Problems and status of innovative development of agriculture in Russia

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Abstract. The article is devoted to the analysis of the current state of innovative development of agriculture in Russia. Innovations are becoming a determining factor in upgrading the efficiency of economic development under conditions when market dynamics undergo revolutionary changes. An integral component of innovation processes is an unbiased assessment of the current state and dynamics of innovation indicators. However, the existing methodology and approaches to estimating innovative development at the macroeconomic level do not provide an objective account of implementation of the given process regarding particular sectors of the economy. The methodology of this research is based on the works of Russian and foreign economists, national laws and regulations, the Oslo Manual on the nature, content and measurement of innovative potential, as well as materials from periodicals on assessment of innovations, and scientific approaches to the study of innovative advancement in agriculture. Specific factors discouraging the process of introducing innovations in agriculture have been revealed. Analysis of key indicators demonstrating the level of innovative development is performed. The ways of increasing performance of innovative activity in agricultural sector are proposed. The prioritized measures for increasing innovation activity in agriculture were formulated. The measures needed to create a multi-level system of training and retraining specialists employed in agribusiness and measures for the development of institutional infrastructure for innovations, development and adoption of legislative and normative acts regulating and stimulating innovative activity have been proposed.

1. Introduction

The transformation processes carried out in the agrarian sector of the Russian Federation are aimed at formation of an innovative socially oriented development model based on the economy of leadership and knowledge. At present, the level of the country’s innovative development in many respects lags behind the leading world powers due to the slow pace of technical and technological modernization in the agro-industrial complex and the immunity of producers to scientific achievements. The problem of innovative development of the agro-industrial complex is becoming particularly relevant in the context of international sanctions and the adopted strategy of imports phase-out. The problem can be solved by the 2017-approved Federal Science and Technology Program for the Development of Agriculture for 2017–2025, the main goal of which is to stimulate the industry’s innovative development and reduce its dependence on technology imports.
Existing forecasts [1] show that by 2050 there will be no less than 9 billion people in the world. According to the Food and Agriculture Organization (FAO) it is necessary to increase food production by 70% compared to 2017 in order to feed such a number of people. According to The World Health Organization (WHO) 7 out of 10 people will live in the city by 2050, and we will not receive any additional resources, such as land, water as well as the number of agricultural producers won’t increase.

Thus, in order to maintain at least the current level of consumption, it is necessary to develop innovative mechanisms that ensure a high level of technological effectiveness, as well as the efficiency of using natural and labor resources.

As noted in the materials [2], in order to ensure the sustainable development of modern agriculture we need some innovative approaches based on four main modes such as:

1. New scientific approaches based on the synthesis of biotechnologies, information and computing systems, which are in fact equivalent to the digital economy.
2. Innovations in farms, where technological, organizational, marketing and other means of innovation will not only be used separately but react upon each other for the sake of agricultural development.
3. Integrated national innovation regimes, when various elements of agricultural production work as part of the national system of the national economy.
4. Mode of stimulating innovation based on a combination of political and market management approaches.

It must be noted that agricultural production is a subject of high risks and depends a lot on natural and climatic factors. The introduction of innovations occurs with a certain time lag in comparison to the other sectors of the national economy, which is determined by a long production cycle and a long pay-off period for innovative investment projects. The modern land economies need reliable technologies that increase the performance, stability and elasticity of production systems. Such changes imply that technologies for development should go much further than simply increasing yield and must be devoted to preserving water resources and energy, reducing risk, improving product quality, environmental security, adaptiveness to gender differences.

Scientific publications of several leading scientists, including V. Bautin [3], A. Golubev [4], E. Kovryakov [5], V. Nechaev [6], I. Ushacheva [7], V. Petrikova [8], I. Sandu [9], are devoted to various aspects of solving this problem. Nevertheless, they have not been studied enough and require further study of the problem of the specifics of innovative processes in agriculture, especially at the stage of dissemination and implementation of innovations and increasing the efficiency of their development; development of innovation infrastructure; increase of motivation for innovation what determines the relevance of the research topic.

2. Materials and methods

Methodologically this study is based on the works of Russian and foreign economic scientists, country specific legislative documents, the Oslo Manual on the nature, content and measurement of innovative potential, as well as materials from periodicals on the assessment of innovations, scientific approaches to the study of innovative activities development in agriculture.

The main methods of this research are logical and situational approaches to the study of methodological apparatus for assessing innovation, also there were used some additional methods of analysis, synthesis, particularization and generalization, formalization, analogy and abstract logical approach.

The world scientific economic community has developed a significant number of various systems of indicators and indices, which allow to assess the level of various countries and regions innovative development. For example, in 2007, there was a method proposed by the INSEAD International Business School in France for ranging the levels of countries’ innovative development around the world for calculating The Global Innovation Index. The method included 80 different variables describing in detail the ratio of innovation costs and the resulting effect. In 2017, the study covered
143 countries of the world. The Russian Federation occupies the 45th position in this rating which is lower than some developed countries as well as Thailand, Chile, Barbados and Qatar. At the same time, it should be noted that, compared to 2014, Russia moved up by 4 positions.

One of the most effective tools for monitoring the implementation of innovative strategies in European countries is the methodology developed by the Organization for Economic Cooperation and Development (OECD), which allows to assess the state of national innovation systems. The rating is carried out on the basis of indicators for 27 European countries - members of the European Union including the USA, Japan and other countries. It includes innovation input which characterize the resources owned by countries for the implementation of innovations, and innovation output reflecting the final results. In 2007, there was developed «a roadmap» adjusting the Russian inclusion to the OECD Convention, but in March, 2014 this process was temporarily put on long at the request of the member states of the organization. The evaluation system of Russian innovation activity indicators differs from the European one since there are restrictions on the collection of statistical information that allow a comprehensive analysis of this process.

According to A.A. Chernyaev (a member of the Academy of Sciences) methodological and methodical approaches to the assessment of the innovative development of the macroeconomic level are poorly applicable for highlighting the innovative component of agribusiness and require a comprehensive solution [8]. For this reason, the analysis of innovation activity in the agro-industrial sector was conducted by the author on the basis of indicators proposed by researchers of the Higher School of Economics, and are combined into the following groups:

- Innovative enterprises activity;
- knowledge generation;
- human development;
- the formation of the information society;
- international comparison.

The indicator of innovation activity is central to the system of indicators determining the degree of the organization’s participation in the implementation of innovations over a certain period of time. Due to the fact that official statistics on this indicator have become available relatively recently, it is not possible to trace the change in this indicator over time (Figure 1).

**Table 1. Innovation activity indicators of Russian agricultural organizations in 2017.**

| Indicator                                                                 | 2017             |
|---------------------------------------------------------------------------|------------------|
| The level of innovative activity (the proportion of organizations implementing technological innovations, the number of organizations in total), % | 3.4              |
| Growing annual crops                                                     | 4.2              |
| Growing perennial crops                                                  | 3.3              |
| Growing seedlings                                                        | 2.1              |
| Animal husbandry                                                         | 3.9              |
| Mixed farming                                                            | 1.3              |
| auxiliary activities in the field of crop production and post-harvest processing of agricultural products | 2.4              |
| The cost of technological innovation, mln. RUB.                         | 14963.3          |
| Intensity of the technological innovation expenses (proportion of the technological innovation cost in the total volume of goods shipped, performance, services),% | 0.9              |
| The volume of innovative goods, works, services, mln. RUB.               | 22222.9          |
Proportion of innovative goods, works, services in the total volume of goods shipped, work performed, services, %

1.4

Data source: The monitoring data by the Federal Office of Statistics, form No. 4-innovation “Information about the innovative activity of an organization”; foreign countries – EUROSTAT database; the results of the project “Development of Theoretical and Methodological Approaches to the Research of Innovative Activity of Economic Entities” of the NRU HSE Fundamental Research Program.

It should be noted that innovative activity of agricultural organizations is rather low, which is predictable due to a number of inevitable causes, such as unfavorable investment climate, weak state support, and high costs of innovation products.

The proportion of agricultural organizations implementing technological innovations is only 3.4%, while it is 59.8% in Norway, 40.8% in Denmark and 8.6% Spain. In comparison to other sectors of the economy this indicator is one of the lowest. For example, the indicator of innovation activity of enterprises of the food processing industry in Russia is 9.5% on average [9].

In general, the contribution of innovative products to the development of agriculture is insignificant: the proportion of the total volume of shipped goods, performance and services is 1.4%, while almost a tenth of the agricultural enterprises’ products fall into the category of “innovative” in a number of European countries such as Denmark - 11.6%; Spain - 12.7%; Netherlands - 9.2%.

All-Russian Agricultural Census 2016 showed interesting results on the application of innovative technologies by producers of various farming categories, some of which are shown in Table. 2

| Table 2. The proportion of innovative technologies used in agriculture by different producers’ categories (July 1, 2016), %.

| Indicator                                      | Agricultural organization | Small enterprises | Farm enterprises |
|-----------------------------------------------|----------------------------|-------------------|------------------|
| Drip irrigation system                        | 4.7                        | 4.3               | 3.7              |
| Biological methods of plant protection from pests and diseases | 10.3                       | 9.4               | 9.3              |
| Livestock feeding system                       | 8.1                        | 7.0               | 4.7              |
| Method of cell free poultry                    | 1.5                        | 0.9               | 1.6              |
| System of water disposal and cleaning of industrial waste | 9.9                        | 8.5               | 3.7              |

Data source: Federal State Service. statistics 2017 Preliminary Results of the All-Russian Agricultural Census of 2016: 2 tons. Vol. 1: Preliminary Results of the All-Russian Agricultural Census of 2016 (M.: IIC “Statistics of Russia”).

These tables reflect the results of a questionnaire survey of representatives for various categories of farms. The largest scale application of innovative technologies is noted in large organizations with large investment opportunities. According to A. Petrikov, despite the progressive scientific and technological development, the industry has to solve many problems in order to expand the use of traditional means of intensifying production, as well as to accelerate the development of new technologies [12].

At the same time, the productivity of agricultural production directly depends on the value of investments aimed at financing agricultural research and development. During the years of market transformation of agroeconomics, innovation activity has not received proper state attention and the necessary participation of private agribusiness in building up the innovation potential in the agro-industrial complex. In the state policy of Russia in recent years, new mechanisms have appeared for stimulating innovation in agriculture. Thus, in the State Program for the Development of Agriculture and Regulation of Agricultural Products, Raw Materials and Food Markets for 2013-2020 includes the subprogram “Technical and technological modernization, innovative development” aimed at stimulating innovation and including a number of activities, stimulating the acquisition of high-tech machines and equipment by agricultural producers; increasing the innovative activity of agricultural producers and expanding the scale of agricultural development on an innovative basis; the creation and development of the institutional environment necessary for the development and large-scale use of...
innovations; creation of infrastructure for the development of biotechnology in agriculture. Stimulation of innovation is carried out by indirect methods, mainly through the subsidization of investment loans.

However, investment loans are unevenly distributed to agricultural organizations and are concentrated in a small group of profitable organizations. This happens mainly because there are no restrictions in the Russian legislation on the total amount of subsidies from the budget received by a single legal entity or individual (such restrictions apply in many developed countries). It is quite obvious that with this distribution of subsidies, the promotion of innovation is extremely limited.

The results of innovation activities have a comprehensive impact on the functioning and development of enterprises in all sectors of the agro-industrial complex, the significant effects of which are manifested in increasing labor productivity and enhancing the competitiveness of products. The institutional environment of agriculture is based on the formation of a full range measures and mechanisms of the state agrarian policy aimed at supporting the subjects of innovation [13]. In this regard, one of the indicators for assessing the level of innovation development is the indicator of the commercialization of innovations, and one of the main incentives for creating innovations and innovative products is the degree of protection of contracts, especially intellectual property rights. Currently, in the agriculture of the Russian Federation there is a very significant intellectual property in the form of inventions and breeding achievements. In 2017, there were 291 scientific institutions of the Russian Academy of Agricultural Sciences in the country, where 11,834 people were engaged in scientific research. In terms of the number of scientific organizations and researchers, the Russian Federation is many times greater than the agrarian innovation complexes of other countries, but less than 1.0% of intellectual property created at the expense of public funds is in the economic circulation.

According to Russian Federal Agency for Intellectual Property, Patents and Trademarks, the use of the IPR by type of economic activity in 2017 for plant growing and animal husbandry 6 inventions and 38 selection achievements were used.

The share of existing patents of the Russian Academy of Agricultural Sciences is 20%, and educational institutions subordinate to the Ministry of Agriculture of Russia - 28%. One of the reasons for the unsatisfactory use of intellectual property in the agro-industrial complex is the imperfect legislative and regulatory legal framework governing relations in this area. Despite the fact that in the Russian Federation there are normative legal acts on the protection and enforcement of rights to the results of scientific and technical activities that meet the requirements of international standards, they are not able to provide solutions to many legal problems that accompany the process of commercialization of innovations. This is due to the balance of interests of the main subjects of intellectual property. According to I.G. Ushachev, I.S. Sandu [14], this factor blocks the implementation of successful activities of agricultural research organizations for the protection and use of rights to created results of intellectual property and leads to an extremely low level of their use in economic circulation. The existing problem is widely covered in many scientific publications, but it is still relevant. Its essence is as follows. Under current Russian legislation, the right to the results of work that are performed under the contract, including objects that are capable of legal protection, may belong to both the customer and the performer, or the customer and the performer jointly. The state remains the main customer for scientific research in the Russian Federation. Domestic expenditures on research and development in agriculture in 2016 are calculated as 529.0 million rubles, or 0.06% of the total state expenditures for these purposes. Only for 2012—2016 the costs increased in 1.85 times. According to this indicator, the Russian Federation is among the ten leading countries of the world, while the share of domestic costs to gross domestic product in 2017 was 1.12% (in Germany - 2.88%, in France - 2.24%). In the structure of domestic expenditure on research and development, the share of the state was 68.2% (in European countries - about 33% (Table 3).
Table 3. The structure of domestic expenses of the Russian Federation in 2016 on research and development by sources of financing, %.

| Country         | Government expenditures | Expenditures of the business sector | Foreign investment | Other expenditures |
|-----------------|-------------------------|------------------------------------|--------------------|-------------------|
| The Russian Federation | 68.2                   | 28.1                               | 1.0                | 2.7               |
| The UK          | 32.2                    | 44.6                               | 17.0               | 6.2               |
| Germany         | 30.3                    | 65.6                               | 3.9                | 0.2               |
| France          | 37.0                    | 53.5                               | 7.6                | 1.8               |

Data source: Gorodnikova N, Gokhberg L, Ditkovskyyt K 2018 Science Indicators: 2018: Statistics Digest (M.: National Research University Higher School of Economics HSE) p 320.

The business sector is less involved in funding scientific investigations. Consequently, intellectual property rights, as a rule, belong to the state. The existing legal mechanisms do not stimulate the innovation process for several reasons:

- firstly, the state does not have sufficient means to protect its rights, including judicial protection in Russia and abroad;
- secondly, the administrative mechanisms for the implementation of the results obtained into the economic turnover have not been developed, since the enterprises of the agro-industrial complex are mostly private;
- thirdly, the authors-developers have no interest in the commercialization of innovations created as part of the fulfillment of government contracts. In Art. 1370 of the Civil Code of the Russian Federation provides for the right of authors-developers to remuneration by entering into an agreement with the employer, which defines the conditions and procedure for their payment. However, the inspection of the organizations executing government contracts conducted by Russian Federal Agency for Intellectual Property, Patents and Trademarks revealed that employers rarely enter into such contracts with the authors;
- fourth, government customers do not have proper control over the fulfillment of the terms of contracts for the implementation of research and development work on securing the rights and commercialization of the results of intellectual activity obtained from the state budget [15]. According to S.B. Ognivtsev, most organizations of agrarian science suffer from illiteracy in the use of intellectual property, while managers pate intellectual property not in order to protect them from competitors, and not for further use, but for reporting to higher organizations [16]. He proposes to use an indicator not of the number of patents as one of the measures to increase the efficiency of commercialization, but an indicator of their use under licensing agreements and under agreements of assignment of rights to patents. The solution of the problem is seen in the implementation of the main directions for the improvement of legislation on the protection and enforcement of rights to the results of scientific and technical activities, regulating the process of involving the results of intellectual activity into economic circulation and stimulating innovative processes. It is possible to increase the interest of private business to participate in innovation processes by subsidizing the acquisition of technology, providing tax incentives, and liberalizing the transfer of intellectual property rights.

The motivational system for the commercialization of intellectual property operating in China is of particular interest. There, the central link of state innovation policy is the intellectual property market, where the rights of developers are enshrined. For example, the Chinese city in which 6 million people live has 25 thousand patents, which corresponds to the approximate volume of patents granted in the Russian Federation for the year [17]. Significant differences exist in the organizational construction of technology parks of the Russian Federation and China. In Russia, technology parks are built on the principle of a triune association: education - science - production. In China, there is a fourth element - the center of intellectual property, which links all the other elements. Without the creation of an appropriate infrastructure, solving the problem of intellectual property commercialization in the Russian Federation will not work. Vice-Rector of the Russian State Agrarian University-Moscow
Agricultural Academy. K.A. Timiryazeva A.V. Golubev notes that techno-parks can only be created in the form of state, state autonomous and state research institutions for budget support, which limits their capabilities. Amendments are needed to laws that allow the creation of a special form of innovative enterprises, for example, in the form of regional funds for agricultural development [16].

One of the indicators of the effectiveness of science is the number of scientific articles and their citation in the leading journals of the world. The strategic goal of developing research and innovation activities in the institutions of higher education of the Russian Federation is to increase the contribution of universities to the technological modernization of the real sector of the economy of the Russian Federation through the development of their research and innovation activities. Currently, the United States is the undisputed leader in the number and citation of scientific research in the international arena. China is increasing its growth rate of citation indicators.

Russia occupies the 9th position in the world in terms of the volume of the national budget for research and development, while it is significantly lagging behind in terms of citation rates in high-rated journals with maximum internal expenditures on research and development. The average normalized citation of publications by Russian authors is 0.76.

Table 4. The proportion of Russian participation in the global number of publications, %.

| Publications-- | 1995 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|----------------|------|------|------|------|------|------|------|
| in total       |      |      |      |      |      |      |      |
| Articles       | 1.78 | 1.68 | 1.64 | 1.73 | 1.98 | 2.33 | 2.70 |
| Reports        | 1.30 | 0.90 | 1.53 | 1.51 | 2.27 | 2.61 | 2.86 |
| Reviews        | 0.39 | 0.43 | 0.96 | 0.97 | 1.04 | 1.32 | 1.78 |
| Others         | 0.27 | 0.55 | 0.49 | 0.43 | 0.46 | 0.67 |      |

Data source: Gorodnikova N, Gokhberg L, Ditkovskiyet K 2018 Science Indicators: 2018: Statistics Digest (M.: National Research University Higher School of Economics HSE) p 320.

The Strategy of Innovative Development of the Russian Federation until 2020 notes that the citation level of Russian scientists in the Web of Science on average per article leaves 2.4 references. In China, this level is 3.62, in Japan - 5.12, Germany - 6.86 references. Thus, Russia is inferior in terms of this indicator to many developed countries of the world.

However, it should be noted that the citation of Russian publications is gradually increasing. Thus, the total number of publications of scientists from institutes subordinated to the Federal Agency for Scientific Organizations in Russia, which are indexed in the Web of Science, increased in 2016 compared to 2015 by 14.4% (from 30377 units to 34745 units). In addition, the number of publications in Scopus increased from 25,628 units to 32,157 units or 25.5% and publications indexed in the Web of Science from 4,368 units to 6,529 units. Indicators of the structure of publications in scientific journals indexed in Scopus by areas of science shows that, on average, agricultural sciences account for 3.2% in Russia and 6.7% in the world.

One of the reasons that negatively affect publication activity is the generation gap that has emerged in modern Russian science. The average age of researchers in 2016 was 47 years, doctors of science - 63 years, and candidates - 51 years (tab. 5).

Table 5. Dynamics of the scientific researchers’ structure in the Russian Federation by age groups, %.

| Age groups | 2010 | 2014 | 2016 |
|------------|------|------|------|
| up to 29 y.o. | 19.3 | 20.3 | 19.3 |
| 30-39 y.o. | 16.2 | 21.1 | 24.0 |
| 40-49 y.o. | 14.7 | 13.2 | 13.6 |
| 50-54 y.o. | 11.6 | 9.7 | 8.0 |
| 55-59 y.o. | 12.3 | 10.3 | 9.6 |
| 60-69 y.o. | 16.5 | 17.1 | 16.5 |
| 70 y.o. and older | 9.4 | 8.3 | 9.0 |
Analysis of the data presented in the table shows that the proportion of scientists aged from 30 to 49 years was only 37.6% in 2016. In this case, the proportion of researchers aged 70 years is 9.0%. This suggests that in many research institutions there is no incentive for young scientists. The overall prestige of science has declined in the country, and the problem of “brain drain” has not been resolved so far and is unlikely to be resolved in the near future without the adoption of radical measures. Therefore, one of the most important areas of innovative development of the agro-industrial complex of the country is the search for measures related to stimulation of innovative activity among students.

In recent years, the major changes have been observed in universities. So, an entrepreneurial function was added to the educational and research functions. Modern organizations need young qualified staff members with an original approach to solving innovative problems. The strategic goal of the university is to prepare highly qualified specialists, and for this it is necessary to create prerequisites for attracting and supporting active teachers, developing innovation infrastructure that will help not only to attract additional funds, but also improve the quality of the educational process. For example, the Saratov Agrarian University annually holds a competition of research and innovation projects of young scientists and students of the university in natural, technical and economic nominations. The winners of the competition receive a grant from the university rector. Student science is actively represented at numerous national and regional conferences. The Ministry of Agriculture of Russia has prepared a draft strategy for the development of agricultural education in the Russian Federation for 2015–2020, which outlines the main negative trends in the current state of staffing for the agro-industrial sector, which include:

- constant aging of personnel; - a constant increase in the turnover rate of personnel (in 2013 - 11.4%), with more than 6% of vacancies remaining unfilled;
- reduction in the number of actually working managers and specialists of agricultural enterprises in recent years; - decrease in the level of qualification of management of agrarian enterprises [17].

The promising areas are the development and creation at the state level of a special educational program that promotes the formation among citizens of the Russian Federation of an understanding of the role of innovation in the economic revival of the country's agriculture. To increase the overall level of organizational culture in the management of the agro-industrial complex, it is necessary to expand the training of managers of scientific and technical programs and projects, researchers of new scientific and technical directions, specialists in advertising, marketing, marketing and implementation of innovation results, strategic management, etc.

3. Conclusions

It should be noted that the problems of enhancing innovation activities in the agro-industrial complex must be solved at a growing pace in order to keep up with the world leaders under tough conditions of economic globalization.

Implementation of innovative trends in the development of agro-industrial complex should include the following components:

- overcoming inertia in the perception of innovations among the representatives of agribusiness;
- creation of a multi-level system for training and retraining specialists of the agro-industrial complex to conduct innovation activities;
- development of institutional infrastructure for the innovation activity;
- development and adoption of a system of legislative and normative acts regulating and stimulating innovative activities;
- implementation of the milestone innovative projects of national standing in the agrarian sector of the economy.

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