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NEOINDUSTRIALIZATION OF THE AGRICULTURAL SECTOR OF THE ECONOMY AS A NECESSARY CONDITION FOR INNOVATIVE TRANSFORMATION OF PRODUCTIVE FORCES AND ACHIEVING TECHNOLOGICAL SOVEREIGNTY

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Abstract

The article is devoted to the problem of ensuring technological sovereignty in the agrarian sector of the Russian economy, its neoindustrialization. The purpose of the work is a scientific and theoretical substantiation of the possibilities of innovative and investment development of the agro-industrial complex in the context of modern trends in neoindustrialization. Empirically, the assessment of the scale of neoindustrialization in the agricultural sector was carried out, a conclusion was made about its initial stage, characterized by a lag in the technological development of agriculture from other sectors of the economy, insufficient use of the results of intellectual activity, and a lower scale of innovative products. A mathematical model of a two-factor regression is constructed that characterizes the process of neoindustrialization in agriculture in Russia, and a predictive assessment of the dynamics of indicators of neoindustrialization of agriculture based on trend analysis is presented. The calculations show that with an increase in the level of labor productivity by 1%, the share of innovative products in the shipped agricultural products will increase by 0.23 percent. The necessity of improving the organizational and economic mechanism for implementing the strategies of innovative and scientific and technological development in order to increase the innovative activity of enterprises in the agricultural sector is substantiated. The practical significance of the results of the study is to develop measures to improve innovation and science and technology policy in order to achieve positive effects from neo-industrialization in the agricultural sector during the transition to Industry 4.0.

***Key words*:** *agro-industrial complex, innovation and investment development, neoindustrialization, technological sovereignty, mathematical modeling*

INTRODUCTION

The priority direction of neoindustrialization in the agricultural sector is the implementation of the Federal Scientific and Technical Program for the Development of Agriculture for 2017-2030, which is aimed at achieving sustainable growth in agricultural production as a result of the widespread use of breeding and seed production, cross-industry technologies and digital solutions. One of the priorities of the program is to stimulate scientific and technical activities in order to achieve technological sovereignty. At the same time, the introduction of breakthrough technologies in the agricultural sector of Russia is also possible if conditions are created for the production of high-tech tools that ensure the innovative transformation of productive forces. It is expected that the mass introduction of domestic innovative technologies will significantly reduce the risks of food security by 2030 [4].

The relevance of the development of the methodological provisions of neoindustrialization in relation to the agro-industrial complex and the justification of the mechanisms for managing innovative systems at the sectoral and intersectoral levels is predetermined by the presence of trends in the scientific and technological development of agriculture and other sectors of the agro-industrial complex.

Achieving the technological sovereignty of the agro-industrial complex of Russia in order to implement the policy of import substitution

is possible as a result of a radical modernization of agricultural systems based on neoindustrialization with a predominance of investment-innovative type of economic growth [12,13,19].

Neoindustrial transformation reflects a complex process of structural adjustment and the creation of a vertically integrated economy that produces competitive products. The policy of neoindustrialization of the economy should be aimed at creating conditions for increasing the innovative activity of predominantly science-intensive and high-tech industries, as well as at justifying program solutions in the field of modernization [6].

Theoretical aspects of the technological development of economic systems and the formation of the foundations of a new industrialization are reflected in the works of such foreign scientists as J. Galbraith, K. Clark, A. Coomaraswamy, A. Penty, D. Bell, M. J. Enright, V.M. Juhi and others. In particular, D. Bell noted that for a post-industrial society, the most significant sign is the change in the nature of knowledge itself in the direction of the dominance of theory, which is a prerequisite for changing the structure of social and economic systems. According to his point of view, the process of modernization of production precedes the development of neoindustrialization, covering the industrial sector [2].

In modern conditions, there has been a change in the paradigm of neoindustrialization, which is viewed from different positions as a system, process, mechanism, strategy [5,7]. The approach to considering neoindustrialization as a system is based on new knowledge and human resources that effectively use progressive technologies that radically change the structure of production resources and provide positive trends in socio-economic development. This theoretical approach develops the provisions of D. Bell and J. Galbraith [28].

The main characteristics of neoindustrialization as a system are: orderliness in order to form a certain structure of interrelated elements, emergence or the possibility of the emergence of new qualities and properties of the system, the realization of the potential of participants in achieving relevant goals.

Neoindustrialization as a process reflects a radical technological re-equipment of the economy through the use of breakthrough technologies and the transition to a new stage of production robotization [24].

To assess neoindustrialization trends, it is recommended to use indicators of technological modernization, human capital, and inter-sectoral interaction. The positive trends of neoindustrialization are reflected in the steady increase in the volume of innovative products, the growth of labor productivity, and the widespread introduction of technological innovations [21].

In the development of this topic, some authors focus on the priority role of such parameters as the introduction of technological and managerial innovations [9]increasing labor productivity [17], increasing the role of human capital in technological development [1].

Some scientists consider neo-industrialization as a complex mechanism for the formation of an effective process control system for industrial sectors in accordance with the principles of vertical integration [10].

Research confirms that the share of advanced knowledge materialized in technologies, equipment, production process in developed countries reaches 70 -90% [11].

The mechanism of neoindustrialization is aimed at deepening the process of transformation of productive forces during the transition to a new technological order, stimulating the effective use of the potential of knowledge, science, results of intellectual activity, innovative technologies [23]. The strategy of neoindustrialization involves the formation of conditions and factors for investment and innovative economic growth using effective models of public-private partnership [8].

In modern conditions, a significant number of scientific works are devoted to the problems of neoindustrialization in relation to various sectors of the economy, including the agro-

industrial complex. This topic is widely represented in the studies of Russian and foreign scientists. Some authors consider neo-industrialization as the main factor in the development of the Russian agro-industrial complex and the achievement of food security [20].

Foreign researchers are exploring the possibilities and prospects for the development of Industry 4.0 in developed countries, where the state supports the introduction of advanced technologies in various sectors of the economy within the framework of relevant programs (Industry 4.0 in Germany, SmartFactory in the Netherlands, UsineduFutur in France). A rather effective model of cooperation between the government, business, universities and research centers operates in Australia. For example, the scientific agency CSIRO Futures, together with the government, has developed a roadmap to address the problems of food security and the development of the agricultural sector. Agricultural start-ups that implement breakthrough technologies in agriculture have become widespread in developed countries. Thus, the SoftBank Vision fund, in cooperation with representatives of large Japanese businesses, invested $200 million in vertical agriculture [3].In order to maintain the continuous development of agricultural production, effective solutions are needed for the problems that Romanian agriculture is currently facing [14,15]. Thus, foreign researchers are guided by the strategy of technological leadership and the positive experience of forming cluster structures in which large companies and agricultural holdings supply science-intensive products to agribusiness enterprises [26]. Based on the study of foreign experience, mechanisms for stimulating investment activity are systematized and ways are proposed in relation to the agro-industrial complex of Russia [27]. A significant problem is the lack of effective mechanisms to stimulate the process of neoindustrialization [30].Neoindustrialization is considered as the most important scenario for involving developing countries in the global fourth industrial revolution based on breakthrough technologies. It is emphasized that this scenario will ensure the sustainable development of African countries in the long term. The positive experience of Kenya and Ethiopia is noted, which were the first to apply the Livestock Index Insurance Program (IBLI) as one of the sensor technologies, which can significantly reduce the risks of animal husbandry [25]. In developed a concept and proposed an algorithm for the neoindustrialization of African countries based on the breakthrough technologies of Industry 4.0. [16]. The purpose of the work is the scientific and theoretical substantiation of new opportunities for innovative and investment development of the agro-industrial complex in the context of modern trends in neoindustrialization.

MATERIALS AND METHODS

The methodological basis of the study was state legislative acts, resolutions, studies of domestic and foreign scientists-economists and experts of the agrarian market on this issue. In the course of the study, monographic, abstract-logical, analytical, economic-statistical, expert research methods were used. Legal and legislative acts, information from Rosstat, National Research University Higher School of Economics, the Ministry of Agriculture of the Russian Federation, as well as regulatory documents and materials from periodicals were used as the information base for the study.

RESULTS AND DISCUSSIONS

One of the conditions for achieving Russia's technological sovereignty is an increase in patent activity. The dynamics of the indicator of technological self-sufficiency of the country, calculated as the ratio of the number of domestic patent applications filed for inventions and their total number, reflects positive trends: for 2015-2022. indicator increased from 0.64 to 0.7)[22].

It is necessary to note the positive trends associated with the development of advanced production technologies (Table 1).

Table 1. Number of developed advanced manufacturing technologies in Russia in 2017-2021

Typesofeconomic activities	2017	2018	2019	2020	2021	2022
Developedadvancedmanufacturingtechnologies						
Economy as a whole	1,402	1,565	1,620	1,989	2,186	2,621
Manufacturing industries	442	502	532	666	737	823
Including: foodproduction	16	24	25	52	65	65
Including fundamentally new advanced production technologies						
Economy as a whole	190	180	217	201	260	307
Manufacturing industries	33	34	35	39	76	93
Including: foodproduction	0	0	0	0	10	7

Source: Own calculations based on data [29].

So, in 2022, 2621 advanced production technologies were developed in Russia, i.e. almost twice as many as in 2017. The positive dynamics is accompanied by an almost unchanged intensity of activity of organizations developing new technologies. Therefore, there are approximately three new technologies per organization per year. Organizations of the research sector are the most active [18].

Advanced production technologies are being developed in the following areas: automated production, transportation and assembly; design and engineering; communication, management and geomatics. During the period under review, from 10% to 13.5% of the total number of developed production technologies were fundamentally new, having no analogues in the world. At the same time, fundamentally new technologies in food production were developed only in 2021-2022, which indicates the uneven nature of neoindustrial transformation. According to research by Russian scientists, unique advanced technologies are created in the field of research and development, and technologies new only to Russia are generated in the manufacturing industry. It is also necessary to note the continuing gap between the availability of advanced technologies and their use. There are frequent cases when an innovative product produced on the basis of advanced technologies is not in demand by the market, which is associated with insufficient stimulation of demand for innovations.

In the process of research, the author's hypothesis was realized: the scale of neo-industrialization in the agricultural sector is determined by the scale of production of innovative products; the pace of renewal of fixed production assets as an indicator of the innovative transformation of the material and technical base; the level of labor productivity as a materialization of the achievements of the research sector. Under the conditions of neoindustrialization, the growth of labor productivity and a decrease in the degree of depreciation of fixed assets should be accompanied by an increase in the share of innovative products in the total output of industrial organizations.

As a result of the research, a mathematical model of two-factor regression was built, which characterizes the process of neoindustrialization in Russian agriculture:

$$Y=-7.38 -0.0002 X1+0.23 X2 \quad .....(1)$$
$$R^2= 0.8$$

where:

Y - is the share of innovative products in the shipped agricultural products, %

X1 - the degree of depreciation of fixed production assets in agriculture,%

X2 - labor productivity in agriculture, thousand rubles. (gross agricultural output per one employed in agriculture, thousand rubles).

The coefficient of determination R^2 shows that the calculated parameters of the model explain the dependence of the function change on the factors under study by 80%, which

indicates the significance of the developed model.

Some indicators of agricultural development and statistical data on the release of innovative products for 2017-2022 were used as primary data. The calculations show that with an increase in the level of labor productivity by 1%, the share of innovative products in the shipped agricultural products will increase by 0.23 percent. Depreciation of fixed assets has a much smaller impact on the release of innovative products: an increase in the degree of depreciation of fixed production assets by 1% will lead to a reduction in the share of innovative products in shipped products by 0.0002%, i.e. the correlation is rather weak.

It should be noted that the weaker impact of the depreciation factor of fixed assets is explained by the unsatisfactory state of the material and technical base of agriculture, which indicates a low level of innovative transformation of productive forces and insufficient efficiency of technological modernization mechanisms: during 2017-2022. the share of depreciation of fixed assets in agriculture ranged from 40% to 43.2percent.

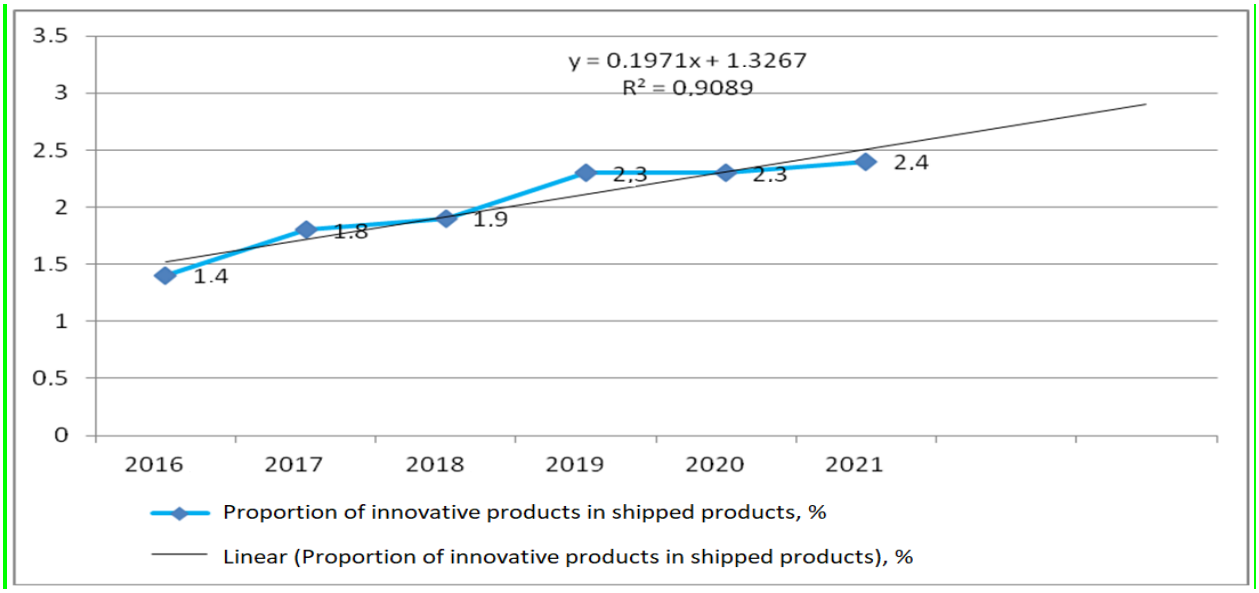

Fig. 1. Trends in the share of innovative products in the total volume of shipped products, work performed and services of Russian agriculture
Source: Own calculations based on data [29].

A more detailed study of the model components was carried out using trend analysis. On the basis of official statistics data, series of dynamics and trend equations were constructed, on the basis of which a predictive assessment of the change in the above indicators in the short term was presented (Fig. 1, 2 and 3).

The trajectory of changes in the share of innovative products in the total volume of shipped products, work performed and agricultural services reflects a slight positive trend, although the scale of its output is much lower than in manufacturing, where this indicator is 3–3.5 times higher. A fairly high coefficient of determination (0.91) characterizes the sustainable nature of the increase in the volume of innovative products, although there is a rather significant intra-industry differentiation: in 2021, the indicator in question ranged from 1.4% for the type of activity “mixed agriculture” to 3.1% for type of activity "growing of perennial crops".

Calculations showed that, under unchanged conditions, the indicator under consideration will reach 2.7% in 2024, and 2.9% in 2025.

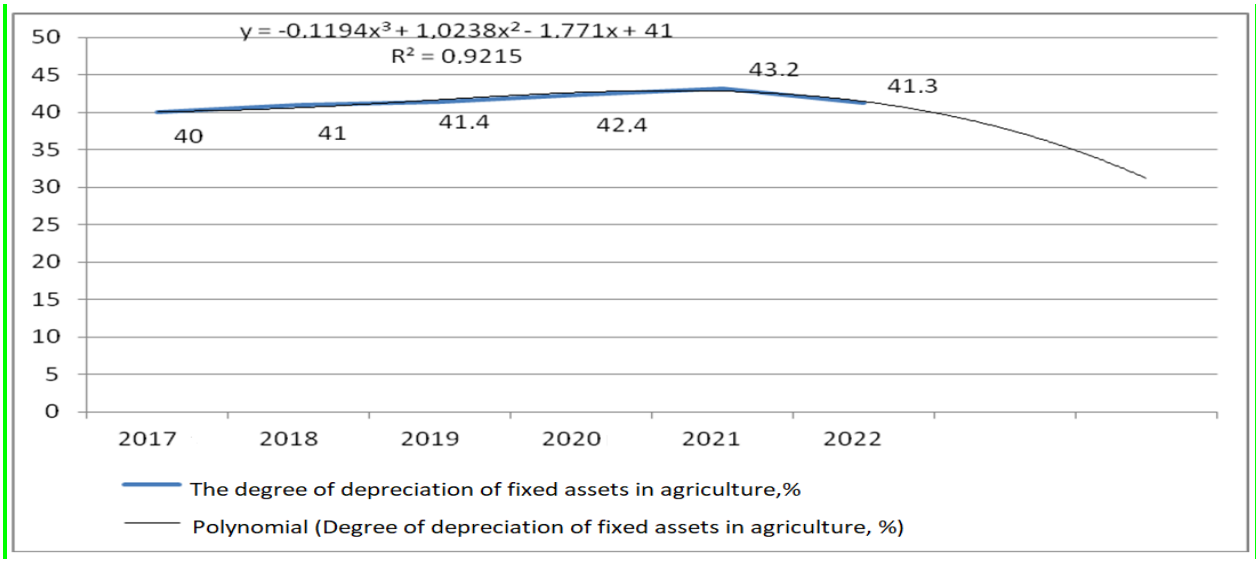

Fig. 2. Trend analysis of the degree of depreciation of fixed assets in agriculture in Russia
Source: Own calculations based on data [29].

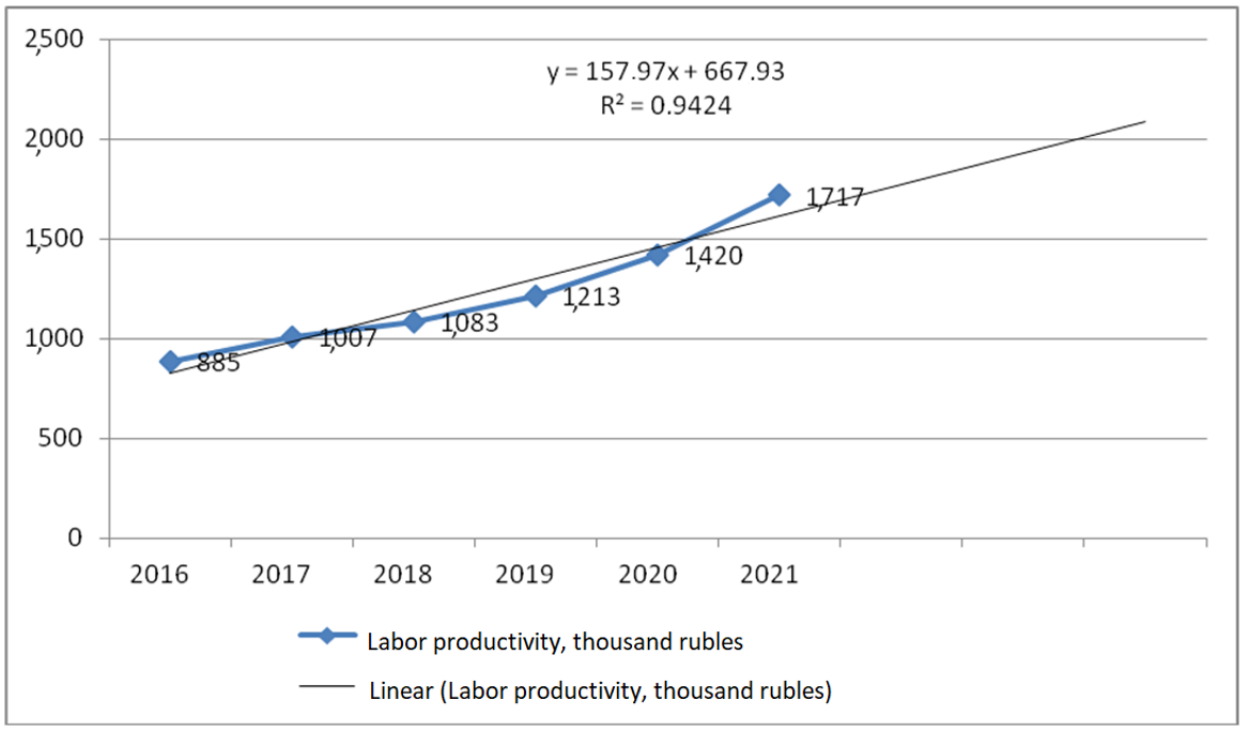

Fig. 3. Trend analysis of labor productivity in Russian agriculture
Source: Own calculations based on data [29].

The dynamics of the depreciation of fixed assets reflects a non-linear nature, which is confirmed by a polynomial trend model with a high degree of significance (the determination coefficient is 0.92). In the event of a large-scale technological renewal of fixed assets, depreciation in the short term may decrease by almost 10 percentage points.

The dynamics of the labor productivity indicator is also characterized by a positive linear trend with a high coefficient of determination equal to 0.94. Prolongation of the current trend, according to our calculations, will increase labor productivity in the short term by 12-15 percent.

The calculations performed showed a certain relationship between the share of innovative products in the shipped agricultural products and labor productivity, which reflects the use of advanced technologies, although the

processes of production, distribution and implementation of innovations are still characterized by a point distribution and strong interregional differentiation. It should be noted that the increase in the number of advanced technologies used is not always associated with the replacement of fixed assets with a high degree of depreciation, which limits the production of innovative products. Scientific research has proven a direct linear relationship between the advanced technologies used and labor productivity. At the same time, an increase in the number of advanced technologies used is not always associated with the modernization of the material and technical base of the agricultural sector, which negatively affects neoindustrialization trends: a high degree of depreciation of fixed production assets remains, and the production of innovative products stagnates. The lack of dependence between the use of advanced technologies and the level of renewal of fixed production assets can be explained to a certain extent by the investment decisions of enterprises on the introduction of innovative service technologies that do not require a radical modernization of the material and technical base.

Thus, there is a gap between the introduction of advanced technologies and the production of innovative products in the agricultural sector. Another situation is possible that explains the lack of a synergistic effect from the introduction of advanced technologies: an innovative product produced on the basis of advanced technologies is either not in demand on the market, or is not promoted effectively enough on it. The problem of marketing innovations arises, for the solution of which it is necessary to study the trends in demand and consumer behavior, as well as the problems of interaction and competition of enterprises participating in the value chain [21].

The successful implementation of the neoindustrialization policy in the agricultural sector necessitates the development of an organizational and economic mechanism for improving the strategies for innovative and scientific and technological development. Organizational instruments are associated with the regulation of fiscal, monetary policy, foreign economic policy at the macro level, forming a certain institutional environment for innovative and scientific and technological development. The economic incentive mechanism should be aimed at developing clustering processes to organize various forms of integration associations of the subjects of the innovation process, which will increase the competitiveness of regional agro-innovation systems. An important role is given to the creation of small innovative enterprises, support for research and development work, stimulation of diffusion of innovations and technology transfer, development of innovative infrastructure. To overcome the gap between the dynamic growth of advanced production technologies and the stagnation of the material and technical base in the domestic industry in the country's agricultural sector, it is necessary to ensure the expanded reproduction of high-tech means of production.

CONCLUSIONS

The most important processes that ensure the successful development of the agricultural sector in the context of neoindustrialization are the development of high-tech production in the domestic industry, contributing to the achievement of technological sovereignty: the growth of labor productivity, the innovative transformation of productive forces. The scale of neoindustrialization in the agricultural sector is determined by the volume of production of innovative products, the pace of renewal of fixed production assets as an indicator of the innovative transformation of the material and technical base, the level of labor productivity as the materialization of the achievements of the research sector, and intersectoral interaction between the subjects of the innovation process. It is concluded that the synergistic effect of neoindustrialization is reflected in an increase in the production of innovative products, an increase in labor productivity, and an increase in intersectoral exchange.

The necessity of improving the organizational and economic mechanism for implementing strategies for innovative and scientific and technological development in order to increase the innovative activity of enterprises in the agricultural sector, achieve a close relationship between the use of advanced technologies and the release of innovative products, enhance the processes of transfer and implementation of innovations, improve the efficiency of innovation and investment processes with taking into account innovation marketing approaches.

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REFERENCES

[1]Akhtyamov, M.K., Zavyalova, N.I., Likholetov, V.V.,2022, Modeling ways to increase the competitiveness of modern organizations in the knowledge economy, Vol.3, 1367–1384.
[2]Bell, D.,2019, The coming of post-industrial society. In Social Stratification, Class, Race, and Gender in Sociological Perspective, Second Edition, Routledge, 805-817.
[3]DeClerqc, M., Vats, A., Biel, A.,2018, Agriculture 4.0: The Future of Farming Technology. World Government Summit and Oliver Wyman. https://www.oliverwyman.com/our-expertise/insights/2018/feb/agriculture-4-0--the-future-of-farming-technology.html. Accessed on June 11, 2023.
[4]Decree of the Government of the Russian Federation No. 996 of August 25, 2017 "On Approval of the Federal Scientific and Technical Program for the Development of Agriculture for 2017-2030" (with amendments and additions),https://docs.cntd.ru.Accessed on June 27, 2023.
[5]Derunova, E., Kireeva, N., Pruschak, O., 2020, The level and quality of inclusive growth agri-food system in modern conditions. Scientific Papers Series «Management, Economic Engineering in Agriculture and Rural Development», Vol.20(3),193-206.
[6]Doroshenko, Yu. A., Malykhina, I. O., Somina, I. V., 2020, Innovative development of the region in the context of modern trends of neoindustrialization, Economics of the region, Vol.16 (4), 1318-1334.
[7]Doroshenko, Yu.A., Starikova, M.S., Somina, I.V., Malykhina, I.O., 2019, Improving the performance of high-tech companies based on interactions with the subjects of the innovation environment, Economics of the region, Vol.15 (4), 1279–1293.
[8]Ermoshina, T. V., 2015, The role of investments and public-private partnership in the neoindustrial economy, Intellect. Innovation. Investments, Vol.3, 26-31.
[9]Kalinichenko, M.P., 2022, Management of the strategic competitiveness of industrial enterprises: assessment, implementation of technological and managerial innovations, Proceedings of the South-Western State University. Series: Economy. Sociology. Management, Vol.1, 80–91.
[10]Krasnyuk, L. V., 2016, Diagnostics of the stages of economic development and the formation of the paradigm of neo-industrialization of the Russian industry, Scientific and technical statements of the St. Petersburg State Polytechnic University, Vol. 1 (235), 158–166.
[11]Minakova, I. V., Solodukhina, O. I., Bukreeva, T. N., 2019, January. Innovative-oriented neoindustrialization as an imperative to the development of the Russian economy. In 2nd International Scientific conference on New Industrialization: Global, national, regional dimension. Atlantis Press, 85-88.
[12]Nechaev V. I., Mikhaylushkin P.V., G. N. Barsukova G.N.,2021, Intensity of agricultural land use and land market activities in the central economic region in Russia, The Challenge of Sustainability in Agricultural Systems. Cep. "Lecture Notes in Networks and Systems, Volume 205" Heidelberg, 309-317.
[13]Nechaev, V. I., 2023, New industrialization of the agrarian sector of the Russian economy or a change in the management paradigm in science and business, Agricultural Economics of Russia, Vol. 4, 2-10.
[14]Popescu, A., 2006, Research concerning the economic impact of investments in dairy farms of various size, International Symposium "Prospects of Agriculture in the 3rd Millennium", UASVM ClujNapoca, 5-6.
[15]Popescu, A., 2021, The Development of Agricultural Production in Romania in the Period 2010-2019 - a Statistical Approach. Annals of the Academy of Romanian Scientists Series on Agriculture, Silviculture and Veterinary Medicine Sciences, 10 (1), 107–123.
[16]Popkova, E. G., Haabazoka, L., Ragulina, J. V., 2020, Africa 4.0 as a Perspective Scenario for Neo-Industrialization in the Twenty-First Century: Global Competitiveness and Sustainable Development. In Supporting Inclusive Growth and Sustainable Development in Africa-Volume II: Transforming Infrastructure Development. Cham: Springer International Publishing,275-299. Cham: Springer International Publishing.
[17]Popova, R.I., Toksanbayeva, M.S.,2022, Characteristics of employment in the conditions of

post-industrialization and de-industrialization, Business. Education. Right, Vol.4 (61), 98–104.
[18]Repina, A., 2018,Development of advanced production technologies in Russia,http://issek.hse.ru. Accessed on July 25, 2023.
[19]Sandu, I., Butorin, S., Ryzhenkova, N. ,2019, Scientific basis for forecasting the innovative development of the agricultural sector of the region's economy (on the materials of the Perm region). In Proceedings of International Scientific and Practical Conference on Agrarian Economy in the Era of Globalization and Integration.IOP Conference Series: Earth and Environmental Science, 274(1), 012016. Bristol, UK: IOP Publishing.
[20]Semenova, N.N., 2018, Import substitution in the agro-industrial complex and neo-industrialization: financial security issues, Greater Eurasia: development, security, cooperation, Vol. 1(1), 487-491.
[21]Starikova, M.S., Rudychev, A.A., Alakhmad, Alcoussa Mazhd, 2023, Analysis of the determinants of the competitiveness of industrial systems in the context of neo-industrial transformation, Economics, Entrepreneurship and Law, Vol. 13 (7), 2127–2146.
[22]Streltsova, E. Nesterenko, A., 2023, Towards Technological Sovereignty: Russian Patent Activity in 2015–2022,http://issek.hse.ru/. Accessed on June 18, 2023.
[23]Sushkova, I. A.,2013, The mechanism of neo-industrialization. Methodology of substantiation, Proceedings of the Saratov University. New episode, Vol. 13 (4(2), 656–661. (Economics. Management. Law).
[24]Tolkachev, S. A., 2015, Neo-industrial challenges to the economic security of Russia, Industrial policy in the conditions of new industrialization, Vol.1, 225–236.
[25]Van Es, H., Woodard, J., 2017, Innovation in agriculture and food systems in the digital age, The global innovation index, Vol.99.
[26]Vasilchenko, M., Derunova, E., 2020, Factors of investment attractiveness of Russian agriculture in the context of innovative structural adjustment, Scientific Papers. Series: Management, Economic Engineering in Agriculture and Rural Development, Vol. 20 (2), 511–522.
[27]Vasilchenko, M., Sandu, I., 2020, Innovative-investment development of agriculture in the conditions of formation of the export-oriented economic sector: system approach, Scientific Papers Series: Management, Economic Engineering in Agriculture and Rural Development, 2020, Vol 20(1), 599–612.
[28]Vasilyeva, N. F., 2016, Neo-industrialization of the economy. Start conditions and implementation, Bulletin of the Institute of Economic Research, Vol. 1(1), 49–63.
[29]Vlasova, V.V., Gokhberg, L. M., Ditkovsky, K.A. etc., 2023, The science. Technologies. Innovations: 2023: a brief statistical collection, Nats. research. un-t "Higher School of Economics". Moscow: HSE, 102 p.
[30]Xu, L. D., Xu, E. L., Li, L., 2018, Industry 4.0: state of the art and future trends, International journal of production research, Vol.56(8), 2941-2962.