Factors of reducing import dependence of high-tech enterprises using artificial intelligence

Aleksandr Zhukov[1], *Tatiana* Berkutova[2], *Denis* Zhurenkov[3], Victor Kashtanov[1], *Elena* Lyutova[1], and *Igor* Kartsan[4, 5*]

[1]«Expert and Analytical Center», 33, Talalikhina str., Moscow, 109316, Russia
[2]M.T. Kalashnikov Izhevsk State Technical University, 7, Studencheskaya str., Udmurt Republic, Izhevsk, 426069, Russia
[3]Federal state unitary enterprise «All-Russia scientific and research institute «Center», 11, p.1., Sadovaya-Kudrinskaya str., Moscow, 123242, Russia
[4]Marine Hydrophysical Institute, Russian Academy of Sciences, 2, Kapitanskaya str., Sevastopol, 299011, Russia
[5]Reshetnev Siberian State University of Science and Technology, 31, Krasnoiarskii Rabochii Prospekt, Krasnoyarsk, 660037, Russia

Abstract. The article presents the analysis of definitions in the field of technological sovereignty, technological independence, import independence, import substitution. Based on the study of different authors' points of view, the authors substantiate the composition and structure of factors to reduce import dependence of high-tech enterprises. Two groups of factors are identified: internal and external. The article considers the possibilities of using artificial intelligence technologies to overcome modern challenges and solve the problems of enterprise adaptation in the conditions of strategic sanctions restrictions.

1 Introduction import-independence characteristics

In the context of an unprecedented number of foreign economic sanctions against Russia, the capacity of domestic markets for high-tech, dual-use and civilian products has increased significantly. Domestic high-tech enterprises are faced with the task of multiplying the production of dual-use and civilian products, the solution of which will reduce the import dependence of the Russian economy.

As part of the solution of this task, the key role is assigned to the enterprises of the defense-industrial complex (DIC). Significant scientific, technological and production potential of the defense industrial complex enterprises should contribute to the reduction of import dependence and the formation of a complex of high-tech industries capable of replacing the products of foreign manufacturers that have left the country in the future [1-3].

The issues of import substitution in the domestic economy have become particularly relevant in the last decade. During this period, a number of legislative acts and programs were adopted at the state level, which made it possible to reduce dependence on imported supplies in the fuel and energy complex, chemical industry, agro-industrial complex and

* Corresponding author: kartsan2003@mail.ru

other sectors. However, under the conditions of the special military operation and related geopolitical challenges, the domestic industry faces new challenges, which can be overcome only by repeatedly increasing the output of high-tech products.

The concepts of "import substitution", "import independence", "technological independence", "technological sovereignty" is considered from scientific and practical points of view in various sources.

At the level of industries and enterprises, technological independence is the ability of scientific and production complex to independently develop and introduce competitive technologies to foreign and domestic markets [2, 4-8].

A synonymous concept used along with technological independence is "technological sovereignty".

Technological sovereignty forms the possibility for the state to have independence in decision-making in terms of technology.

Technological sovereignty is the achieved level of real independence of the country in the fields of science, engineering and technology, which ensures the unimpeded realization of national interests in the techno sphere, taking into account existing and future threats [9].

The problems of this direction are characterized by such threats as: Russia's lagging behind in the transition to the next technological mode, dependence on the supply of foreign equipment, devices, electronic components and materials, uncontrolled transfer of advanced Russian technologies abroad, underdeveloped regulatory and legal framework, low level of activity and investment in the field of innovation and industrial policy, etc. The problematics of this direction is characterized by such threats as: import substitution [10-15].

A number of definitions of import substitution suggests its interpretation as a type of economic strategy and industrial policy aimed at improving the competitiveness of domestic products in domestic and foreign markets [16-18].

2 Import-independence characteristics

Import substitution as a form of economic growth and development of the state, regions, industries and enterprises.

Thus, the following areas should be integrated in the structure of factors to reduce import dependence of domestic industrial enterprises:

- increasing the competitiveness of domestic products in domestic and foreign markets;
- creation and development of competencies of domestic developers and manufacturers of high-tech products;
- integration of the Russian economy into the system of world economic relations;
- ensuring economic security of the state and protection of its geopolitical interests;
- economic growth and development of the state under conditions of reduced import dependence.

Summary characteristics of import-independence of the economy and domestic market segments:

- the share of the total volume of imports used in the economy in the total volume of resources of domestic and imported products (including exports) used in the economy;

$$IZ_E = \frac{IM}{X+IM} \quad (1)$$

- the share of imported products IM_K in the volume of products used for intermediate consumption of the economy (K=1), final consumption of households (K=2) and gross fixed capital formation (K=3).

$$IZ_K = \frac{IM_K}{X_K + IM_K} \quad (2)$$

where, IM - volume of imported products; X - volume of produced domestic products; i - index of product type.

Characteristics of import-independence of the economy and domestic market segments by products of type *i*:

- share of imports of type IM_i, in products of type i used in the economy;

$$IZ_{Ei} = \frac{IM_i}{X_i + IM_i} \quad (3)$$

- the share of imports of type IM_{iK} in the volume of products of type *i* used in the K direction.

$$IZ_{Ki} = \frac{IM_{iK}}{X_{iK} + IM_{iK}} \quad (4)$$

Characteristics of import dependence of sectoral industries. Share of imports in products of type *i* used in intermediate consumption of industry *j*:

$$IZ_{ij} = \frac{IM_{ij}}{X_{ij} + IM_{ij}} \quad (5)$$

Share of imports in intermediate consumption of industry *j*:

$$IZ_{PPj} = \frac{\sum IM_{ij}}{\sum (X_{ij} + IM_{ij})} \quad (6)$$

Import intensity of output of industry *j* by product *i*:

$$im_{ij} = \frac{\sum IM_{ij}}{X_j} \quad (7)$$

Import intensity of output of industry *j*:

$$im_{xj} = \frac{\sum_i IM_{ij}}{X_j} \quad (8)$$

Characteristics of estimating the full cost of imports in the value of final domestic products:

$$IZ_{KIO} = \frac{IM_{PP}}{KP + VN + EX} \quad (9)$$

where, IM_{PP} is the volume of intermediate imports consumed in sectoral production; $KP + VN + EX$ - total volume of domestic production in final consumption, gross accumulation, exports).

In the issues of reducing import dependence, it is critical to adapt the enterprises of the defense industry based on the use of their innovative potential, technology transfer, and methods of state support, which will contribute to the strengthening of the processes of civil-military integration with the subsequent innovative development of related industries.

The analysis of the activity of defense industry enterprises in modern conditions allows us to identify the following tasks, the solution of which is aimed at reducing import dependence:

- increasing production volumes;
- development of new types of high-tech products;
- accelerated production and modernization of high-tech products for dual and civil purposes.

The solution of the above tasks is conditioned by the impact on enterprises of a complex of factors, both internal and external in nature.

3 Promising artificial intelligence methods to reduce import dependence

The composition of factors affecting the possibilities of reducing import dependence of the Russian economy indicates the need for technological transformation of defense industry enterprises, introduction of digitalization methods in the management of production systems, supply chains, in the management processes of enterprises.

In order to comprehensively address the urgent tasks of reducing import dependence, it is necessary to introduce new technologies that would significantly accelerate the pace of introduction of high-tech products for military, dual-use and civilian production. Overcoming modern challenges and solving adaptation problems by domestic enterprises of the defense industry directly depends on the application of methods and technologies of artificial intelligence.

The analysis of various sources allows us to identify the following promising methods of artificial intelligence used for the digitalization of the economy [13, 19, 20]:

- search for new methods and approaches to creating universal artificial intelligence;
- search for new methods and approaches to problem solving, including those capable of learning under conditions of distortion, absence or loss of relevance of historical data or exceeding the capabilities of existing methods of machine learning and mathematical modeling;
- development of autonomous intelligent agents, including those based on reinforcement learning; multi-agent systems with artificial intelligence;
- use of quantum computers to accelerate the solution of artificial intelligence problems;
- development of quantum machine learning algorithms, libraries and tools for realization of practical tasks;
- synthesis (generation) of three-dimensional, two-dimensional images and video objects with preservation of recognizability;
- using artificial intelligence to design complex objects (systems, robots, algorithms), including end-to-end design of hardware and software parts, operating algorithms, for use in intelligent computer-aided design systems for designing algorithms and technical devices;
- data markup using artificial intelligence, including for automation of data preparation for applied tasks;
- data management using artificial intelligence (integration, enrichment, quality control, etc.), including through systems for combining data from different sources (digital profile, single source of knowledge from unified information systems, geomarketing services, master data management systems), systems for improving data quality and consistency;
- automation of neural network training (automated machine learning, including evolutionary algorithms), including for the purpose of cheapening or simplifying the model development process;
- creation of hybrid models - combination of data-based models with "classical" models, as well as complexification of various methods of artificial intelligence, including when it is used in poorly formalized applied areas;
- creation of models trained in the course of activity or by analogy;
- creation of models for primary data processing (verification) and data quality monitoring;
- semantic dynamic analysis and complexification of multimodal data from various sources, including video, text, voice, taking into account their context;

- interpretable artificial intelligence models and methods for generating rationales for automatically made decisions (explainable artificial intelligence);
- creation of energy-efficient cognitive systems and noisy signal processing systems;
- creation of artificial intelligence systems providing protection from purposeful destructive influences at the stages of training and functioning;
- creation of artificial intelligence systems that provide reasonable protection of training sample data from compromise (subsequent extraction from the trained model);
- development of techniques for assessing the bias of artificial intelligence systems (techniques for assessing statistical deviations in conclusions);
- analysis of multimedia materials in order to identify signs of alterations and falsifications, as well as to establish the date, time and place of shooting, diagnose and identify audio, photo and video recording equipment and software and hardware means of multimedia information processing;
- identification of vulnerabilities and undeclared capabilities in software and operating systems;
- restoration of lost information on machine data carriers;
- creation of control systems that take into account physical processes occurring with an object, including air and ground transportation traffic control systems;
- dynamic adaptive control and orientation of an individual object in complex or non-deterministic conditions, including for control systems for autonomous objects, object control systems that take into account signal lag;
- centralized control of a group (swarm) of objects;
- decentralized control of a group (swarm) of homogeneous objects;
- decentralized control of a group (swarm) of heterogeneous objects (including infrastructure);
- development of hardware gas pedals and hardware-software solutions to improve the efficiency of calculations in systems with artificial intelligence.

4 Conclusion

The following methods based on artificial intelligence technologies have the greatest practical application in industry:

- digital twins;
- digital trials;
- industrial Internet of Things;
- use of big data (Big Data);
- methods using virtual reality (including augmented virtual reality);
- additive technologies.

The potential of using technologies based on artificial intelligence will make it possible to solve the problems of reducing the import dependence of domestic high-tech enterprises by increasing the efficiency of managerial decision-making, increasing operational efficiency, ensuring the availability of information and the efficiency of its use for decision-making.

The work was carried out within the framework of the state assignment of the Ministry of Education and Science of Russia on the topic "Development of methodology of production of dual-use products by high-tech companies of Russia using elements of artificial intelligence in the conditions of digitalization of the economy and sanctions pressure" № 123011600034-3.

References

1. Y. Chen, M.H. Riordan, RAND Journal of Economics **39(4)**, 1042-1058 (2008)
2. A.R. Admati, P. Pfleiderer, Review of Financial Studies **1**, 3-40 (1988)
3. M.R. Baye, J. Morgan, American Economic Review **91**, 454-474 (2001)
4. B. Caillaud, B. Jullien, European Economic Review (Papers and Proceedings) **45**, 797-808 (2001)
5. I. Kartsan, A. Zhukov, S. Pronichkin, V. Gedzyun, M. Bondareva, E3S Web of Conferences **460** 03006 (2023). https://doi.org/10.1051/e3sconf/202346003006
6. A. Zhukov, T. Berkutova, D. Zhurenkov, A. Kolosov, S. Kheruvimova, I. Kartsan, E3S Web of Conferences **486** 04020 (2024). https://doi.org/10.1051/e3sconf/202448604020
7. D.W. Diamond, Review of Economic Studies **51**, 393-414 (1984)
8. J. Farrell, G. Saloner, RAND Journal of Economics **16**, 70-83 (1985)
9. R. Innes, R.J. Sexton, European Economic Review **37**, 1569-1597 (1993)
10. M.L. Katz, C. Shapiro, American Economic Review **75**, 424-440 (1985)
11. M.L. Katz, C. Shapiro, Journal of Economic Perspective **8**, 93-115 (1994)
12. M. Pagano, Quarterly Journal of Economics **104**, 255-274 (1989)
13. A. Rubinstein, A. WOLINSKY, Quarterly Journalof Economics **102**, 581-593 (1987)
14. M.O. Yanelle, European Economic Review **33**, 294-301 (1989)
15. A. Yavas, Journal of Labor Economics **12**, 406-429 (1994)
16. H. Cremer, M. Marchand, J.F. Thisse, International Journal of Industrial Organization **9(1)**, 43-53 (1991)
17. G. Gowrisankaran, A. Nevo, R. Town, American Economic Review **105(1)**, 172-203 (2015)
18. D.S. Lee, Review of Economic Studies **76(3)**, 1071-1102 (2009)
19. C. Cameron, J. Segal, D. Songer, American Political Science Review **94**, 101-116 (2000)
20. M. Armstrong, Review of Economic Studies **66(1)**, 151-168 (1999)