

# Russian agricultural innovations prospects in the context of global challenges: Agriculture 4.0

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## Abstract

For the last 10–15 years, Russia has become the key player in the world agricultural market. Increasing export volume up to \$45 billion by 2025 is the ambitious plan of the Russian Government. Windows of opportunity that create fundamentally new prospects for increasing competitiveness are opened mainly during the period of changing technological patterns, such as the current transition of the world’s agriculture towards Agriculture 4.0 paradigm. This is crucial for further economic growth. Information for this article was prepared based on “desk research” methods and then all data and hypotheses obtained were tested by conducting detailed in-depth interviews with key industry decision makers. According to the results of research there has been a huge interest on the part of business to implement innovative solutions in agriculture. Yet significant institutional constraints, problems in the legislative and regulatory sectors, the absence of a system of transfer or commercialization of technology from research center to the final manufacturer are still present. At the same time, all the instruments of state support are currently configured only for conventional, as opposed to innovative agriculture.

*Keywords:* Agriculture 4.0, agricultural innovations, agricultural biotechnologies, digital agriculture, new farming systems, innovation implementation, Russian agriculture.

*JEL classification:* Q16, Q18.

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## 1. Introduction

This article will assess the key challenges and prospects for Russian agriculture competitiveness in the context of global innovative trends and transition to a new level of technological development in the world of Agriculture 4.0.

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The first part of this article examines the global context in the form of varied modern challenges, related prerequisites and promising directions for global agriculture and food processing industry innovative development, and its potential technological responses. Special attention is paid to key areas of investment. Maybe not all the technological trends described here will become a reality, but we may be sure that a completely new original idea is being born somewhere right now and will change the world.

Our goal is to show the complexity of the agri-food sector and its relationship with technical achievements in the context of social, economic and political trends. We want to review the environment that will determine the future of global agriculture and push it to technological innovation. We wish to note the activity with which the agricultural sector integrates the achievements of various fields of scientific knowledge and increasingly goes beyond traditional agricultural activities, defying stereotypes about the archaic technologies used.

The second part of the article shifts the focus to the review of Russian innovative potential in agriculture, assessing its compliance with the tasks of increasing global competitiveness<sup>1</sup> in the new technological order. It is necessary to determine the main directions for improving science and technology policy, analyze the innovation activity of the industry and identify key barriers to its implementation, as well as business expectations in terms of state support for innovation.

All these tasks and challenges could not be considered objective without considering expert opinions from various sectors of the modern food systems and related fields of expertise. Almost two dozen representatives of the real sector actively participated in the expert survey organized by the HSE Institute for Agrarian Studies in March–April 2020.<sup>2</sup> The willingness of businesses to share their unique knowledge and experience allowed us to comprehensively assess the current state of the industry, clarify its current problems, and “revive” theoretical theses and hypotheses with the voices of real industry participants. Our hypothesis is that business interest in innovation reveals the prospects for the competitiveness of Russian agricultural technologies and products on the world market. In this study, we want to determine the current position of Russia in terms of agricultural innovative development, products and research, and not only the performance of conventional or traditional agriculture. What challenges for the competitiveness of Russian agriculture in the new world paradigm of “Agriculture 4.0” are really critical? We wish to formulate recommendations to improve the current situation.

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<sup>1</sup> For the last 10–15 years, Russia has become the key player in the world agricultural market. Increase export volume up to \$45 billion until 2025 is the ambitious plan of Russian Government. As part of the Federal project “Export of agricultural products,” according to the Ministry of Agriculture of the Russian Federation 406.8 billion rubles (\$5.16 billion) are provided until 2024. President of the Russian Federation Vladimir Putin set an export target of \$45 billion by 2024. For this purpose, it is planned to increase the supply of oil/fat, fish and seafood products, food processing industry meat and dairy products, as well as other agricultural products abroad. For each of the priority subsectors, export growth plans will be developed and key sales markets will be identified—China, India, Japan, South-East Asia, the Persian Gulf, and Africa.

<sup>2</sup> The study of various aspects of innovation activity in agriculture and the food industry was carried out as part of an expert survey conducted by the HSE Institute for Agrarian Studies in February and March 2020. The results can be found in HSE (2020).

## 2. Data and methods

The research methods for this paper belong to the desk research—the collection, study, systematization and analysis of secondary marketing information obtained from available sources, i.e. data processed in a certain way and contained mainly in official and other printed sources: periodicals, economic publications, statistical reference books and internal reports, etc. This entire research methodology consists of both quantitative and qualitative key insights and includes, among other methods, the study of agribusiness top players, financial reports, and interviews with agro-experts etc).

Unfortunately, the official statistics do not take into consideration innovative agricultural products very much, or almost not at all. Many methods of data collection, and also indicators, require significant adjustments and revision. When preparing the study, we also used data from the Ministry of Science and Higher Education of the Russian Federation reporting on the scientific projects' financing, and data from Rospatent<sup>3</sup> on the number and themes of patents.

All percentage shares, splits, and breakdowns have been determined using secondary sources and verified through primary sources. All the possible parameters that affect the markets covered in this study have been verified through primary research, and analyzed to obtain the final quantitative and qualitative data. This data has been consolidated and supplemented with detailed inputs and analysis presented in this report.

After data collection and analysis, experts from the HSE Institute for Agrarian Studies conducted two-hour expert interviews. The discussions were attended by representatives of the real sector—20 leading agricultural companies in the Russian Federation: producers of crop and livestock products, means of production (fertilizers, feed additives and plant protection products), as well as industry associations. The majority of respondents are senior managers or business owners, people who determine the company's development strategy. The expert survey was conducted using in-depth interviews on 3 key topics:

- Block 1. Key technologies and trends for the company and industry development. The planning horizon for the technological innovations' implementation;
- Block 2. What are the goals and motivation of the company to create and implement innovations? The share of R&D expenditures in total corporate budget. How does the process of creating innovations work?;
- Block 3. The role of business and government in creating innovative solutions. Government support.

The results were presented both in aggregate form and as the key most significant statements and experts' suggestions.

## 3. Premises for agricultural transformation and global trends

Fundamental technical and scientific changes and discoveries have occurred in recent decades. The updating of the global problems (socio-demographic,

<sup>3</sup> Rospatent is the Federal service for intellectual property that is responsible for legal protection of state interests in the sphere of economic and civil turnover of the research dissemination etc.

environmental, and economic) created the preconditions for the transition of agriculture to a new stage. The current transformation is so rapid and widespread that in the next decade the appearance and conditions of development of world agriculture, which has now ceased to be limited to a simple function of food production, will change dramatically.

Agriculture 4.0 is the new stage of world technological development in agriculture, based on the use of smart solutions (artificial intelligence, internet of things<sup>4</sup>), bio- and nanotechnologies, robotics, the growing influence of consumers and new value orientations, changes in the structure of key factors for ensuring competitiveness.

Innovative solutions raise scientific potential and are designed to ensure the sustainability of further development of Russian agriculture and food processing industries. So it is absolutely necessary to pay great attention to the nature of specific challenges, as well as their combinations that induce key innovation trends and new systems of socio-economic interaction (often going beyond the scope of the agriculture in its traditional understanding), which makes it possible to more clearly define the problems of national scientific, technical and economic development. Otherwise, the technological gap with developed countries may significantly increase. Entire markets could simply cease to exist for Russian agricultural products in the next decade.

#### 4. Investment in agribusiness innovations

The rapid growth of private investment in relevant technology projects (startups) indicates an active transformation of the world agriculture and its transition to a new way of life. According to AgFunder<sup>5</sup> data, their volume has more than tripled in 2014–2019 alone (compound annual growth rate, CAGR 28%) and reached \$20 billion in the last two years.

The total investment volume for this period exceeded \$75 billion (9,900 transactions), structured by AgFunder (2019) in two key areas: industrial technologies “from the field to the counter” (upstream) and consumer technologies of the stage “from the counter to the plate” (downstream).

According to our consensus forecast,<sup>6</sup> the volume of the global agribusiness 4.0 market in the horizon of 2025 will show an increase of 58% and reach \$2,300 billion (CAGR of 6.7% or +\$832 billion to the base indicator of 2018—\$1,400 billion; Fig. 1).

The key drivers of growth will be:

- Final innovative products of agriculture: the largest segment, of which the volume will reach \$1,600 billion by 2025 (+\$509 billion, which will provide 62% of the total increase in the agro-industrial complex 4.0);

<sup>4</sup> IoT (internet of things) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are endowed with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. <https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT>

<sup>5</sup> The mission of AgFunder, founded in Silicon Valley in 2013, is to invest in agrifood innovative technologies. <https://agfunder.com/>

<sup>6</sup> The consensus forecast was done by the HSE Institute for Agrarian Studies and based on the average forecast data of a number of analytical companies specializing in the study of target markets.

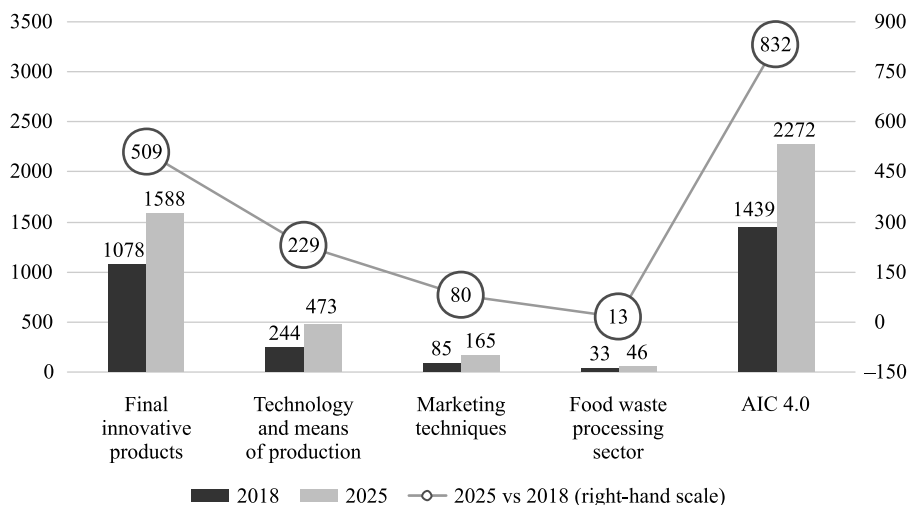


Fig. 1. Structure of growth of agro-industrial complex 4.0 in the world, 2008 and 2025 (forecast) (billion U.S. dollars).

Source: Consensus forecast of the HSE Institute for Agrarian Studies.

- Technology and means of production Agriculture 4.0: the fastest growing segment, of which the volume is expected to increase by nearly \$230 billion (CAGR 10%), which will provide a 29% total increase in agro-industrial complex 4.0;
- Marketing techniques (online platform for delivery of food products) will add about \$80 billion or 10% increase Agriculture 4.0 on the background demographic and socio-cultural changes;
- Food waste processing sector: will show an increase of \$13 billion (2% of the increase).

Final products: against the background of faster growth in other sectors, the segment’s share in the total volume of the Agriculture 4.0 market will decrease from 77% to 71%.

Growth points in this segment will be:

- Healthy and therapeutic nutrition (traditional products with added properties): an increase of \$419 billion, which will be largely due to an increase in the organic products sector (+\$240 billion). In addition to organic products, the segment includes functional nutrition, products with excluded undesirable ingredients, for diet therapy and various types of intolerance (lactose, gluten, etc.);
- Non-food products of the agriculture (bio-refining): +\$79 billion, mainly due to the biofuels segment (+\$68 billion).

Technologies and means of production: against the background of faster growth, the segment’s share in the structure of Agriculture 4.0 will increase from 17% to 21% in 2018–2025.

Key areas and growth points:

- Integrated technological solutions for Agriculture 4.0. (Farm management technologies, robots and equipment, new farming systems): growth of \$120 billion, mainly due to robotics (+\$80 billion) and closed agriculture technologies (+\$27 billion);

- Closed agriculture is structured by object types: vertical and container farms, deep-water crop systems (DWS), greenhouses; systems: hydroponics, aeroponics, aquaponics, ground and hybrid; also includes specialized equipment and software services);
- Food production equipment: will add about \$62 billion by 2025, amid growing demand for healthy and fast food products, and the active introduction of new conservation technologies, including non-thermal methods;
- Agro-biotechnologies: a total increase of \$28 billion, driven by biologics for crop production (+\$11 billion) and technologies in the field of genetics and breeding (+\$9 billion), including plants and farm animals to approximately the same extent (+\$4.7 and +\$4.3 billion, respectively);
- Security and supply chain tracking technologies: expected growth of up to \$20 billion, including through the segment of product safety testing and smart packaging, they will add \$12 billion and \$7 billion, respectively.

From the above facts and forecasts, we may outline the following most influential trends for the development of global agriculture in the next decade (see also Table 1):

1. The approach to a new agriculture order combining information, nano-, bio- and cognitive technologies, which will cause drastic shifts in the placement of priority factors of production and competitiveness, increasing the speed of technologies to increase productivity and safety and eliminating dependence on natural agro-climatic and biological factors;

2. Changes in value chains: the development of cross-industry solutions will create new growing markets and help to wash out some traditional links, eliminating intermediaries and ensuring the closest possible level of interaction between the consumer and the manufacturer. Value added innovations will come

**Table 1**

Structure of Agriculture 4.0 growth in the world, 2008 and 2025 (forecast).

Segment	Volume, billion U.S. dollars		CAGR, %	Growth, billion U.S. dollars
	2018	2025		
Agriculture products	1078.0	1588.0	5.7	+509.3
Food industry	905.0	1336.0	5.7	+430.4
healthy and therapeutic nutrition	894.4	1313.7	5.6	+419.2
organic products	140.0	380.0	15.3	+240.0
other types	10.8	22.0	10.7	+11.2
Non-food (bio-refining)	173.0	252.0	5.5	+78.9
biofuels	166.0	233.6	5.0	+67.6
other types	7.2	18.5	14.5	+11.3
Technologies and means of production	244.0	473.0	9.9	+229.3
agro-biotechnologies	35.4	63.7	8.8	+28.3
robotics	7.5	87.9	42.1	+80.4
precision farming	4.3	13.4	17.7	+9.1
closed agriculture	26.0	53.1	10.7	+27.1
food production equipment	135.0	196.6	5.5	+61.6
security and traceability technologies	34.1	53.9	6.8	+19.8
other types	1.5	4.5	17.2	+3.0
Marketing technologies	85.0	165.0	10.0	+80.4
Food waste management	33.0	46.0	5.0	+13.4
Total	1439.0	2272.0	6.7	+832.4

Source: Consensus forecast of the HSE Institute for Agrarian Studies.

from genetics, breeding, IT and geoinformation technologies, engineering and other knowledge-intensive sectors;

3. Large agroholdings that take control of food systems are gaining in importance. Such structures are the engines of innovative technologies implementation and are able to achieve economic, environmental, social, and other key goals and form global value chains. Both industry participants such as Bayer, Syngenta, John Deere, Nutrien and others, as well as new interested entities such as Alibaba, Microsoft, and Amazon, are actively investing in Agribusiness 4.0;

4. Increasing the role of “sustainability” factors and ensuring product safety, standards and certification systems, which in the future may become an important additional tool for regulating international trade, imposing restrictions on the circulation of products that do not meet newly established environmental or ethical requirements;

5. Transition to the knowledge economy: the process of digital transformation and robotization in agriculture will affect the structure of employment drastically. On the one hand, the dependence on low-skilled labor will decrease, and demand for individual professions will rise. On the other hand, ever higher and rapidly changing requirements for key competencies will emerge. All this requires the formation of a new model of education focused on rapid adaptation to new conditions.

## **5. Global challenges for Russia. Preconditions for the transition to Agriculture 4.0**

In recent years, Russia has achieved impressive results in strengthening national food security and has joined the ranks of the largest agricultural powers. So far, the main drivers of the sector’s development have been mainly increased investment and improved management quality, the increased purchasing power of the population, and the food embargo. At the moment, however, the sector’s resources are almost exhausted.

Modern Russian agriculture faces global challenges and must move to a new technological level in order to maintain and strengthen its role in domestic and foreign markets.

As a principal world producer of raw materials (cereals, vegetable oils, and some others) and localizing import dependence on certain commodity groups of products of deep processing, Russia remains critically dependent on outside input. Figuratively speaking, Russian agriculture is now a large workshop for “screwdriver” assembly of final products, using genetic material, technologies and equipment mainly of foreign origin.

According to calculations carried out by the HSE Institute for Agrarian studies, by the end of 2019 the level of import dependence in the agricultural biotechnology sector was over 80%<sup>7</sup> in the segment of functional food supplements and even up to 95% in the segment of functional food supplements. It is also high in the absolute majority of other segments. This is an Achilles heel of Russia’s global competitiveness even within the current technological structure: purchasing feed

<sup>7</sup> The authors took the data on imports for each segment (codes and declarations) from the website <https://www.trademap.org>, summed up and estimated the total volume.



additives, veterinary drugs, etc. at world prices implies that Russia has a very low resource to achieve a price advantage in foreign markets. Accordingly, strengthening national food security is the most important current task.

Russia, although occupying 10% of the world, has a problem regarding the low fertility of agricultural lands with scarce fertility and low resilience: according to the 2016 Agricultural census risky agriculture is estimated at 97 million hectares or 44% of all agricultural land (Uzun, 2019). Fertile soils are situated in the South, while fresh water is mostly located the Northern part of the country. Despite relatively favorable forecasts of the impact of global warming on the agricultural potential of Russia (in comparison with Australia, for example), its impact will create additional challenges due to a serious increase in the risks of declining yields (Dokuchaev Soil Institute, 2018). With volatility and productivity concerns taking into account all of this, this requires the rapid transition to a new technological level of infrastructure for climate-independent and precision agriculture. Lagging behind the leaders in the intensity of agricultural production also has a certain positive aspect for the rapid introduction into circulation of organic farming. Amid the rapid growth of demand for organic products in the world (relative to the increase in the resources of production) and the threat of global supply shortage this could be one of the most important high-margin areas of the Russian exports of agricultural products. The prospects for realization of this potential, however, require solving a number of major problems— from creating appropriate integrated information and technological solutions adapted to agro-climatic conditions, to the harmonization of standards and the development of a certification system.

The socio-demographic structure of the Russian population is favorable for the development of healthy food markets and digital technologies: the high level of urbanization (74% in 2018), the high proportion of its population being educated (over 60% have university degrees; Agranovich et al., 2019), comparative to Eastern European countries' income level in PPP terms and millennials' growing share in the structure of the economically active population, which is expected to be slightly lower in comparison with the global rate (from 53% to 57% depending on the variant of Rosstat forecast vs. 75% globally<sup>8</sup>; EY, 2015).

This means that the Russian agriculture and food processing industry has a fairly high potential for development in line with the 4.0 paradigm not only in export-oriented segments, but also based on the domestic market. Rapid dynamics is shown by the online food delivery sector, the volume of which increased by 50% in 2019 and reached 35 billion rubles (circa \$500 million at the beginning of May 2020; Infoline data<sup>9</sup>). The results of sociological research conducted over the past year by major agencies (VTSIOM<sup>10</sup>, GFK<sup>11</sup>, Nielsen<sup>12</sup>) show the huge interest of Russian consumers in healthy nutrition and its high percentage in choosing it.

<sup>8</sup> Rosstat Demographic forecast until 2035. <https://www.gks.ru/folder/12781> (in Russian).

<sup>9</sup> Infoline is a news agency conducts research on the FMCG sector in Russia. <https://infoline.spb.ru> (in Russian).

<sup>10</sup> VTSIOM—Russian Public Opinion Research Center. <https://wciom.com>

<sup>11</sup> GFK is a global leader in data and analytics, and has been researching consumer behavior and markets since 1934. <https://www.gfk.com/about-gfk>

<sup>12</sup> Nielsen is a global measurement company that provides data and analytics for the most comprehensive study of consumers and markets. <https://www.nielsen.com/>.



Nielsen (aggregated information presented at Metro Expo 2019): 80% of consumers are focused on choosing a healthy diet and would like to see more natural products on the shelf; of these, only slightly more than half believe that their needs can be met by the current offer. About 34% of consumers consider superfood (products with additional useful properties) an alternative measure to prevent chronic diseases. The growing interest in healthy eating is supported by data on the actual increase in consumption of vegetable milk (+40%), herbal teas (+24%), fruit and protein bars (+19% and +99%). About 30% of respondents are more likely to choose natural or “organic”(according to the label); 67% are willing to pay a large amount for products from the superfood category.

VTSIOM (Healthy lifestyle monitoring, May 2019): 59% of respondents make a choice in favor of a healthy diet (a combination of motives: a diet recommended by a doctor, a self-selected diet and a desire for healthy food).

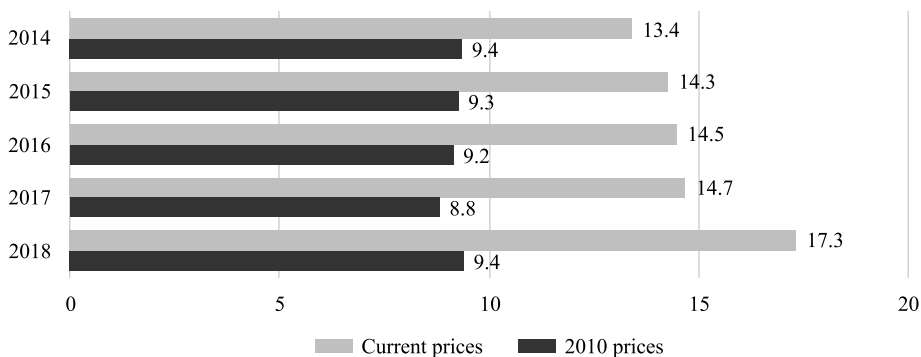
GFK (GFK Eating Habits, November 2019–January 2020): 58% of consumers, regardless of their motives, are guided by the principles of healthy lifestyle when purchasing food, while 22% of respondents are more likely to choose bio-/eco-/organic (according to the label).

The problem of promoting healthy nutrition and correcting existing food patterns is becoming more and more relevant for Russia in terms of health care. According to the Institute of the Ministry of Health of the Russian Federation the number of people suffering from obesity has almost doubled in 2010–2018 and exceeded 2 million people or 1.4% of the population. The highest rate of obesity is for children up to 14 years, and adolescents from 15 to 17. The problem of food waste is becoming fundamental for the country. The unsolved problem of food waste disposal leads to significant pollution of the environment with illiquid raw materials. Enterprises of the agribusiness of the Russian Federation annually produce about 20 million tons of waste from processing meat and poultry, grain alcohol, beer pellets and yeast, whey and other types of secondary raw materials. The annual volume of “discarded food” in the retail sector alone is about 700 thousand tons or 2–6% of the sales volume (data from ACORT<sup>13</sup> member companies). At the same time, the share of used and neutralized agricultural waste in Russia is no more than 50% (2015–2017) of which only 5–10% is processed into products with high added value (the same indicator in the EU is at least 60%). This problem does not have a single effective solution and in the world practice is solved comprehensively and with the direct participation of all participants in the chain and at all stages of the life cycle.

## 6. Innovative potential of Russia today

At the moment, the agricultural sciences occupy a fairly modest place in the structure of the scientific and technical potential of the Russian Federation in terms of funding (the country spending on R&D). Continuing the long-term

<sup>13</sup> Association of retail companies (ACORT). <http://www.acort.ru> (in Russian).



**Fig. 2.** R&D spending in the field of agricultural sciences in Russia (billion rubles).

Source: HSE Institute for Agrarian Studies based on Rosstat data.

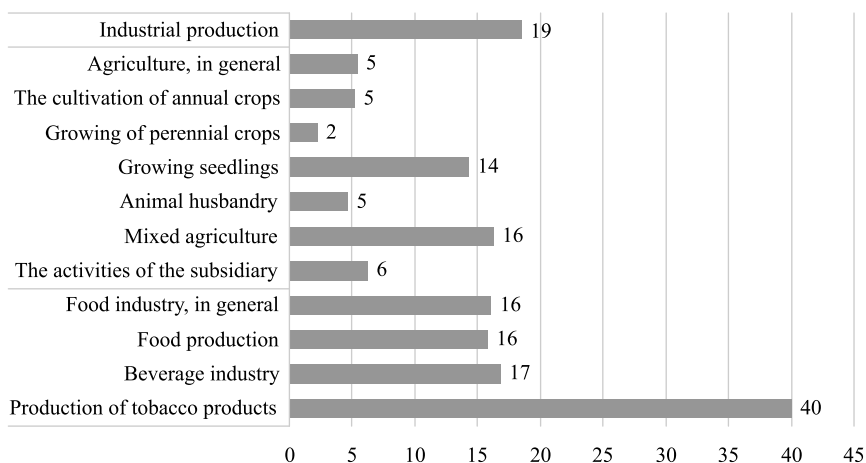
historical trend laid down in the 1990s, the share of expenditures on agricultural sciences in Russia for R&D reached a minimum in 2017 (1.4% of all expenditures on science against 3.6% in 1994), only at the end of 2018 showing a positive increase (up to 1.69%). The increase in costs in 2018 provided only a return to 2014 indicators (Fig. 2).

The public sector is the dominant player in the agricultural science and innovation development in the Russian Federation: the share of budget funds in the structure of the country spending on R&D consistently exceeds 60%. In recent years, more than 95% of all current expenditures are accumulated by state institutions.

However, it is necessary to note the growth of extra-budgetary sources, namely, the increase in expenditures from organizations' own funds and investments from businesses: the total share of these sources increased from 29% to 34% over the period 2014–2018. This is certainly a positive signal that indicates an increase in the willingness of businesses to invest in the development of innovations. A negative signal indicating the insufficient effectiveness of the existing system of development institutions is the actual reduction of the already low volume of expenditures on agricultural research projects received from funds to support scientific, technical and innovative activities. Their share of total R&D expenditures in Russia decreased from 2.9% to 1.3% over the period.

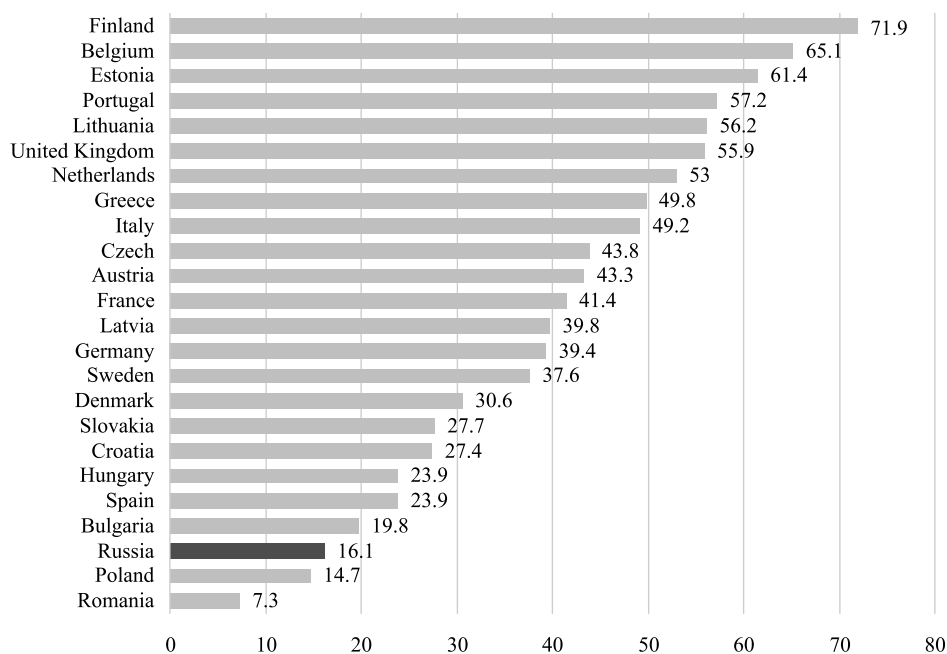
In addition, stagnation in the development of Russian agricultural science is also illustrated by the low level of contribution of Russian authors to the total number of publications indexed by Scopus and Web of Science. In terms of the number of agricultural publications Russia lags behind not only the traditionally leading countries (USA, Germany, Japan, UK, Canada, and France) and fast-growing China, India and Brazil, but also Iran and Poland. As for the innovative activity of the agricultural business, its key growth vector in recent years is the introduction of technological innovations (product and process) (Fig. 3). At the same time, there is still very low activity of enterprises in the development of organizational and marketing innovations: in the agricultural sector, their share is 1% or less, in the production of food products, this share ranges from 2% to 4%, depending on the segment.

However, despite the positive trend, compared to global competitors of the Russian manufacturers, this seems quite modest. The gap in innovation activity with some EU countries is 4 times (Fig. 4).



**Fig. 3.** Share of innovation activity in the agricultural sector of Russia, 2018 (%).

Source: HSE Institute for Agrarian Studies based on Rosstat data.



**Fig. 4.** Share of innovative products and technologies implemented in food industry in different countries over the year (%).

Note: Comparison of indicators for 2018 or the next few years for which data is available.

Source: HSE based on Rosstat and Eurostat data.

Russia has a low share of innovative products<sup>14</sup> as well as low growth rates. In the food industry, this indicator increased by only 0.7 p.p. over the period 2014–2018 (from 5% to 5.7%), in agriculture it increased from 1.4% to 1.9% (2016–2018), while the livestock sector has achieved greater innovation (2.1%)

<sup>14</sup> Innovative products are fundamentally new products on the market or produced with the improvement of existing production technologies.

than crop production (1.6%). Meanwhile, there have been positive changes in the structure of the innovation range, indicating the shift of manufacturers from the development of existing markets towards developing new niches and building new markets for products.

As an example, we can cite the opinions of experts who expect radical changes in the industry in the next 5–10 years due to the widespread use of alternative technologies for obtaining traditional products—both food and feed, which is considered as an absolute threat to the crop and livestock industries. For example, according to Vladimir Kalensky (Head of the strategy and investment department of EuroChem Group AG),<sup>15</sup> artificial meat and artificial protein in general will be widely used in a few years. This will not only be artificial food for humans, including meat and milk, but also artificial feed for livestock. This will replace a significant part of traditional crop and livestock production.

## 7. Expert opinions: Innovative activity of agribusiness and investment in agricultural technologies in Russia

### 7.1. Planning horizon and key trends

The results of the expert survey<sup>16</sup> conducted by the HSE Institute for Agrarian Studies showed great interest from business in new directions and a high level of awareness about the main global technological trends.

The main focus is on solutions that have already been widely tested in the world practice, ready-made commercial technologies, which is associated with a fairly short horizon of strategic planning—the absolute majority of participants evaluate it in no more than 3–5 years. Only companies affiliated with foreign players, as well as representatives of the dairy cattle industry, operate with more distant horizons.

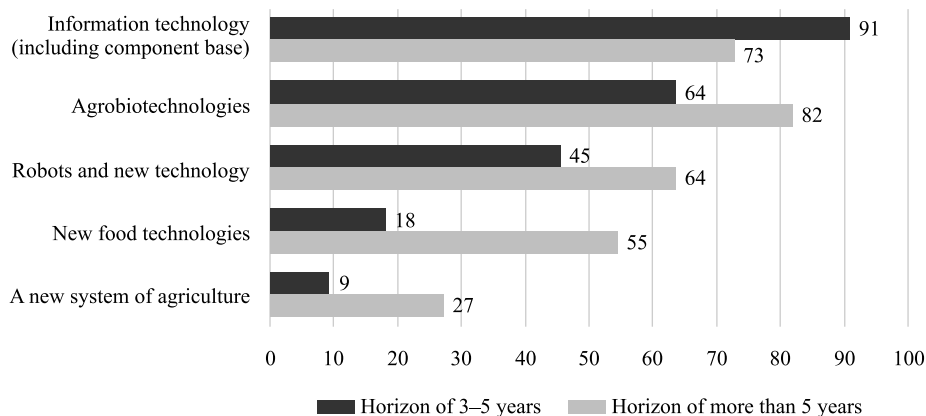
Artem Belov (Soyuzmoloko): the planning horizon in the industry is 5–10 years; this is due to the fact that dairy farming has a very long investment cycle. The technologies and solutions that are currently being purchased for the construction and modernization of dairy complexes will be used in the industry in the next 10 years, but we can also talk about 15 years.

The most powerful influence on the development of agriculture in the coming years (Fig. 5) will be:

- *Digital technology.* According to experts' estimates on digitalization and the implementation of the "Internet of things" (including the corresponding component base in the form of sensors, etc.) this sector will have the strongest impact on the processes of innovative transformation of the industry over the next 3–5 years. In the future, when such technologies are widely adopted, their influence will gradually decrease and will be directed primarily at optimizing already created solutions and building new schemes based on them.

<sup>15</sup> The opinion of Vladimir Kalensky obtained through expert interview (HSE, 2020).

<sup>16</sup> The study of various aspects of innovation activity in the agrarian sector was conducted in February–March 2020 by the HSE Institute for Agrarian Studies. The expert survey was conducted by in-depth interviews on four key topics. See Section 2.



**Fig. 5.** Share of experts indicating that a certain technology will play a key role for Russian agriculture (%).

Source: HSE Institute for Agrarian Studies based on the results of the expert survey.

Artem Belov (Soyuzmoloko): Russia follows the general technological trend. Major industry players are now actively implementing such solutions and our industry has been upgraded by 60%. For the next 3–5 years, implementation issues will be relevant mainly for small manufacturers. Technological progress will be mainly related to the improvement of all sensors and controllers around the animal, the introduction of “smart” farm technologies.

Alexander Eremin (Uralkali PJSC, URALCHEM Group): Digitalization also means a fundamentally different organization of agricultural production, which will be carried out mainly on a contract basis: giants like Nutrien will lease land from its owners for robotic production, organizing it in accordance with global schemes of specialization, redistribution of financial and other resources. In fact, we are talking about global control over agricultural production based on digitalization, Big Data and the use of remote sensing of the Earth.

- *Agrobiotechnologies.* The development in this direction will ensure a steadily growing influence on the industry, which will have the greatest effect in the long term. Among the most significant technologies, experts identify genomic selection, new biotechnologies for plant protection and animal health, and the development of synthetic biology.

Stepan Plisko (Progress Agro LLC): The main trends in agribiotech are now related to the development of breeding: methods of genomic technologies for accelerated creation of varieties/hybrids in crop production. For animal husbandry, these are embryo technologies for livestock reproduction and genomic assessment methods for effective breeding. The sector is now very actively following all global trends and technologies, but compared to Western Europe and the United States, we are far behind in the speed and scale of their implementation in the production chain.

Olessya Smirnova (Association of Holstein Cattle Producers): Good genetics is now the main factor of competitiveness in the industry, and it sets the parameters of efficiency. Everything else only determines how well this genetic potential is realized.

- *Robots and automated machinery/equipment.* Such solutions are beginning to change the industry now, and the main trends in the medium term (up to 5 years) will be the spread of drones, automatic control systems, and, in certain segments, robotic equipment. In the long term (more than 5 years), according to experts, the industry expects a conceptual change in the base of used technical means, associated with the introduction of self-driving systems, unmanned heavy equipment, and the transition to new energy sources.
- *Transition to new food products.* In the medium term, this factor will have a moderate impact on the development of individual segments, mainly due to the need to introduce innovations that correspond to the change in consumer value orientations (increased attention to safety and environmental factors, assortment diversification).

Sergey Filippov (Dmitrov Vegetables Group): In vegetable growing, the main trend for this period will be a decrease in demand for the so-called “borscht set” and an increase in demand for specific vegetables—broccoli, cauliflower, legumes and asparagus. This has a certain problem: if there was at least some tradition of selection for potatoes, cabbage, carrots, etc. In Russia, there is no selection for specific vegetables.

- *Introduction of new farming systems (vertical, container farms, etc.).* According to experts, in the coming years, it will be constrained by the shortcomings of the solutions used, in particular, high energy costs. However, in the future, as these barriers are overcome and alternative energy and energy saving technologies become more efficient, such models can significantly change the vegetable growing industry.

Viktor Semenov (Belaya Dacha JSC): In the upcoming 3–5 years, the main trends will be the shift of greenhouse farming to the south of the country and the spread of vertical farms for green vegetables (salads, greens). So far, technology has made it possible to produce only these crops cost-effectively. But their development is very fast, and in the future the main driver will be vertical farms for cucumbers and tomatoes.

## 7.2. Motivations for implementing innovations

The desire to reduce costs and minimize risks is the most popular motivation for innovation (91%). Experts note that in conditions of high competition and complexity of the overall market situation, the transition to new solutions and technologies is a fundamental factor in ensuring competitive advantages. This direction is associated primarily with the introduction of process and organizational innovations and includes two key motives.

The first one is a striving for business growth and diversification (including chain integration), which aims to achieve leading positions in the industry and



increase the gap from competitors using more conservative technologies and traditional business models (27% of the experts surveyed). The motive in this case is usually combined with ambitious goals of achieving leadership.

Viktor Semenov (Belaya Dacha JSC): The motivation is to be the first in the industry, it allows you to be competitive, the first always takes the cream off (and a bit of vanity).

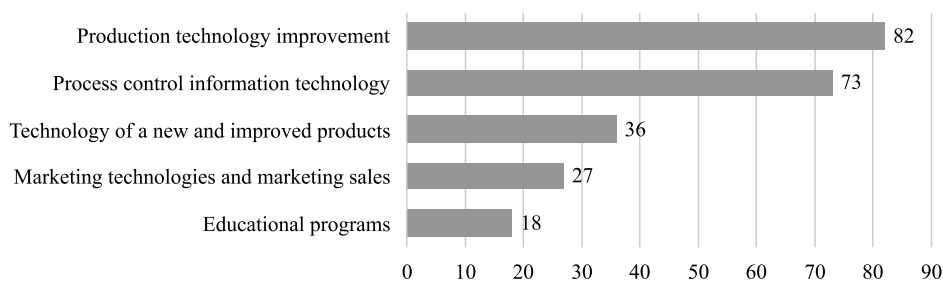
The second is the maintenance of the competitiveness—the majority of experts, however, consider the introduction of innovations as the main way to maintain positions already achieved in industry, and not as a means to achieve new goals: 64% of respondents adhere to the catch-up model.

Creation of new or unique products for the market (9%) is a motivation that is relevant mainly for manufacturers developing niche agricultural products with a relatively higher margin. This direction is more associated with the introduction of product and marketing innovations.

The selected motivations fully determine the structure of distribution of priority areas for investment in innovations (Fig. 6):

- Introduction of new production technologies and digital models aimed at reducing costs, increasing productivity and profitability of production: this area is of primary importance for 82% of the experts surveyed. Among the key areas of investment are precision farming and production automation systems, agro-biotechnologies, including genomic assessment and modern reproductive technologies in animal husbandry. Almost a third of experts noted the effectiveness of vertical integration experience in achieving the set goals (both top-down, aimed at ensuring control over the chain of obtaining raw materials and genetic material, and bottom-up).

Viktor Semenov (Belaya Dacha JSC): We have fully digitized the potato farm and are setting up our own weather stations to optimize irrigation and chemical application. Digitization provides up to 50% fertilizer savings. The yield of potatoes is much higher in reference farms in the same area. GPS for tillage and sowing provides significant savings on seeds. We have created a digital platform for online potato trading. There are many positive effects, and digitalization dramatically reduces employees' opportunism, including theft.



**Fig. 6.** Share of experts indicating that a certain technological improvement is a priority for investment in Russian agriculture (%).

Source: HSE Institute for Agrarian Studies based on the results of the expert survey.

- New information technologies for process management: 73% of experts see high relevance in the implementation of ERP and CRM systems, ensuring the standardization of processes in accordance with international industry requirements. 55% of respondents find it necessary to implement GLONASS/GPS monitoring systems, vehicle tracking control, and logistics system optimization programs.
- Technologies for new products and improved properties: 36% of experts agrees that in the near future the task is to expand the product range and improve the product properties. In the latter case, the most relevant areas of innovation are solutions in the field of packaging and ensuring longer terms of product safety, achieving a new level of quality.

Alexander Grigel (A2 Milk Company, LLC): We have created and promote the A2 line of dairy products. It is absolutely natural, but unlike the traditional one, it does not contain A1 protein, which is often the cause of intolerance to cow's milk or unpleasant sensations after consuming it. Our task now is to extend the life of such milk: we have a maximum of seven days without pasteurization, in Australia it is at least two weeks.

- Investments in the development of new marketing technologies are among the priorities of 27% of the surveyed experts. The key trend is the development of alternative sales channels: online trading platforms and online stores; promotion tools: targeted advertising and opinion-leaders in social networks (the latter options are relevant for companies focused on working in the B2C segment).
- Investments in the development of joint training programs, training of young specialists. According to experts' comments, the popularity of this direction is gradually decreasing. Currently, only 18% of experts support this practice. The main problem here is the riskiness of investments, due to the developed industry practice of "hunting."

Sergey Filippov (Dmitrov Vegetables Group): We cooperate with several universities in terms of personnel, but we face a very strong trend of attracting specialists from other companies. The shortage for us is a serious problem, innovations provide an opportunity to substitute capital for labor. Innovation is about reducing all costs.

### 7.3. *Proposals for measures to encourage innovation in industry*

During the discussions and expert interviews, several proposals were formulated that are necessary as infrastructure solutions to stimulate the development and implementation of innovations in agriculture in Russia.

Experts noted the need to create a single coordination center for scientific and technological development for agriculture (55%). This proposal reflects the high demand from business to improve the efficiency of communication with Federal ministries and executive authorities. Experts assign it the functions of forming long-term strategies for scientific and technological development and vectors of agricultural policy, developing appropriate measures and support tools.

Igor Istomin (New Biotechnologies LLC): We are at the forefront of innovation, we have all non-standard equipment, technologies, and specialists. We are “not a format” in literally everything, we only have a good market, the shortage of animal feed protein in the world is 20–25 million tons per year. Someone should specifically supervise projects like ours, they are at the intersection of disciplines and competencies, and there will be more and more of them over time. Nature-like systems are the trend of the future.

Andrew Orobinsky (Agriculture-Garant Group): It is necessary to create a structure that allows you to quickly and effectively respond to new requests in the field of agricultural innovation. It is physically impossible to specify all the points. The principle is important.

Alexander Krichevsky (Sibbiopharm LLC): Unlikely to need a separate structure to assess innovation, it is necessary to have an attestation commission, need some working group under the auspices of the commission to issue orders.

The development of rural infrastructure (social, transport, information) is recognized by most experts as the key task of state policy (45% of respondents). At the same time, the task of creating and promoting a positive image of modern life in rural areas and working in the agricultural sector in the media and mass cultural products is necessary, but remains a neglected area.

Stepan Plisko (Progress Agro LLC): Rural depopulation is a big problem, not only for the agricultural sector, but for the country as a whole. Life in the countryside can be more comfortable compared to the city, and the cost of quality of life is different. It is necessary to fully finance the rural development program and implement all planned infrastructure development initiatives. But this will not be quite enough. We need to show people that working in the agricultural sector now allows you to have good salaries, a comfortable life and an interesting career.

It is necessary to create a special development of innovation fund for agrarian sector needs (36%), whose activities could compensate for the “bottlenecks” and limitations of existing support tools, expanding their set.

Another desideratum is the development of the innovation transfer system (27%) in order to bridge the technological gap between industry leaders and small producers.

Artem Belov (Soyuzmoloko): The industry is quite fragmented, and while large companies can afford to buy and optimize innovative technologies and equipment for themselves, medium and small manufacturers cannot. We need standard package technological solutions for the implementation of information and automated systems, planning and management systems. There should be special support measures or subsidies for these solutions.

Stepan Plisko (Progress Agro LLC): The Technological gap is a very important problem. We need to provide targeted support to domestic digital and machine-building Champions and create digital competence centers based on them, i.e., in machine-building—Rostselmash, in digital development—Yandex, in plant protection products—August or Schelkovo Agrohim. At the same time, we need a mechanism for cooperation of their competencies to create integrated solutions.

## 8. Conclusion: Russian agricultural innovations prospects in the context of the global challenges

Agriculture has become one of the most rapidly developing economic sectors in recent years in Russia. The main growth drivers were investment and the corresponding improvement in quality of management. This period was characterized by increased domestic demand and occasional protectionism. However, now these growth factors have almost exhausted themselves and the development of the industry in the medium term is facing a new challenge.

The introduction of the food embargo and the subsequent process of import substitution has significantly stepped up innovation processes. Despite positive trends in the growth of innovative activity of domestic producers, Russian agriculture has maintained a significant gap in this indicator not only in comparison to the leading countries (with some EU countries it is more than 4 times), but also in terms of the average indicators for industrial production.

Yet the dominant share in the innovation costs structure is occupied by capital investments, while investment in R&D and accordingly their significance in the overall cost structure remains at a fairly low level (12% in agriculture and 7% in the food industry). The consequence of insufficient investment is a low share of innovative products, as well as low growth rates. In the food industry, this indicator increased by only 0.7 p.p. over the period 2014–2018 (from 5% to 5.7%), in agriculture—from 1.4% to 1.9% (2016–2018).

Due to insufficient efficiency of investments in agricultural science and its unbalanced structure Russia lags behind the other developed countries:

- Public sector remains dominant as the customer and executor of R&D. In terms of state support for agricultural science, Russia is among the leading countries in terms of R&D expenditures for state research institutes, comparable to Germany. This determines a significant predominance of fundamental research areas, which, however, is not accompanied by adequate cost effectiveness;
- By the volume of publications in the field of agrarian sciences indexed by Web of Science, Russia is behind of not only global leaders: US, China, Brazil, Canada, Germany, but also even Iran and Poland;
- The share of Russian patent applications in the global indicator by the end of 2019 is 1%. At the same time, the main part of copyright holders are universities and state research institutes, whose portfolios contain a high proportion of invalid patents, which indicates a weak interest of business in the commercialization of such developments and problems in the existing transfer system;
- Low level of agricultural science and R&D costs in the commercial sector—by this indicator, Russia is more than 50 times behind the Netherlands, about 10 times behind Turkey and Poland (private investment is most responsible

for converting fundamental knowledge into commercially oriented scientific products). This problem is caused by the capital intensity and long investment cycles of such projects, and indicates the need to build an appropriate system to support innovation in the business sector.

The high concentration of R&D in the public sector, the lack of coordination of actions and the lack of a common vision of priority issues between key stakeholders—science, business and federal ministries—account for the predominance of fundamental research areas over applied ones, as well as a significant gap between the tasks set by departmental institutions and the tasks faced by the real sector. The result of this imbalance is a low level of quality of the domestic scientific products (indicators: a low level of demand for developments, a low contribution to the global volume of publications, a reduction in the share of patent applications in key areas).

Based on the existing assumptions and experts' opinions, the most promising technological areas of development in Russian agriculture include:

- Digital technologies and cross-platform solutions decreasing the food waste and losses, including “smart” robotic systems;
- Strengthening fundamental base for productivity growth in the field of breeding, genetics, fertilizers, animal health, plant protection, green technologies, etc. This direction should not be focused exclusively on conventional segments of agriculture, but should also include the possibility of supporting new promising sectors;
- Promotion strategy for high-margin healthy and ‘green’ products, characterized by high growth rates of demand in the foreign and domestic markets. The most important emphasis should also be placed on improving and ensuring a consistently high level of quality and safety—this is an essential condition for the effective integration of domestic products into global food chains;
- The development of low climate sensible closed farming systems, which are especially important not only in megacities, but also in remote regions;
- Development of the agro-industrial waste processing sector: technologies created in the world over the past 20 years demonstrate the possibility of efficient waste processing, not only into energy resources (heat and electricity, motor fuels), but also into many other products with high added value, as well as of making them competitive. Modern technologies of sterilization, preservation and packaging allow us to ensure significantly longer shelf life of products without changing the valuable nutritional and physical properties of the product.

The reduction of human resources is becoming an increasingly acute problem in implementing the innovative path of development of the Russian agriculture facing a growing shortage of qualified personnel. In the QS World University Rankings 2021 in the subject area “Agriculture & Forestry,” there is only one Russian university—RSAU–MTAA,<sup>17</sup> which is included in the group of universities ranked 351–400.

The results of an expert survey show a high interest of industry representatives in the transition to a new technological stage, readiness to invest in innovations and to form public-private partnerships in the scientific and technical sphere.

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<sup>17</sup> Russian State Agrarian University – Moscow Timiryazev Agricultural Academy.

In real practice, however, the focus is mainly on the catch-up model of innovation, on commercial technologies that have already been widely tested in the world, and the strategies are guided by the desire to maintain the positions already achieved. The choice of such a strategy is forced by existing short planning horizons: “we simply do not dare to play for long.”

The key barriers to innovative transformation of the industry, identified by experts, relate to the mismatch between business, science, and government who are the main players:

- Faulty regulatory base (largely outdated, contradictory, but rapidly changing, insufficiently developed legislation; inaction of officials, their unwillingness to understand new issues, lagging in decision-making);
- Lack of dialogue between business and science, which is caused by a complex range of factors (obsolete equipment, lack of competent personnel, different vision of tactic and strategic goals, understanding of current priorities, etc.);
- Inefficient knowledge and technology transfer system: existing support measures are aimed at the conventional path of agribusiness development and are not focused on breakthrough and truly innovative areas.

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