelation analysis of the endogenous and exogenous variables was performed on order to determine the lags for exogenous variables in the autoregressive model. Using the autocorrelation coefficients as a criterion, lags that are statistically significant are included in the model.

In the model for the Northern Sea Route the endogenous variable was included with $t-1$ lag and two exogenous variables were included with $t-1$ and $t-2$ lag (x_{t-1}^1, x_{t-2}^1 and x_{t-1}^2, x_{t-2}^2).

In the model for the South Sea Corridor the endogenous variable was included with $t-1$ and $t-2$ lag. Two exogenous variables were included with $t-1$ and $t-2$ lag (x_{t-1}^1, x_{t-2}^1 and x_{t-1}^2, x_{t-2}^2).

In the model for the Trans-Siberian Railway Road the endogenous variable was included with $t-1$ and $t-2$ lag. Two exogenous variables were included with $t-1$ and $t-2$ lag (x_{t-1}^1, x_{t-2}^1 and x_{t-1}^2, x_{t-2}^2).

In the model of the North-West sea passage the endogenous variable was included without a lag because of a small correlation coefficient between y_t and y_{t-i}. The exogenous variables were included with $t-2$ lag (x_{t-2}^1 and x_{t-2}^2).

The significance was checked using the standard error criterion and Q-Box-Pearson criterion.

Analysis of multicollinearity revealed the following pattern. The correlation coefficients in the models for all corridors showed a close relationship between the volume of transported goods and GDP (0.89; 0.82; 0.69; 0.65 at r = 0.9).

The correlation coefficients between the volume of transported goods and the average cost of passage through the route do not show close relationship (r = 0.9). The correlation coefficients in the model for Southern Sea route, Trans-Siberian Railway Road, Northern Sea Route, and Northwest Passage are -0.0967,-0.0076, -0.215, and -0.88 respectively.

Calculation of the coefficients of equation (1) for stationary series has been performed. Based on the regression model (1), the equation with the remaining variables after the analysis is as follows:

$$y_t = a_0 + a_1 \cdot y_{t-1} + a_2 \cdot y_{t-2} + b_1 \; x^1_{t-1} + b_2 \cdot x^1_{t-2} + c_1 x^2_{t-1} + c_2 x^2_{t-2} \qquad (2)$$

The coefficients of the models for each corridor were determined using ordinary least squares. Student's t-test was used to assess the statistical significance of the coefficients.

3.4.1 Model of Northern Sea Route

$$y_t = 2.415 + 0.01 y_{t-1} - 0.05 x^1_{t-1} + 0.07 x^1_{t-2} + 0.007 x^2_{t-1} - 0.045 x^2_{t-2} - 0.13 x^3_{t-2}$$

The significance level of the coefficient of the variables x^1_{t-2}, x^2_{t-1}, is 0.696 and 0.864 respectively. Thus these variables may be removed from the equation.

3.4.2 Model of South Sea Corridor

$$y_t = 733.477 + 0.069 y_{t-1} + 0.016 y_{t-2} - 0.026 x^1_{t-1} - 0.025 x^1_{t-2} + 95.192 x^2_{t-1} + 13.198 x^2_{t-2} - 0.017 x^3_{t-2}$$

The significance level of the coefficient of the variable x^2_{t-2} is 0.794. Thus this variable may be removed from the equation.

3.4.3 Model of Trans-Siberian Railway Road

$$y_t = 642457.687 + 80.743 y_{t-1} + 0.169 y_{t-2} - 0.214 x^1_{t-1} - 1.076 x^1_{t-2} + 259.061 x^2_{t-1} + 45.211 x^2_{t-2} - 3.01 x^3_{t-1}$$

The significance level of the coefficient of the variable x^2_{t-2} is 0.873. Thus this variable may be removed from the equation.

3.4.4 Model of Northwest Maritime Passage

$$y_t = 0.261 - 0.017 x^1_{t-2} - 0.143 x^2_{t-2}$$

The significance level of the coefficient of the variables is 0.99.

4 Conclusion

Climate change in the northern regions leads to ice melting and thus to a greater availability of routes in the Arctic Ocean in terms of days. This trend suggests that the number of vessels on the Northern Sea Route and the Northwest sea passage will increase, and therefore, the volumes of transported goods will also increase. The Northern Sea Route is the shortest path and the shortest sea transit corridor between Northern Europe and the Asia-Pacific region, which runs through the seas of the Arctic Ocean (Barents, Kara, Laptev, East Siberian, and Chukchi Sea) and part of the Pacific Ocean (Bering Sea).

The Northern Sea Route and the Northwest Sea Passage can become cost-effective alternatives because of the emergence of large transit transportations, further development of the territory and the reduction of transportation costs.

The models of transportation corridors allow us to estimate the volume of traffic depending on various factors that characterize the different operating conditions of transport corridors, inter alia, natural, organizational, technological, economic factors. The results of the research outlined in this paper show that at the moment the lack of information on many indicators represents the biggest limitation to the full modelling of the operations in the corridors. This suggests that as the development of the Arctic Zones forges ahead it is necessary to form a database needed for the analysis and forecasting.

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