Approaches to modelling economic system of the northern region

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Abstract. The article presents the results of the review of the applied approaches to modelling regional branch systems. The article justifies the task of modelling the extractive industries as a basic branch of the economy of the northern regions of resource type. Technical prerequisites determine the need for the formation of new approaches to the methodology and algorithm for modelling complex systems. The author's conceptual map of the production subsystem is presented: mining in the relationship with the blocks (graphs) of the regional system. The requirements to the functionality of dynamic models and the choice of their factors for determining the stability of the components of the regional industry system are highlighted. The developed models will take into account system transformations from structural and technological shifts: cyclicality of industry crises, depletion of reserves, digital maturity, and ESG effects.

1 Introduction

The management of regional systems requires an understanding of the relationships that arise among them in order to make strategic and scientifically based organisational decisions adapted to existing and forecast conditions. The relevance of the development and implementation of decision support systems is increasing, while the cost and responsibility of management decisions are increasing, and the time for information processing and analytics is decreasing. In the period of uncertainty of the geopolitical situation around Russia, the society's demand for predictive analytics and modelling of future options has formed. The research and forecasting of socioeconomic, spatial development and comprehensive security of the region, as well as the formation of predictive economic and mathematical models and their intersectoral balances becomes a priority scientific direction. Thus, the relevance of the need to use modern methods of modelling complex systems to prevent unjustified management decisions is determined. They are capable of destabilising the forecasted activity of regional branch systems [1].

2 Approaches to modelling regional industry systems

Technological prerequisites and evolution of intelligent systems allow storing and processing big data (Big Data, Internet of Things, Smart Systems). Limited cognitive abilities of a human

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being are unable to cope with large volumes of information. Today, the possibilities of machine learning, process automation allow to transfer some part of diagnostic and descriptive analytics to interactive systems of a new level, where a person remains in the control loop [2, 3]. The undesirability or impossibility of physical experimentation and complex testing over such complex systems requires preliminary modelling of the systems in both real and model time. Various modelling approaches that can be applied to regional economic systems are discussed below.

Scenario planning. It is possible to reduce the risks of uncertainty by applying scenario planning methods for the strategic development of regional systems. In modern conditions under the existing technical prerequisites, it is more preferable to use hybrid approaches to scenario planning of complex systems, including search (trend), normative and probabilistic approaches [4]. The strategic development of Russia's regional systems is formed on the basis of the probability of investment projects implementation at the national, regional and sectoral levels. At that, an important component of planning and forecasting of regional systems is the probability and success of investment projects implementation, their connectivity and infrastructure provision. These components for northern regions sometimes become critical and directly affect the efficiency and feasibility of investment project implementation.

Situational approach to process modelling. This approach is characterised by the construction of models of multifactor representation of possible situations and generation of multivariate solutions to a problem situation when the model parameters are changed. The situational approach is interesting when building decision support systems for situational management of complex socio-economic systems [5].

During the transition of the economy to the post-industrial stage of development in the country, the nature of direct and backward linkages of economic sectors has changed. In general, the determinant influence of the sectoral structure on the regional one is weakening and the role of regional conditions in the placement of production is increasing.

Cognitive process modelling is an integral part of simulation modelling [3]. The construction of a cognitive map of different complexity allows building sign oriented graphs of a regional system, adapted to certain conditions of the region. The methodology of cognitive modeling has so far been applied to various scales of complex systems: regional socio-economic systems [6, 7, 8], and their subsystems (interregional exchange, education system, health care system, labour market, tourism, industrial enterprises and others) [9, 10, 11], adaptation processes of peoples, ecosystems, geopolitical systems and others.

The continuous organisation of ongoing processes within each subsystem requires systemic approaches to their effective management aimed at sustainable development. Increasing risks, uncertainty problems, lack of stable trends and high resource dependence of the modern Russian economy significantly limit the possibilities of forecast extrapolation [6].

3 Interrelationships of the socio-economic system of the resource region

For the northern regions of the resource type, the production subsystem prevails and is characterised by its sectoral structure in the direction of a significant share of mineral extraction in the region's industry. The raw material orientation of the development of economic sectors in the northern regions of the resource type is preserved and is characterised by a high potential of the mineral resource base [12, 13]. Over the previous decade, the raw material orientation of production in the northern regions of the resource type only strengthens and grows, which is associated primarily with imperfect competition and the established (sometimes pseudo-market) organisation of economic space in the Russian North. The resource-dependent economy is influenced by a "bundle" of complex and far from
obvious economic and political relations [6, 14], thus increasing the uncertainty of their forecasts and development scenarios.

Figure 1 shows the authors' conceptual map of the production subsystem: mining in relationship with the blocks (graphs) of the regional system.

Underdeveloped energy, transport and social infrastructure of the northern regions does not allow other sectors of the economy to achieve competitiveness [15, 16]. Consequently, the conditions for the organisation of industrial production in the northern regions of the resource type are initially non-equilibrium. These circumstances force the northern regions to orient the vector of their development towards the mineral and raw materials complex through the extraction of highly liquid minerals (oil, gas, coal, gold, diamonds, etc.). Unfortunately, a number of quantitative indicators that can characterise the mineral resource complex in practice cannot be correctly applied at the regional level.

The problem of resource regions is that they are sensitive to fluctuations in the global mineral markets due to the high share of regional revenues from export sales of extracted raw materials. The risks of deepening technological gaps with the most developed regions of the Russian and world economy are also high. A serious problem remains the adaptation of economic systems of these regions to long-term changes caused by technological, structural and social shifts. This requires the creation of such institutional conditions that allow the use of resources derived from mineral extraction for the development of these regions themselves, reducing their resource dependence and improving the quality of life of the population.

4 Requirements for building economic system models of the northern resource-type region

Based on the earlier analysis of approaches to modelling the extractive industry, the following requirements for the functionality of dynamic models and the choice of their factors were identified:

- models must take into account the provision of limited non-renewable minerals to meet the needs of the economy for extraction of commercial minerals (ECM), including export commitments, global resource market conditions;
- the model should take into account the limitations, underdeveloped infrastructure and difficult economic conditions of Russia's northern territories;
- the model should be flexible and responsive to exogenous and endogenous factors of the ECM subsystem, including not obvious external economic and political factors;
- the model should output an estimate of the effects of ECM activities on the development of the territory of presence;
- the model curve should describe real statistical data and capture the general trend of sustainable development of the extractive industry.

When analysing the extractive industry as a key element of the production subsystem of relatively northern resource-type regions, it is recommended to use the following principles of sustainable development assessment:

1) Quantitative assessment methods based on statistical data. The set of indicators should be minimal, credible, accurate and sufficient to fulfil comprehensiveness.
2) A time horizon of at least 10 years in the dynamics of indicators to observe changes in trends on the basis of retrospective analysis for the forecast assessment of future development.
3) Indicators should not have a direct dependence on the territory of location and population of the region, it is recommended to use specific indicators in interregional comparative analyses.
4) The application of an integrated approach should be accompanied by an assessment of the sustainability of the region's economic and social development, the interconnections of the regions with the internal (country) and external environment (world community).

5) Adaptation of the main characteristics of the overall process to the specific conditions of a particular region, which will make it possible to develop an overall strategy for the development of the system within the framework of the implementation of national strategic goals and objectives.

Fig. 1. Conceptual map of interconnection of blocks (graphs) of the production subsystem: mineral extraction (ECM).

5 Conclusion

To find a solution to the stated scientific problem, the task of substantiating the application of adequate models and methods of building various types of scenario forecasting to anticipate the possible future development of regional systems depending on resource endowment is set. The purpose of further research is to build dynamic models of coordinated processes in the branches of specialisation (mining) of the regional socio-economic system taking into account the factors of scientific, technical and innovative development. The models are planned to be tested in the "newest" conditions of the socio-economic system of the northern region of resource type, the Republic of Sakha (Yakutia).
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References

5. N.V. Smirnov, V.P. Peresada, D.V. Girdyuk et al., The input-output model: one of the basic elements of information support for the work of regional situational centers, Informatization and communication, (2019), DOI: 10.34219/2078-8320-2019-10-3-20-25.
7. G.V. Gorelova, Lecture Notes in Networks and Systems, 442, 212-224 (2022), DOI: 10.1007/978-3-030-98832-6_19
13. V.V. Nikiforova, Regional Economics: Theory and Practice, 10(505), 1879-1901 (2022), DOI: 10.24891/re.20.10.1879.