Institutional-functional approach to the modelling of foreign economic activity

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Abstract. The article presents an analysis of the development of a foreign economic strategy as it affects the Arctic region. The foreign economic development strategy of the Arctic regions is embodied in their modelling on the basis of the institutional environment and the Road Map for the Development of the Foreign Economic Activity of the Region. Six areas of the institutional environment are studied: production and economic, innovative and technological, demographic, social, political and spiritual. The methodology for building the model includes a number of steps: setting goals and objectives; environmental analysis of the Arctic region; development of a model according to the levels of the Arctic space; empirical verification of the model; development of a Road Map; generalization and formulation of conclusions. An empirical verification of the model is carried out on the example of the Yamal-Nenets Autonomous Okrug. The model of foreign economic development of the Yamal-Nenets Autonomous Okrug is represented by a system of six equations for the number of six areas of the institutional environment. The system of six equations is a system of interdependent econometric equations, each of which is an ADL model.

Keywords: Arctic regions, foreign economic activity, ADL-model, foreign economic development strategy, roadmap.

1. Introduction

Foreign economic activity is considered as one of the priority policy areas of developed countries. Contemporary processes of globalisation have qualitatively changed the conditions of foreign economic activity. Due to the main decisions now being taken at the level of municipalities and regions, these subjects of international activity increasingly come to the fore.

From the point of view of socio-economic development, foreign economic relations are a tool by means of which a region is able to improve its standard of living.

The strategically-important Russian Arctic territories dispose extensive reserves of marine biological resources and unique minerals, of which energy reserves are of particular interest.

This implies the need for fundamental and applied research of the Arctic territories in order to develop a concept and strategy for the foreign economic development of each region in the context of ongoing processes associated with globalisation.

The concept of development of foreign economic activity of a particular region should include priority areas of foreign economic activity, principles of strategic development of foreign economic and interregional relations, a list of the main regions and partner countries, defined areas of cooperation in the context of systemic changes in the global economy and a recognition of the need to modernise the regional economy. The elaborated foreign economic activity development concept
forms the basis for a development strategy, a model and a Road Map for the foreign economic activity of the Arctic region. Activities structured in the format of a “Road Map” can act as a guide to action for self-governance bodies of the Arctic regions in carrying out socio-economic policies, including regional governments, as well as all business entities operating in the Arctic territory.

In Russia, the differentiation of regions in the field of foreign economic activity can be seen as due to several factors:
- the level of industrial development of the region;
- geographical location and environmental conditions;
- the degree of financial infrastructure development.

To this can be added the differentiation of the institutional environment for the development of the Arctic territories. In general terms, the institutional environment for the development of the Arctic territories is determined by economic, political, historical, geographical and environmental factors.

The differentiation of regions according to foreign economic development can be determined by the degree of openness, characterised by the proportion of enterprises actively participating in the foreign economic activity of the region.

The purpose of the present article is to elucidate the institutional-functional approach to developing a foreign economic development strategy for the Arctic region.

2. Methods

2.1. Methodology for constructing a model for the development of foreign economic activity in the Arctic region

The methodological principles for constructing the model are based on a system of interconnected econometric equations [8]. We chose the ADL model for the analysis because it allows us assess the dependence of the indicator from the current and past values of the series of other indicators that reflect the processes of the subspace of human activity in the Arctic space.

A step-by-step model building technique includes the following steps:
1. Instantiation of goal setting and model-building tasks.
2. Analysis of the state of the institutional environment of the Arctic concerning space.
   The institutional environment of the Arctic comprises the following elements: institutions, organisations, actors.

   The result of the analysis according to this point will be a description of the institutional environment of the Arctic regions from the perspective of the institutional economy.

3. Elaboration of a model of the Arctic space.

   In constructing a model for the development of the Arctic space informed by the institutional-functional approach, subspaces and space levels of the institutional environment are considered.

   The subspace of the institutional environment is as follows: environmental management; production and economic; innovative technological; demographic; social; political; spiritual.

   Space levels of the institutional environment:
   - enterprises / sectors;
   - municipal territories;
   - regional territories;
   - national economy.

3.1. Elaboration of a model that represents the first space level of the institutional environment – Enterprises / Sectors operating in the Arctic space on the territory of municipalities and describing the action processes of actors and organisations.

3.2. The development of a model that displays the second space level of the institutional environment, which comprises the development of the Arctic space on the territory of municipalities, as well as describing the process of interaction between organisations and actors in the development of the Arctic space. Endogenous variables are indicators used to evaluate the results of the development of the Arctic space.
3.3. The development of a model that displays the third space level of the institutional environment, comprising the development of seven subspaces of the space of the institutional environment of the region, also describes the development of the Arctic space at the regional level:
- substantiation of indicators evaluating each subspace of the space of the institutional environment of the territory;
- the formation of time series of indicators for evaluating the subspace of the space of the institutional environment of the territory;
- analysis of the time series of indicators in order to select endogenous and exogenous variables;
- analysis of stationarity of time series;
- multicollinear analysis between indicators; the purpose of the analysis is to determine the closeness of the relationship between the indicators (correlation analysis), as well as the degree of mutual influence of indicators and the choice of indicators for use in further analysis.

The dependence of endogenous factors on exogenous is expressed in the form of econometric equations. Taken together they will take the form of a model comprising a system of econometric equations.

Elaboration of a model reflecting the fourth level of the space of the institutional environment and the relationship between the development of the Arctic space and the national economy

The fourth-level model is interconnected with the third-level model in that the endogenous parameters of the third-level model simultaneously coincide with those of exogenous fourth-level models.

For endogenous variables of the fourth level, it is expedient to select such indicators as the proportion of exports from the Arctic space relative to the total exports of the country,

4. Empirical verification of the model
For this step, statistics are collected for the seven Arctic regions of Russia.

5. Development of a “Road Map” of the foreign economic activity of the region, taking trends in the region’s economy into account.
- Formulation of clear objectives of foreign economic activity of the region.
- Decomposition of the goal of the foreign economic activity of the region into a set of subgoals.
- Establishment of the initial state, “starting positions” of the “Road Map”.
- Formation of the implementation of parallel (but not alternative) work, permitting a transition from the initial to the final state, as well as accounting for the presence of interconnections between parallel paths.
- Formation of a phased target information and logical model of the regional foreign economic activity strategy.

6. Generalisations and the formulation of conclusions.
After describing the full methodology, we proceed to the justification of the selected indicators for the model of the third and fourth levels.

2.2. Selection of indicators for the model
When beginning to design the model, it is necessary to define the boundaries of the areas belonging to the Arctic zone.

Each subject appears as holistic in terms of its economic status and the direction of development of the territory. Therefore, following the logic of the study, as well as to ease the collection of statistical information for all regions, we will not divide the entities into separate municipalities.

We study six areas of the institutional environment: industrial-economic, innovative-technological, demographic, social, political and spiritual, drawing up an equation for each of them and obtaining a system of equations describing the development of the region.

Selected endogenous and exogenous indicators are presented in table 1.

| Endogenous variables | Exogenous variables |
|----------------------|---------------------|

Table 1. Endogenous and exogenous variables.
| $Y_t^1$ - export of goods and services | $Y_t^1$ | $X_t^1$ - GRP | $X_t^2$ - GRP per capita | $X_t^3$ - fixed capital investments |
|--------------------------------------|---------|-----------------|-------------------------|---------------------------------|
| $Y_t^2$ - export / import of technologies and services | $Y_t^2$ | $X_t^4$ - number of organisations engaged in research and development | $X_t^5$ - costs of technological innovation | - |
| $Y_t^3$ - population | $Y_t^3$ | $X_t^6$ - natural increase | $X_t^7$ - life expectancy | - |
| $Y_t^4$ - average per capita income | $Y_t^4$ | $X_t^8$ - unemployment rate | $X_t^9$ - number of doctors | $X_t^{10}$ - number of university students |
| $Y_t^5$ - number of spectators in theaters | $Y_t^5$ | $X_t^{11}$ - number of library users | $Y_t^4$ - average per capita income | - |
| $Y_t^6$ - emissions of pollutants into the atmosphere | $Y_t^6$ | $X_t^{12}$ - capture of pollutants | $Y_t^3$ - population | - |

Source: compiled by the author

Let us formulate the following assumptions:

$Y_t^1$ – export of goods and services, characterising the production and economic sphere, dependent on variables $Y_{t-1}^1$, $X_t^1$ – Gross regional product, $X_t^2$ – Gross regional product per capita, $X_t^3$ – investment in fixed assets.

Export of goods and services – export abroad of goods sold to foreign buyers, intended for sale in foreign markets or for processing in another country.

GRP (Gross Regional Product) – the total market value of all final goods and services produced in the region’s economy within one year.

GRP per capita – one of the primary determining characteristics of the level of a region's economic development. In this case, labour productivity plays a role.

Fixed capital investments – one-time expenses for the creation, reproduction and acquisition of fixed assets.

$Y_t^2$ – export / import of technologies and services of a technical nature, characterising the innovation and technological sphere, dependent on variables $Y_{t-1}^2$, $X_t^4$ – the number of organisations performing research and development, $X_t^5$ – costs of technological innovation.

Export of technologies and services of a technical nature – the process of transferring the results of research and development abroad for any use according to an agreement.

Import of technologies and services of a technical nature – the process of obtaining from abroad the results of research and development for any use according to an agreement.

The number of organisations involved in research and development is an indicator characterising the level of innovative development of scientific activity in a region.

Technological innovation costs – actual monetary costs associated with the implementation of various types of innovative activities carried out across an organisation (industry, region, country).
\( Y_t^3 \) – the population characterising the demographic sphere depends on the variables \( Y_{t-1}^3, x_t^7 \) – natural increase, \( x_t^7 \) – life expectancy.

*Population* – one of the main demographic indicators characterising the number of people in a certain population.

*Natural increase* per 1000 people – the difference between the number of births and the number of deaths over a certain period of time. This metric serves as a characteristic of the intensity of population growth / decline.

*Life expectancy at birth* – the forecast, estimated period of the lifespan of a representative of a given generation, undertaking a given professional activity and in a given territory. One of the determining parameters in risk analysis and the regulation of national security.

\( Y_t^4 \) – per capita income characterising the social sphere depends on variables \( Y_{t-1}^4, x_t^8 \) – unemployment rate, \( x_t^8 \) – number of doctors, \( x_t^{10} \) – number of university students.

*Per capita cash income per month* – calculated by dividing the total amount of cash income for the reporting period by the number of inhabitants.

*Unemployment rate* – the percentage of unemployed relative to the total labour force. This comprises the primary indicator of the labour market.

*Number of doctors* per 10,000 people – a calculated indicator that reveals the general availability of doctors in a given territory relative to the current population.

*Number of students of higher educational institutions* – an indicator that determines the graduation of qualified personnel.

\( Y_t^5 \) – number of spectators of theatres, characterising the spiritual sphere, depends on variables \( Y_{t-1}^5, x_t^{11} \) – number of library users, \( Y_t^4 \) – per capita income.

*The number of theatre spectators* (per 1000 people) is the main calculation indicator used to determine the development of the spiritual sphere.

An additional calculated indicator used to determine the development of the spiritual sphere is the number of users of public libraries.

\( Y_t^6 \) – the emission of polluting substances into the atmosphere, characterising the sphere of environmental management, depends on variables \( Y_{t-1}^6, x_t^{12} \) – capture of polluting substances, \( Y_t^3 \) – population.

The emission of pollutants into the atmosphere, as well as the capture of pollutants, represents the mass of pollutants emitted into the atmosphere by stationary sources of pollution and the mass of emitted pollutants filtered by stationary sources, respectively.

Following an analysis of the obtained models for each of the Arctic regions, it is necessary to draw general conclusions, find similar development vectors and summarise them, as well as develop a roadmap based on the data of the analysis and construct a forecast with using the obtained ADL model.

### 3. Results

From the institutional economic perspective, the model of foreign economic development of the Yamal-Nenets Autonomous Okrug will be represented by a system of equations representing six areas of the institutional environment.

The main information base for the study comprises: the official state statistics website http://www.gks.ru/, official regional statistics websites and the unified informational interagency statistics service https://fedstat.ru/.

Here we show the calculation for the demographic sphere.
The initial data of the demographic sphere are taken for the period 2000-2014. Indicators: \( Y_t^3 \) – population; \( x_t^6 \) – natural increase per 1000 people; \( x_t^7 \) – life expectancy, years.

All time series were tested for stationarity and autocorrelation of variables.

The multicollinearity verification results demonstrated a strong relationship between indicators \( x_t^6 \) and \( x_t^7 \); therefore, to construct the equation, we selected indicator \( x_t^6 \) – natural increase.

We used regression analysis to determine the coefficients of the equation as well as to check it for reliability. Figure 1 shows the results of regression analysis.

| R-squared | 0.8375 |
|-----------|--------|
| F         | 82.2181 |
| Significance F | 2.418E-07 |

| Coefficients | t-statistic | P-Value |
|--------------|-------------|---------|
| Y-intersection | 126799.8363 | 1.3655 | 0.0433 |
| Variable Y3(t-1) | 0.7371 | 3.3256 | 0.0067 |
| Variable X6 | 1421.604 | 0.8265 | 0.0426 |

Source: compiled by the author

According to the results of the regression analysis \( R^2 > 0.7 \), \( F_{cal.} > F_{theory} \); \( P \)-value <0.05; therefore, validation passed.

We write, in general terms, the functional dependence of the indicators for the demographic sphere of the Yamalo-Nenets Autonomous Okrug: \( Y_t^3 = 126799 + 0.73 \cdot Y_{t-1}^3 + 1421 \cdot x_t^6 \).

The resulting equations in six spheres can be represented as a system of equations in structural form:

According to the results of verifying the conformity of the structural form of the model with the identifiability condition, the identity \( D + 1 > H \) is valid for all equations of the system, which means that the equation is overidentified. We applied the two-step least-squares method.

We obtain the system of reduced equations:

\[
\begin{align*}
Y_t^1 &= 327.8 + 0.4 \cdot x_t^2 + 0.0008 \cdot x_t^3 \\
Y_t^2 &= -1611 + 0.59 \cdot Y_{t-1}^2 + 1.9 \cdot x_t^5 \\
Y_t^3 &= 126799 + 0.73 \cdot Y_{t-1}^3 + 1421 \cdot x_t^6 \\
Y_t^4 &= 4876 + 1 \cdot Y_{t-1}^4 - 273 \cdot x_t^8 \\
Y_t^5 &= 130.4 + 0.003 \cdot Y_{t-1}^4 - 0.8 \cdot x_t^8 \\
Y_t^6 &= 842 + 39.4 \cdot x_t^{12}
\end{align*}
\]

It should be noted that the equations of industrial, economic, innovative, technological and environmental management \( Y_t^1, Y_t^2, Y_t^6 \) did not pass the validation test; therefore, in order to construct the ADL model, it is necessary to derive other exogenous variables.
4. Discussion

An analysis of the works related to the research areas covered in the article demonstrates a fairly wide range of research areas: the development of the Arctic territories, the representation of the Arctic territories as target subspaces, the institutional-functional approach, and the construction of the model.

The analysis of the development of the Arctic territories is given a considerable amount of attention in the scientific literature. The importance of the Arctic regions in world development is drawn by such researchers as N. Didenko, D. Rudenko, D. Skripnuk, V.I. Cherenkov, E.A. Afonichkina, A.I. Afonichkin [1], [2], [3], [4], [5].

The representation of the Arctic territories as target subspaces is found in articles by T.D. Prowse, C. Furgal, F.J. Wrona and J.D. Reist [6], as well as R.F. Tallman, M.J. Roux and A. Fisk [7].

The problems of modelling as a means of predicting the development of the Arctic are reflected in the works of N. Didenko, [8], [9], G. Silkina [10], S. Antipov, [11], Y. Klochkov et al. [12], K. Kikkas, [13], [14], K.V. Kireev et al. [15].

The works of N.A. Konakhina [16] and A.Y. Gazizulina et al. [17] set out the prospects and problems of the development of foreign economic activity in the context of globalisation, determining the theoretical foundations of foreign economic activity and describing methodological approaches to assessing the effectiveness of foreign economic activity of enterprises in the regions.

The findings differ depending on the source data and settings. Thus Pawel Bozyk [18] describes the impact of globalisation on all areas of foreign economic activity.

The choice of an institutional-functional approach that improves the development of a foreign economic development strategy for the Arctic regions is supported by an analysis of the main sources for the development of a foreign economic development strategy for the Arctic regions [19].

R.C. Feenstra, H. Ma, & Y. Xu [20] note that it is difficult to empirically obtain objective estimates of the effects of export expansion due to endogeneity. While expanding access to foreign markets increases the demand for employment, including in laboratories, new technologies also have the capability of stimulating exports and possibly even reducing employment. Baliamoune-Lutz, M. [21], Wenyu Hou & Huifang Liu [22], Ceren Pekdemir [23], Adam Marszk, & Ewa Lechman [24], Mariya Teteryatnikova [25] analyses the complexity of trade in developing countries. The results obtained by the authors confirm the existence of a causal relationship between export destinations and higher wages in the sense that “industries supplying products to high-income destinations pay higher average wages”. High-income countries export higher-quality products and use skilled labour more intensively at the same time as paying higher wages.

M. Shafiullah, S. Selvanathan & A. Naranpanawa [26] analyse the hypothesis of export-based growth by conducting research at the level of Australia and its regions. Commodity exports were divided into four broad sectors: (i) agriculture; (ii) mining and fuel; (iii) manufacturing; and (iv) other sectors.

The results of the analysis show that new trends in the global economy and the international division of labour, as well as increased competition in foreign markets, require new approaches to developing a foreign economic research strategy that increases the efficiency of export activities. In our opinion, the institutional-functional approach is best-suited to meet such requirements.

An institutional and functional approach to developing a foreign economic development strategy for the Arctic region implies the development of a model and “Road Map”.

5. Conclusion

Summarising the results, the following can be noted.

When modelling the foreign economic activity of the Arctic region, a system of six simultaneous econometric equations is compiled. The equations that have passed the necessary verification, reliably reflecting the dependence of endogenous on exogenous indicators, remain in the system. However, some equations may not pass the verification test. From this we conclude that, in order to describe the spatial spheres of different Arctic regions, it is necessary to use different indicators depending on the particular region and sphere. A forecast of such indicators as GRP and export volumes is constructed on the basis of the obtained models.
The presented model of the foreign economic activity of the Arctic region in the form of a system of six simultaneous econometric equations, along with a list of advantages and unique characteristics of the Arctic region, forms a basis for the development of a “Road Map”.

The primary recommendations when developing the “Road Map” are as follows: the necessity of improving the social conditions of the population; the need for structural transformations of the industrial sector; the integration of regions into the world community; and the development of transport infrastructure.

References

[1] Didenko N I, Skripnuk D F and Mirolyubova O 2017 Modeling the changes in global temperature due to pollution *Int. Multidisciplinary Scientific GeoConf. Surveying Geology and Mining Ecology Management* **17(53)** pp 577-586

[2] Rudenko D Y, Pogodaeva T V and Didenko N I 2015 Poverty alleviation strategies in the Russian Arctic zone regions *Mediterranean J. of Social Sciences* **6(1)** pp 32-39

[3] Didenko N I and Cherenkov V I 2018 Economic and geopolitical aspects of developing the Northern Sea Route *IOP Conf. Series: Earth and Environmental Science* (Institute of Phys. Publishing Press) **180(1)** 012012

[4] Afonichkina E A and Afonichkin A I 2018 Synergies of the Economic Development of the Arctic Cluster System *IOP Conf. Series: Earth and Environmental Science* (Institute of Phys. Publishing Press) **180(1)** 012011

[5] Didenko N I, Skripnuk D F and Mirolyubova O V 2017 Urbanization and Greenhouse Gas Emissions from Industry *IOP Conf. Series: Earth and Environmental Science* (Institute of Phys. Publishing Press) **72(1)** 012014

[6] Prowse T D, Furgal C, Wrona F J and Reist J D 2009 Implications of climate change for northern Canada: freshwater, marine, and terrestrial ecosystems *Ambio* **38(5)** p 282

[7] Tallman R F, Roux M J and Fisk A 2012 Management of ecosystem effects, potential and realized, in emerging arctic fisheries in South Baffin Island (In: G H Kruse, H I Browman K L Cochrane, D Evans, G S Jamieson, P A Livingston, D Woodby and C I Zhang (eds.), Global Progress in Ecosystem-Based Fisheries Management /Alaska Sea Grant Univ. of Alaska Fairbanks)

[8] Didenko N I, Skripnuk D F, Mirolyubova O V, Sevashkin V and Samylovskaya E 2018 System of econometric equations of the world market of natural gas *Int. Conf. on Information Networking* pp 217-222

[9] Didenko N I, Kulik S V, Kikkas K N and Kudriavtceva R E A 2018 Models of the impact the global crisis has on the world economy *Int. Multidisciplinary Scientific GeoConf. Surveying Geology and Mining Ecology Management* **18(5.3)** pp 585-592

[10] Silkina G 2019 From analogue to digital tools of business control: Succession and transformation *IOP Conf. Series: Materials Science and Engineering* **497(1)** 012018

[11] Antipov S 2018 Neural network model as a way of processing complex systems of econometric equations characterizing the interaction of the Russian Arctic *MATEC Web of Conf.* (Publisher: EDP Sciences) **170** 01025

[12] Klokchov Y, Klokchova E, Didenko N, Frolova E and Vlasova N 2018 Development of methodology for assessing risk of loss of a consumer through the fault of an outsourcer *Int. Conf. on Infocom Technologies and Unmanned Systems: Trends and Future Directions* (Amity Univ. Dubai U ARAB EMIRATES/Publisher: IEEE) pp 719-724

[13] Kikkas K 2018 Territorial-sectoral modelling of the automotive industry in the Russian Federation *IOP Conf. Series: Earth and Environmental Science* (Institute of Phys. Publishing Press) **180(1)** 012015

[14] Kikkas K N, Cherenkov V I, Berezovskaya I P and Anosova N E 2019 The application of the ARCH model for the assessment of transport routes in Northern Europe and Southeast Asia
[15] Kireev K V, Ermakov V V, Kikkas K, Gasyuk D P and Rodionova U 2018 Mathematical modeling of Arc extinction process in devices with liquid-metal contact *Int. Conf. on Infocom Technologies and Unmanned Systems: Trends and Future Directions* (Amity Univ. Dubai U ARAB EMIRATES/Publisher: IEEE) pp 273-277

[16] Konakhina N A 2018 Evaluation of Russian Arctic Foreign Trade Activity *IOP Conf. Series: Earth and Environmental Science* (Institute of Phys. Publishing Press) 180(1) 012018

[17] Gazizulina A Y, Mirolyubova O V, Konakhina N A, Grigorieva A A and Danilova S Y 2018 Problems of forming requirements to training of specialists for industrial and economic complex *Int. Conf. on Reliability, Infocom Technologies and Optimization: Trends and Future Directions* (Amity Univ Uttar Pradesh Noida INDIA/Publisher: IEEE) pp 196-198

[18] Bożyk P 2006 *Globalization and the Transformation of Foreign Economic Policy* (Warsaw: Warsaw School of Economics Press) p 337

[19] Dyatlov S A, Didenko N I, Lobanov O S and Kulik S V 2019 Digital transformation and convergence effect as factors of achieving sustainable development *IOP Conf. Series: Earth and Environmental Science* (Institute of Phys. Publishing Press) 302(1) 012102

[20] Feenstra R C, Ma H and Xu Y 2017 *US Exports and Employment* (Cambridge, MA 02138 / National bureau of economic research) p 49

[21] Baliamoune-Lutz M 2018 Trade Sophistication in Developing Countries: Does Export Destination Matter? *J. of Policy Modeling* 41(1) pp 39-51

[22] Hou W, Liu H and Wu F 2018 Structure and patterns of the international rare earths trade: A complex network analysis *Resources Policy* 55 pp 133-142

[23] Pekdemir C 2018 On the regulatory potential of regional organic standards: Towards harmonization, equivalence, and trade? *Global Environmental Change* 50 pp 289-302

[24] Marszk A and Lechman E 2018 New technologies and diffusion of innovative financial products: Evidence on exchange-traded funds in selected emerging and developed economies *J. of Macroeconomics*

[25] Teteryatnikova M 2018 R&D in trade networks: The role of asymmetry *Int. J. of Industrial Organization* 61 pp 307-350

[26] Shafiullah M, Selvanathan S and Naranpanawa A 2017 The role of export composition in export-led growth in Australia and its regions *Econ. Analysis and Policy* 53(c) pp 62-76