Factors of influence on the innovative activity of agricultural enterprises

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Abstract. The aim of the study is to analyze and evaluate the effectiveness of budgetary and extra-budgetary support and stimulation of innovative activity in agriculture. Using the methods of complex and structural-dynamic analysis, expert assessments and some others, studies of domestic and foreign scientists, statistical data, materials of state programs have been analyzed. This article discusses the main indicators of innovative activities of agricultural. The study showed that the level of innovative activity in the industry remains low due to the lack of finance from manufacturers; it depends on the level of government support. Small and medium-sized enterprises are most dependent on government support; incentive measures and the amount of government support should be long-term. It is proposed to create a center of competence, the purpose of which will be to stimulate innovative activity and reduce the influence of obstacles. To solve the problem of lack of financial resources for the implementation of innovative activities, an operator is needed, such functions can be taken over by Russian Venture Company (RVC) or the National technology initiative (NTI) project office.

1. Introduction
The modern model of technological development provides for the accelerated development and modernization of the Russian economy through the widespread development of the basic innovations of the fifth and accelerated transition to the sixth technological structure, the core of which is nano-, bio-and information and telecommunication (digital) technologies [1, 2].

The effectiveness of agricultural production, its sustainable development and competitiveness depend largely on the timely implementation of the latest scientific achievements. Strategic documents have identified the priority areas of scientific and technological development of agriculture for the medium and long term [3]. The implementation of measures in these areas will ensure the transition to a highly productive and environmentally friendly agriculture and aquaculture, the development and implementation of systems for the rational use of chemical and biological protection of agricultural plants and animals, the storage and effective processing of agricultural products, and the creation of safe and high-quality food products including functional ones.

The introduction of innovative technologies in agricultural production is an uncontested paradigm of its further development.
Domestic and foreign authors dedicate directly or indirectly a significant number of their work to various aspects of tackling the issues of the agribusiness innovation activities. The works [4-6] and some others are devoted to the study of the processes of the transfer and commercialization of innovation, formation of innovation systems, innovative policy development in the agricultural sector.

For example, authors [7, 8] have presented the definition and classifications of barriers in the field of innovation activity. As opposed to the literature background, the authors propose their own classification of technology transfer barriers.

The main scientific aspects of the creation of the innovation transfer mechanism in agrarian sector of the country when forming the innovative system of agrarian and industrial complex are discussed in the work. The features of formation of the system of development of innovations in agriculture are allocated and prerequisites of realization of innovations in productive and economic activity of the agricultural enterprises are studied [9].

The authors of [4] have identified four main problems that impede the development and implementation of innovations in agricultural production in Russia, identified factors and trends that do not contribute to the effective and advanced innovative development of the agricultural economy, and proposed in [9] an innovative toolkit for ensuring food security through state support of the Russian agricultural sector.

Therefore, it is especially important to analyze and evaluate the application of innovative technologies in agriculture, to study foreign and domestic experience of budgetary and extra-budgetary support and stimulate demand for innovative products and technologies in agriculture, which are the purpose of the study.

2. Materials and methods

The materials used were results of research from domestic and foreign scientists, information from the Federal State Statistics Service of the Russian Federation (Rosstat), scientific organizations of the Russian Academy of Sciences and the Ministry of Agriculture of Russia, administrative bodies of the agribusiness of the regions, materials from the State Program for the Development of Agriculture and Regulation of Agricultural Products, Raw Materials and Food Markets for 2013-2020, and for the period until 2025, the priority project titled ‘Export of agricultural products’ and other strategic documents.

In the process of the study, methods of complex and structural-dynamic analysis, mathematical modeling, expert estimates, extrapolation, and other methods were used.

3. Results and discussion

In order to systematize the data on the innovative activity of agricultural producers in the agricultural sector, Rosstat has approved a new edition of the quarterly form of federal statistical monitoring No. 4-Innovation titled ‘Information on the organization’s innovative activity’, which is provided by legal entities, except for small businesses engaged in economic activities in agriculture in accordance with the All-Russian Classifier of Economic Activities. Since 2018, the organizations carrying out activities in the field of agriculture shall report for three last years (previously they did not) [10].

The new edition of Form No. 4-Innovation was developed taking into account international recommendations in the field of statistical measurement of innovation (Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data. 3rd edition. Paris: OECD / Eurostat, 2005. Oslo Manual: Recommendations for data collection and analysis on innovation).

According to Rosstat in 2018 there were 217 organizations in agriculture that had completed technological innovations over the past three years.

According to the Institute of Statistical Studies and Economics of Knowledge of the Higher School of Economics National Research University, other studies [4, 11] for 2016 and data from the State Statistics Committee for 2017, the share of agricultural enterprises implementing agricultural innovations in crop production and animal husbandry, in their total number, amounted to maximum 3.9% (table 1).
Table 1. Key indicators of innovation activities of agricultural enterprises [12].

| Indicator                                                                 | 2016 | 2017 | 2018* |
|---------------------------------------------------------------------------|------|------|-------|
| Level of innovation activity (proportion of organizations engaged in technological innovation, in the total number of organizations),% | 3.7  | 3.9  | 3.9   | 2.9   |
| Costs of technological innovation, million rubles                         | 6,276| 5,669| 9,402 | 6,403 |
| Intensity of cost of technological innovation (proportion of cost of technological innovation in the total cost of goods shipped, work performed, services rendered),% | 1.1  | 0.6  | 1.5   | 0.7   |
| Amount of innovative goods, works, services, million rubles               | 6,542| 14,937| 11,844| 16,602| 52,357| 78,433|
| Proportion of innovative goods, works, services in the total amount of goods shipped, work performed, services rendered | 1.1  | 1.6  | 1.9   | 1.7   | 2.1   |

I - crop production, II - livestock

*N A, official innovation statistics for 2018 have not yet released.

Compared with a number of European countries, the backlog in the level of innovation activity in agriculture is ten times and more (Norway: 59.8%; Netherlands: 48.3%; Denmark: 40.8%).

In the economy as a whole, this indicator amounted to 7.5% in 2017. Annually, the share of domestic research and development costs in Russian agriculture, forestry and fisheries relative to GDP is 0.01%, while that is 2.2% in the USA, 4.42% in Australia, and 2.59% in South Africa.

One of the main reasons for the low innovation activity in agriculture is the weak public and private support for the formation of the material and technical base for the subsequent creation of innovations, which is due to the long payback period for innovations and the insignificant amount of state investments. The existing innovative potential is used by 4-5%, while it is used by 50% in the USA [4, 11, 13].

In 2017, the amount of innovative goods (works, services) produced using new and improved technologies in crop and livestock production amounted to 28.4 billion rubles against 21.5 billion rubles in 2016, of which 58.4% were livestock. In general, the contribution of innovative products is low: its share in the total amount of goods shipped is 1.9% in crop production and 1.7% in livestock (7.2% in the economy as a whole). In a number of European countries, about a tenth of the output of agricultural enterprises are classified as ‘innovative’ (Spain: 12.7%; Denmark: 11.6%; Netherlands: 9.2%).

The costs of technological innovations amounted to 9.4 billion rubles in crop production and 6.4 billion rubles in animal husbandry in 2017. According to this indicator, domestic agriculture is also inferior to that of European countries (in the Netherlands: 8.5%; Norway: 2.4%; Denmark: 1.9%; Spain: 1.3%).

The structure of costs for technological innovations in agriculture is dominated by investments in the purchase of machinery and equipment (50.3%), which is also characteristic of industrial production sectors. Research and development expenditures are only one eighth reflecting the low demand of agribusiness for the results of scientific and technical activities.

Innovation activity is implemented mainly at the expense of enterprises' own funds accounting for 59.3% of the total cost structure for technological innovation, while loans and borrowings amount to 39%. Budget support in total provides only 1.1% of the costs of technological innovation (including 0.5% from the federal budget; 0.6% from the budgets of the constituent entities of the Russian Federation and local budgets). Foreign investment is 0.5% [12, 14].
Smart technologies in crop production, according to [12], are applied to 7 million hectares. The data of the 2016 All-Russian Agricultural Census are also close to this: the share of agricultural enterprises, peasant farms and private entrepreneurs, small forms of farming using these or those elements of innovative technologies are maximum 15.6%, and these are usually large agricultural enterprises (table 2).

Table 2. Share of agricultural enterprises, peasant farms and private entrepreneurs that applied innovative technologies,% [12].

| Innovative technologies                                      | Agricultural enterprises | Agricultural enterprises not applying to small forms of farming | Small forms of farming | Peasant farms and private entrepreneurs |
|--------------------------------------------------------------|--------------------------|---------------------------------------------------------------|------------------------|-----------------------------------------|
| Integrated Irrigation System                                 | 4.7                      | 5.9                                                           | 4.3                    | 3.7                                     |
| Biological methods for protecting plants against pests and diseases | 10.3                     | 12.0                                                          | 9.4                    | 9.3                                     |
| Individual livestock feeding system                          | 8.1                      | 11.5                                                          | 7.0                    | 4.7                                     |
| Methods of biological poultry farming                        | 1.5                      | 3.4                                                           | 0.9                    | 1.6                                     |
| Wastewater treatment plants at livestock farms               | 4.8                      | 10.1                                                          | 3.1                    | 1.2                                     |
| Wastewater and sewage treatment system                       | 9.9                      | 14.0                                                          | 8.5                    | 3.7                                     |
| Renewable energy sources, including:                         |                          |                                                               |                        |                                         |
| Wind power plants                                            | 1.9                      | 2.0                                                           | 1.8                    | 1.8                                     |
| Solar panels                                                 | 0.1                      | 0.1                                                           | 0.1                    | 0.1                                     |
| Precision driving system and system for diagnostic quality control of production processes | 0.8                      | 1.0                                                           | 0.7                    | 1.2                                     |

According to surveys, no more than 1% of farmers use differential fertilizer and plant protection systems. Elements of precision farming and innovative technologies in animal husbandry are used by domestic large companies and agricultural holdings from different regions. In 2017, Lipetsk (812 farms), Oryol (108 farms) and Samara (75 farms) Regions led in the number of farms using precision farming elements in Russia, while Lipetsk (51 farms), Leningrad (46 farms) and Kostroma (24 farms) Regions led in the number of farms using innovations in livestock husbandry. Precision farming and animal husbandry are used in more than 40 regions of Russia. Integrated innovative developments were introduced in the Green Valley Group of Companies, Belgorod Region.

Unmanned aerial vehicles (UAVs) are being used more and more actively in the agribusiness. Russia is in the top-3 manufacturer countries, which produce about 180 different UAV models. According to the Agrophysical Research Institute, the elements of the Internet of Things are used by 0.05-5% of domestic agricultural producers. For comparison, this indicator is 60% in the USA and 80% in the EU. According to the Analytical Center of the Ministry of Agriculture of Russia, there was an increase in digital platforms by 11% in 2017.

However, there are not enough IT specialists for widespread adoption. 112,900 IT specialists are occupied in the agribusiness; this is only 2.4% of the total number of employees in agriculture. To achieve the indicator of the leading countries (USA, Germany, Great Britain), the additional need for IT specialists is estimated to 90,000 employees [1, 12].
The active use of elements of the precision farming system (parallel driving, informatization and monitoring, yield mapping, differential fertilizer application) allowed agricultural holdings, agricultural enterprises and peasant farmers to create electronic field maps.

The advantages of precision farming are the possibility of introducing new forms of management of the production process along with minimizing capital investments and environmental impact.

This system is already used in large agricultural enterprises. The ExactFarming system is used to control the plant growth cycle by Izvolsky, Kaluga Region. Mobile terminals installed on agricultural machinery are used by the Kuban agricultural holding, which allows tracking fuel costs, improving the logistics system and the use of vehicles. At the same time, it was possible to reduce fuel costs by 32%.

The use of spot farming requires some preparation (selection of fertilizers and other means, determination of the boundaries and characteristics of plots, crops and other parameters) and the installation of various sensors that are a source of information for agronomists to determine the nature and content of current and planned operations, to select the optimal crop structure, and to model production processes.

Russian companies, such as ExactFarming, develop and release services and software for managing and monitoring fields. They contain information on changes in climatic conditions and soil conditions; keep inventory and record fieldwork. Based on this, ExactFarming assesses risks, which makes it easier for banks to make decisions on granting loans to a particular agricultural enterprise. A similar Smart4agro service allows you to predict the condition of the fields and the level of productivity.

The grouping of agricultural enterprises shows by profitability level that, despite government support in 2017, 12.5% of agricultural enterprises were unprofitable, and a profitability level of 50.7% did not exceed 20% taking into account subsidies. In 2017, only 24.1% of enterprises whose profitability level was more than 30% and the share of subsidies in total costs was above average were able to introduce innovations in production. Agricultural holdings, poultry farms and other large agricultural producers predominate in these groups of enterprises [12].

According to preliminary data on the results of the financial and economic activities of agricultural enterprises in 2018 prepared based on the reports on the financial and economic condition of agricultural producers receiving state support provided by the constituent entities of the Russian Federation, the profitability of agricultural enterprises (including subsidies) was also 12.5%, which was below the target indicator (15%) by 2.5 percentage points excluding subsidies amounted to 6.4% as compared to 5.3% in 2017 (table 3). Among the main reasons for the deviation of the actual value of the indicator from the target one, difficult weather conditions, increased costs due to rising prices for material resources and an increase in wages due to bringing the minimum wage to a living wage are shown.

As the data in table 3 show, the proportion of profitable farms in the total number of agricultural enterprises amounted to 83% (0.3 percentage points higher than in the previous year) with a decrease in their total number. In general, by group, the distribution of farms by the level of profitability did not change significantly. In 2018, EBT (including subsidies) amounted to 314 billion rubles, which is 15.1% higher than the level of 2017 [14, 15].

Numerous studies indicate the lack of financial resources for agricultural producers to introduce innovations [1]. Thus, surveys conducted in the agricultural enterprises of the Novosibirsk Region identified the important hindering innovation activity factors, such as deficiencies in own financial resources (60.0%), high risk in introducing innovations (56.3%), high costs of developing innovations (54.0%), long payback period of innovations (49.5%), high rates on commercial loans (46.7%), shortage of qualified personnel (45.9%), etc. The lowest level of importance is the factor of the shortage of commercial borrowed funds (17.9%), which indicates the reluctance of enterprises to attract borrowed funds due to high interest rates for financing innovative activities [10, 11].
Table 3. Grouping of agricultural enterprises by the level of profitability in the Russian Federation [14].

| Grouping                       | 2017      | 2018      |
|--------------------------------|-----------|-----------|
|                                | Units     | %         | Units     | %         |
| Total                          | 18,178    | 100       | 17,499    | 100       |
| Of these, in terms of profitability (loss ratio) taking into account subsidies: | | | | |
| over 100%                      | 599       | 3.3       | 580       | 3.3       |
| from 90 to 100%                | 132       | 0.7       | 106       | 0.6       |
| from 80 to 90%                 | 154       | 0.8       | 148       | 0.8       |
| from 70 to 80%                 | 218       | 1.2       | 217       | 1.2       |
| from 60 to 70%                 | 310       | 1.7       | 292       | 1.7       |
| from 50 to 60%                 | 468       | 2.6       | 472       | 2.7       |
| from 40 to 50%                 | 705       | 3.9       | 655       | 3.7       |
| from 30 to 40%                 | 1,182     | 6.5       | 1,017     | 5.8       |
| from 20 to 30%                 | 1,855     | 10.2      | 1,743     | 10.0      |
| from 10 to 20%                 | 3,048     | 16.8      | 3,082     | 17.6      |
| from 0 to 10%                  | 6,429     | 35.4      | 6,260     | 35.8      |
| from -10 to 0%                 | 838       | 4.6       | 802       | 4.6       |
| from -20 to -10%               | 573       | 3.2       | 549       | 3.1       |
| from -30 to -20%               | 395       | 2.2       | 405       | 2.3       |
| from -40 to -30%               | 251       | 1.4       | 253       | 1.4       |
| from -50 to -40%               | 222       | 1.2       | 174       | 1.0       |
| from -60 to -50%               | 150       | 0.8       | 132       | 0.8       |
| from -70 to -60%               | 102       | 0.6       | 104       | 0.6       |
| from -80 to -70%               | 80        | 0.4       | 75        | 0.4       |
| from -90 to -80%               | 63        | 0.3       | 53        | 0.3       |
| from -100 to -90%              | 44        | 0.2       | 54        | 0.3       |
| less than -100%                | 360       | 2.0       | 326       | 1.9       |

The survey also identified the conditions necessary to increase the innovative activity of agricultural enterprises. The degree of importance of these conditions was estimated by respondents from 0 to 100%.

The analysis of respondents' answers showed that the main condition is an increase in financial resources and an expansion of funding sources (75.7%). It can be both own funds and external sources of financing, such as state support, soft loans, venture capital investments and foreign investments. Important conditions include changing the training system (50.2%), developing innovative infrastructure (49.8%), reducing the payback period for innovations (47.9%), improving soil fertility (46.8%), reducing the costs of developing innovations (46.1%), increasing the demand for innovative products (45.8%), increased staff motivation to introduce innovations (42.1%), development of new forms of integration of science and production and improved quality of scientific products (41.0%), increasing the level of innovation (37.4%), development of land reclamation of agricultural land (34.2%), etc. [12].

The introduction of innovations in dairy cattle breeding is closely connected with the robotization of farms: the use of automatic milking systems, feed preparation and feeding systems, manure removal, etc. Because the industry is characterized by a long payback period for capital investments,
import dependence on foreign manufacturers and suppliers of equipment, technical equipment and consumables, the number of enterprises with robotic farms in Russia is small: there were 113 in 2018. As new enterprises were established, technical and technological updating of existing farms and complexes and their constant growth were observed.

The use of robotic milking increases the profitability of dairy farming by an average of 15% due to an increase in milk production, an increase in the productive longevity of cows, as well as lower personnel costs.

According to experts, the economic effect of robotization, selection and informatization in Russian agriculture will reach 10 trillion rubles, of which 30% will be in robotics, by 2030.

The main problems, according to scientists and experts [6, 11, 12], which hinder the development of the digital economy in the Russian agricultural sector, are as follows:

- Low penetration of digital technologies in rural areas and agricultural production, poor coverage by data transmission networks
- Lack and incompleteness of information on the applied and developed digital technologies
- Insufficient legal and regulatory consolidation of the legal framework necessary for coordination and interagency cooperation in the collection of information and the introduction of digital technologies
- Lack of government programs that promote the implementation (subsidizing production costs) of the digitalization of the agribusiness, especially for small and medium-sized agricultural producers, including private farms
- Lack of legal grounds for interaction and collection of information on agricultural activities of private household plots and the associated limited ability to support their activities
- Low profitability as the main reason for the unattractiveness of the industry for a technology and infrastructure investor.

At the same time, in recent years, positive shifts have taken place in the innovation environment of agriculture in Russia: key elements of infrastructure support for innovation have been created, such as funds, technological platforms, technology transfer centers, etc., as well as a system of development institutions. Agro-industrial clusters, technological platforms (‘BioTech2030’; ‘Technologies of the food and processing industry of the agricultural sector: healthy food products’; ‘Bioenergy’) and agricultural parks are actively functioning. New forms of interaction between participants in innovative activities are developing. A network of federal and national research universities has been created. The government invests in the research infrastructure of scientific institutions within the framework of the national project titled ‘Science’. Large manufacturers are starting to finance scientific research and the creation of infrastructure for research, e.g. the Miratorg Group Center for Genomic Breeding, the Shchelkovo Agrokhim Research Center, etc., have been created. This gives grounds to conclude that the knowledge to be implemented in production is growing.

However, broader involvement of manufacturers in innovation will require the formation of a globally competitive national innovation system, that is to say, a set of interconnected structures engaged in the production and commercialization of knowledge and technologies that ensure the interaction of scientific and entrepreneurial organizations and structures, as well as manufacturers at all stages of the transformation of knowledge into innovation.

For the qualitative growth of innovative activity in the agricultural sector, it is advisable to create a competence center, which should promote the increase of innovative activity and conduct systematic work to reduce the influence of factors that impede its growth. For the large-scale growth of innovative activity, an operator with free-targeted financial resources is needed, such functions can be taken over by Russian Venture Companies (RVC) or by a National Technological Initiative (NTI) project office, within which work is underway on FoodNet, which is a food market with intellectualization, automation and robotization of technological processes, as well as the development of biotechnology.
4. Conclusion
The study has shown that despite the increase in innovation costs in 2017 compared to 2016 in crop production by 49.8% and by 12.9% in livestock the level of innovative activity of agricultural enterprises does not exceed 4%. Regarding the level of application of innovative technologies, regions and agricultural producers of different forms of management differ significantly. They are widely used by agricultural holdings, large agricultural enterprises and peasant farms in the Lipetsk, Leningrad, Belgorod Regions and some other regions.

In general, the low level of innovative activity of most agricultural enterprises is due to a lack of their own financial resources and high rates of commercial loans. In addition, important factors are the improvement of personnel training and the improvement of innovative infrastructure; the decisive role belongs to measures of state support in this area.

Government support measures to stimulate innovative development are mostly needed by medium and small agricultural producers, since large agricultural enterprises in recent years have received the largest amount of state support funds from the federal and regional budgets.

At the same time, large manufacturers are increasingly actively funding scientific research and the creation of infrastructure for research, which indicates their understanding of the role of knowledge in the formation of competitiveness.

For a large-scale qualitative growth of innovative activity in the agricultural sector, it is necessary to form a national innovation system with a developed infrastructure to support the demand for innovations and their implementation. It is proposed to create a center of competence, the purpose of which will be to stimulate innovative activity and reduce the influence of obstacles. To solve the problem of lack of financial resources for the implementation of innovative activities, an operator is needed, such functions can be taken over by RVC or the NTI project office.

At the same time, mechanisms to stimulate demand for innovative products and technologies, new equipment and the size of state support should be long-term.

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