Potential Opportunities for the Arctic Transport Space

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Abstract. Two distinct routes from Europe to South-East Asia via the seas of the Arctic Ocean are considered in the work: the Northern Sea Route (NSR) and the Northwest Passage. Potential opportunities for the Arctic transport space under the conditions of melting polar ice and expanding navigation period on the Arctic Ocean are substantially increasing. Some alternatives to the NSR and Northwest Passage are described: a) by sea – this is the transport artery going along the Suez Canal; b) by land – these are the transport arteries including the Trans-Siberian Railway (Trans-Sib). The research is aimed at creating a model of the international transport corridor. The model is based on the autoregressive distributed lags (ADL) model. Separate models are constructed for the Northern Corridor, the Trans-Siberian railway, the transport corridor of the Suez Canal and the Northwest Passage. Factors influencing the endogenous variable of the model, consisting in the volume of goods transported for all corridors, are analysed. The exogenous variables were selected separately for each model. The time series covers the 1990-2013 period. The major steps of the implementation of the ADL-model are described: testing the endogenous and exogenous variables for auto-correlation; checking for stationarity of the time series; regression analysis. Finally, conclusions pertaining to the comparison of the NSR with other transport corridors are drawn.

1. Introduction
Although the transport capacity of the Arctic Region is attracting increased attention worldwide, it is of particular interest to the countries of the Arctic region. Arctic routes are of interest due to the possibility to use them to deliver goods from Europe to Asia via the shortest sea route thereby shortening the trip from Asia to America at the expense of cross-polar routes [1]. Strategic interest in the development of the Arctic region is also due to its huge hydrocarbon reserves. Thus, industrial development of the Arctic focusing on the exploitation of hydrocarbon and biological resources will go hand in hand with the development of transport infrastructure and traffic flows in 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, harmonisation of legal legislations of the Arctic states and the development of next generation technologies to minimise the impact on the fragile ecosystem. Effective use of the Northern Sea Route (NSR), as well as associated trans-Arctic air corridors, will only be possible if there is a modern infrastructure and full communication and navigation systems.

Several studies have analysed the effects of the economic potential of the transportation in the Arctic zone. In studies [2-4] the forms of international cooperation in the transport sector are presented taking into account the technological complexity of transport operations in the Arctic climate. The legal practices of the Arctic states in field of this cooperation are analysed. In the paper [2] the sea
transportation models and their transformation over the last decade are studied and some routes through sea passages in the Canadian Arctic Archipelago are described in detail. The network structure of the various product groups shows the diversity of trade models in the Arctic water between Canadian and foreign fleets. The key challenges for transpolar transportation through the North West Passage are described in terms of climate change, market development and new regulations in [5-7].

In [3] some of the economic risks of exploiting the Arctic sea routes are investigated. Along the coast of Siberia, the average Arctic summer sea ice level has decreased, reducing the time of shipping through the NSR along the Siberian coast from 20 days in the 1990s to 11 days in the years 2012 and 2013. The state of the Arctic Ocean is characterised by a thinning of sea ice and increase of maritime activity. In order to explore the navigation of the Arctic sea routes, a detailed design of oceanic and sea ice (RCP8.5 IPCC emission scenario) is used.

An econometric structural equation model is presented in [4] to test hypotheses explaining how the temperature, rainfalls and wind speed fluctuations affect the passenger and cargo transportation. The model considers changes in traffic rate due to adverse weather conditions in the Arctic region. As a test object, northern Norway's Saltfjellet mountain area is selected. It is proposed to use standardised parameters in transport models to predict the impact of adverse weather conditions on the traffic rate.

The model of the Northern Air Bridge is demonstrated in [8]. The Northern Air Bridge provides air routes from Asia to North America across the Arctic. Mathematical models for analysing the flight routes used by the countries of Southeast Asia are presented. Depending on the flight route, flight times are decreased by 2-5 hours.

The growth of human activity multiplies the problems associated with the management of the Arctic Ocean. In paper [9], a mechanism is proposed for responding to emerging needs in the management of the Arctic Ocean based on the United Nations Convention on the Law of the Sea. This multi-functional mechanism, which is being developed for the regulation of human activities throughout the Arctic Ocean, allows different participants to be assigned to different categories having different rights and responsibilities.

The idea of creating an international Arctic governance framework is not a new one. In paper [10], the development of transport corridors in the Arctic is associated with the exploitation and development dynamics of rich hydrocarbon resources in the Arctic region. When comparing Arctic hydrocarbon exploration and development cycles with global energy prices, unified methods for combating possible pollution of the Arctic shelf are proposed. The oil prices fluctuations, technical problems of oil extraction in the Arctic and issues of sovereignty between circumpolar countries only strengthen the problem of establishing an international framework for the governance of the Arctic.

In study [11, 12], the economic development of Canada’s adjacent Arctic shelf is analysed. According to postulates relying on contemporary 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 duration of navigability has increased. In the case of a complete melting of the ice, the strait will be comparable in terms of economic attractiveness to the NSR around the Arctic coast of Russia. The reason for this is that it significantly shortens the route from East Asia to Europe, the United States East Coast and Canada (in comparison with the route through the Panama Canal).

In researches [13], [14], [15], the NSR is compared with the Trans-Siberian transport corridor and the Suez Canal. According to the authors, the Arctic maritime transport route is virtually uncontested in terms of being most effective way of delivering equipment, energy, industrial products and food, all necessary for the functioning of Russian clusters located in the coastal zone of the Arctic seas.

Dodin [16] addresses the issue of education for the sustainable development for the entire circumpolar Arctic, patterns of distribution of important natural resources, the state of the main traffic routes – the NSR and the Northwest 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 an inter-state government programme dubbed 21st Century Arctic.
Konishev and Sergunin [17] analyse 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 in order to advance economic development in these areas. At present, the Arctic zone provides 11% of national income in Russia, even though only around 1.4% of the national population lives there. Mazur [18] 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 terms of geopolitical and geo-economic processes due to global climate change and the possibility of using natural resources and communications based there. In discussing international cooperation around the Arctic, Tennberg [19] states that associated environmental issues have become a global problem.

In the published Proceedings of the International Conference “The Arctic Region Development and Cooperation”, it is noted that the Arctic comprises an ideal region in terms of international cooperation and opportunities for complementary investments.

Since the effective development of the Russian Arctic is impossible without adequate transport provision in the region, the Northern Sea Route (NSR) plays a key role in its development. The NSR is the shortest waterway connecting the western and eastern parts of Russia, as well serving to connect European and Asian ports. In the long run, this transport artery has an excellent chance to become the shortest and most efficient connection between the Asia-Pacific region and Europe.

2. Characteristics of the Northern Maritime Corridors
The Northern Maritime Corridor (NMC) project began in 2002 with the support of the European Union. Its implementation has demonstrated the importance and potential success of cooperation between Russian and Nordic participants. 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, the Netherlands, Great Britain, and others. The main objective of the project is to create the most favourable 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 to facilitate 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 the oil and gas sector and the implementation of large projects in this area. Using the 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 already transporting goods to and from Russia through the ports of the Gulf of Finland.

The NSR in Europe begins at Novaya Zemlya Straits (Cape of Desire), and ends in the Bering Strait, Asia. The transportation of goods along the NSR can be carried out along two distinct shipping routes: high-latitude and coastal. The distance along the high-latitude route is 2,200 nautical miles; along the coastal route, it is 2,990 nautical miles. Since the Northwest Sea Passage, Trans-Siberian Railway, and Southern Sea Route are considered to be the most important alternatives to the NSR, these alternatives are incorporated into the econometric analysis. The Northwest Sea Passage comprises a network of several maritime routes through the Canadian Arctic Archipelago, including around 19 thousand islands, as well as many hazardous rocks and reefs. With rapid climate change due to global warming, the shipping lines of the Arctic Ocean are becoming increasingly congested. However, by connecting the Atlantic and Pacific oceans, the Northwest Sea Passage reduces transport routes and thus saves time and money in the implementation of commercial trade. In effect, the melting ice of the Arctic Ocean reduces dependence on the Panama and Suez Canals.

With a total length of 9,288.2 kilometres, the Trans-Siberian Railway, which consists of a railroad network that runs across the Eurasian continent, connecting the European part of Russia comprising its largest industrial areas and capital with its median (Siberia) and eastern (Far East) areas, is the longest railway in the world. In 2002 it became fully electrified.
The key element of the Southern Sea Route is the Suez Canal. The legal status of the Suez Canal is currently regulated by the Convention of Constantinople relating to free passage through the Suez Canal. The most important principles of navigation through the canal, established by the Convention of Constantinople, are the freedom of use of the canal by ships of all countries, the equality of all countries in their use of the canal and the principle of neutrality, implying a prohibition on blockading the Suez Canal.

3. Econometric model of the transport corridors

3.1. Auto regressive distributed lag model

The autoregressive distributed lag (ADL) model was chosen for a formalised description of the economic representation of the transport corridors. ADL is a time-series model, in which the current values depend on the number of past values of the series, as well as on the current and past values of other time series [20, 21].

The ADL model has the form:

$$y_t = a_0 + \sum_{i=1}^{n} a_i y_{t-i} + \sum_{j=0}^{q} b_j x_{t-i}^j + \sum_{j=0}^{q} b_j x_{t-i}^k + E_t$$

where \( k \) – the number of exogenous variables; \( q \) – the number of lags; \( n \) – the highest lag, \( E_t \) – residues forming white noise process.

3.2. Data

Data on the NSR, the Southern Sea Route, the Trans-Siberian Railway and the Northwest Passage were obtained from the World Bank database, the Administration of NSR Russia, the 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, the Administration of the Trans-Siberian Railway, and the Nordic Council.

3.3. Endogenous and exogenous variables used in the model

In all models, the endogenous variable represents the volume of transported goods. The exogenous variables were selected on the basis of their effect on the volume of goods transported and being commonly referred to in the literature on the economics of transportation.

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

NSR: Russia’s GDP \( (x_t^1) \); Number of vessels passing through the route \( (x_t^2) \); Average cost of passage through the route \( (x_t^3) \).

Southern Sea Route: GDP of the EU \( (x_t^1) \); Number of vessels passing through the route \( (x_t^2) \); Average cost of passage through the route \( (x_t^3) \).

Trans-Siberian Railway: Russia’s GDP \( (x_t^1) \); Number of containers transported along the Trans-Siberian Railway \( (x_t^2) \); Average cost of transportation along the Trans-Siberian Railway \( (x_t^3) \).

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

Stationary analysis was carried out using the Dickey-Fuller test. This showed that all time series have a unit root. Therefore, the first differences form a stationary time series. Autocorrelation analysis of the
endogenous and exogenous variables was performed in 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 NSR the endogenous variable was included with $t - 1$ lag and two exogenous variables were included with $t - 1$ and $t - 2$ lag $\left(x_{t-1}, x_{t-2}^2 \text{ and } x_{t-1}^2, x_{t-2}^2\right)$.

In the model for the Southern Sea Route, the endogenous variable was included with $t - 1$ and $t - 2$ lag. Two exogenous variables were included with $t - 1$ and $t - 2$ lag $\left(x_{t-1}, x_{t-2}^2 \text{ and } x_{t-1}^2, x_{t-2}^2\right)$.

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

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

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

Multicollinearity analysis 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, NSR, and Northwest Passage are -0.0967, -0.0076, -0.215, and -0.88 respectively.

The coefficients of equation (1) were calculated for the stationary series. Based on the regression model (1), the equation with the remaining variables after the analysis is as follows:

$$y_t = a_0 + a_1 \cdot y_{t-1} + a_2 \cdot y_{t-2} + b_1 \cdot x_{t-1}^1 + b_2 \cdot x_{t-2}^1 + c_1 x_{t-1}^2 + c_2 x_{t-2}^2$$

(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.

Model of NSR:

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

(3)

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

Model of Southern Sea Route:

$$y_t = 733.477 + 0.069 y_{t-1} + 0.016 y_{t-2} - 0.026 x_{t-1}^1 - 0.025 x_{t-2}^1 + 95.192 x_{t-2}^2 + 13.198 x_{t-2}^3 - 0.017 x_{t-2}^4$$

(4)

The significance level of the coefficient of the variable $x_{t-2}^4$ is 0.794. Therefore, this variable may be removed from the equation.

Model of Trans-Siberian Railway:

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

(5)

The significance level of the coefficient of the variable $x_{t-2}^3$ is 0.873. Thus, this variable may be removed from the equation.

Model of Northwest Sea Passage:

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

(6)

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

3.5. 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 available days of passage. This trend suggests that the number of vessels on the NSR and the Northwest sea passage will increase, as will, consequently, the volumes of transported goods. The NSR 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 (the Barents-, Kara, Laptev-, East Siberian- and Chukchi Seas) and part of the Pacific Ocean (Bering Sea).

The NSR and the Northwest Sea Passage can become cost-effective alternatives due to the emergence of large-scale transportation, further development of the territory and a reduction in transportation costs.

The transportation corridor models allow the volume of traffic us to be estimated depending on various factors that characterise the different operating conditions of transport corridors, including natural, organisational, technological and economic factors. The results of the research outlined in this paper show that at present a lack of information on many indicators represents the biggest limitation to a full-scale operational modelling of the corridors. With the development of the Arctic zones proceeding pace, this suggests the necessity for a database of information to support analysis and forecasting.

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