INNOVATION ACTIVITY IN AGRICULTURE: A CROSS NATIONAL COMPARISON

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Abstract: the paper analyses the results of a cross national comparison of innovation activity in agriculture in different countries which are identified by incomes and specialization. The Russia's situation deserves special concern: the innovation potential of the national agriculture turns out to be lower than the average for the group of poor countries. Besides the paper presents such sphere of innovation activity as patenting and intellectual property protection which has been seriously changed and there is a necessity for Russia to develop this sphere intensively especially when the entry into WTO is taken onto account.

Keywords: agriculture, innovations, cross national comparisons.

In the context of world's economic development, the agricultural sector starts becoming a focus of attention again for public people, economists and representatives of other sciences all over the globe. Agriculture had temporarily disappeared from the world's developing business lists in 1980-1990, and had only become the key aspect in the beginning of the XXI century, partly because of negligence and underinvestment [1, 7]. For Russia, the agro-industrial complex (AIC) starts being not only a development goal itself, but also it is a means to manage the lands, to provide food and, consequently, national safety and unity of the country.

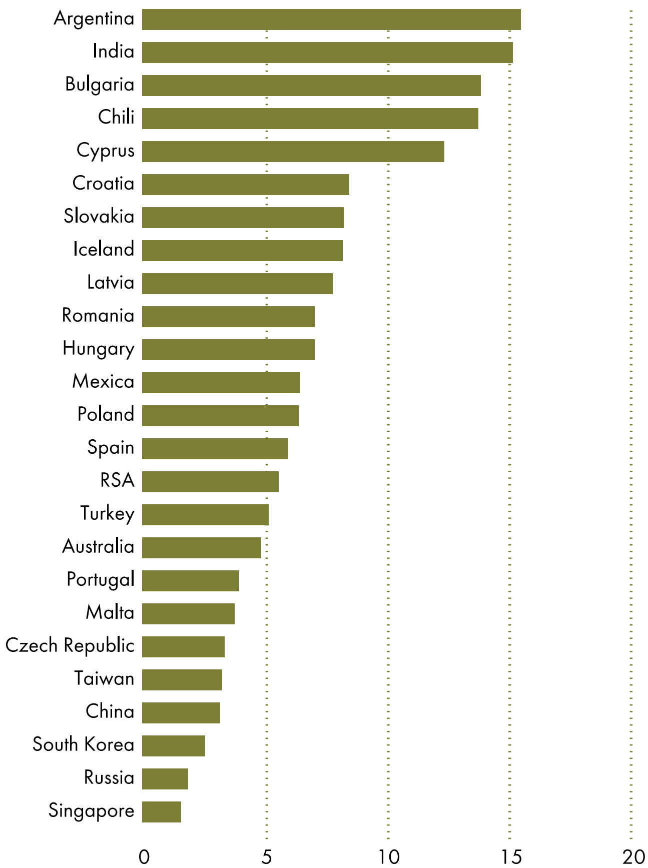
Innovations are the most important factor of modern development, and in agriculture they have their specific nature which will be analyzed in this paper. According to statistics data analysis, Russian agricultural innovation sector, as well as the agriculture itself, is currently at the recovery stage, so the new forms are not completely developed, that's why we refer to experience review of innovation activity management in other countries, first of all in the USA and Europe in order to define the main innovation activity development prospects in this sector.

For thirty years (from 1976 until 1995) the world's agricultural research government investments had almost *doubled* in comparable prices, from around 11,8 US Dollars Billion up to almost 21,7 billion of dollars. This data also shows the new age beginning in the agricultural innovation sector: in 1990 the developing countries started making more efforts in the agricultural research government investments sphere than the developed countries [5].

For today, the difference in agricultural research and development (R and D) costs of different countries is obvious. Our paper analyzes R and D internal costs in agricultural sciences percentagewise to the total amount of R and D costs, according to the data of 2011 (fig. 1). It becomes obvious that the countries have a specialization in the directions of their scientific research, which is, by the way, supported in many different ways on the international level.

So, the list of leading countries in agricultural innovations sector includes the members of so called Cairns Group[1]. Summary data cannot show that the agricultural R and D costs were concentrated in several countries. Only four countries – the USA, Japan, France and Germany have formed two-thirds of 10,2 billion of dollars of research government costs, invested by rich countries in 1995. In the same manner, only four developing countries – China, India, Brasil and Southern Africa have invested 44% of agricultural research government costs in the developing countries in 1995, in comparison with 35% in the middle of 1970 [4].

[1] Cairns Group (association of countries, exporting the agricultural production, it was formed in 1986 in Cairns (Australia) for common protection of interests of the countries, participating in Uruguayan negotiations under the authority of General Agreement on Tariffs and Trade; main goal of the group — agricultural production free trade development assistance; in particular, the group supports prohibition against export subsidies and a number of government subsidies for support of agricultural production manufacturers; the group includes the following countries: Argentina, Australia, Bolivia, Brasilia, Canada, Chili, Columbia, Costa-Rica, Guatemala, Indonesia, Malaysia, New Zealand, Pakistan, Paraguay, Peru, Philippines, RSA, Thailand and Uruguay).



Source: made according to [2].

Fig. 1.
R and D internal costs in agricultural sciences percentagewise to the total amount of R and D costs

In spite of a stable long-term increase in *agricultural research and development* expenditure (Agricultural R and D) from 1970, many parts of the world had a fast and quite an expanding increase in Agricultural R and D expenditures within 1970 and in the beginning of 1980, in the first half of 1990 it dramatically slowed down. In rich countries the governmental Agricultural R and D expenditures increased only to annual 0,2% between 1991 and 1996, in comparison with annual 2,2% during 1980. Africa did not have any increase at all – continuation of more long-term tendency which started after a fast increase in expenditure in 1960, progressively interrupted by crises in 1980 and by government expenditure limitations in 1990.

Analysis of situation, based on per capital income, shows that the expenditures of low income countries were increasing more rapidly, so their general proportion in the global volume had increased from 19% in 1976 up to 28% in the middle of 1990. It should be mentioned, that such a tendency shows a comparatively fast increase in Agricultural R and D expenditures in India and China, two big countries, the expenditures of which are dominating over the mean value in the group. Indeed other low income countries lose their positions. Their proportion in global Agricultural R and D expenditures had shortened from 8,7% in 1976 to 8,3% in 1996, plus it continues shortening at the present time.

Group of developed countries had spent in relative terms 2,64 dollars on Agricultural R and D expenditures of every 100 dollars of agricultural production in 1995, having increased them from 1,53 dollars, which they spent on 100 dollars of production two decades before. From 1975 the developing group's research intensity had increased, but such an increase was unsteady. In spite of that China had gained a big absolute proportion in total Agricultural R and D expenditures among the developing countries, in the middle of 1990 this country's research intensity was not higher than in the middle of 1980. In other words, China's research expenditures had increased as well as the agricultural sector itself had increased.

By comparison if we count the proportion of Russian Agricultural R and D expenditures according to the activity type [2] «Agriculture, Hunting and Fishing» (rub.) in the ratio of the index «Agricultural production» (rub.) in 2010, we will get the value 7,78 E –05. This is around 190 less than the expenditures of developed countries in 1975, even if in favor of Russian statistics we do not take into consideration «hunting and fishing».

Other indices of research intensity also show that the rich countries had spent more than 590 dollars per an agricultural laborer, having considerably doubled the corresponding proportion in 1976. Poor countries had only spent 8,50 dollars per an agricultural laborer in 1995, having increased the expenditures two times less than in comparison with 1976. Such differences between rich and poor countries may be explained in the following way: much less labor power in used in the agricultural sector of rich countries, so the absolute number of agricultural laborers had reduced quicker in the rich countries than in the poor ones. Agricultural R and D expenditures per capital income had in increased at the average rate of 25% for the developed countries (from 9,6 dollars in 1975 up to 12,0 dollars in 1995) and of 79% – for the developing countries (from 1,5 dollars in 1975 up to 2,5 dollars in 1995). Agricultural R and D expenditures per capital income (in the context of both: total population and agricultural laborers) had shortened in Africa, the only world's region where such a situation had occurred.

According to different accounting version in 2010 Russia had a result from 9 up to 43 rub. per one agricultural laborer. The fact is that «Science indicators» for 2013 provide information on type of economic activity «Agriculture, Hunting and Fishing» and on social and economic goals и «agricultural development» [2]. One way or another, Russia spends on these goals even less than the poor countries in 1976.

In the middle of 1990 almost one third of total investments volume (33 billion of dollars) in the world's Agricultural R and D expenditures was contributed by the private companies, including farms and agricultural processing companies.

The majority of these researches (94% from total amount) were carried out in the developed countries. The developing countries had the proportion of private research only at the level of 5,5%. Government funds provide almost half of the full support in the rich countries. Agricultural scientific research is an area where, in all the countries, the public sector dominates over the private one, as the source of support. More than half of world's governmental Agricultural R and D expenditures are made in the developing countries, while in the very countries only 1/3 of all the researches (public plus the private ones) are carried out. These facts show the role of private agricultural research.

Intensity gap in Agricultural R and D expenditures between rich and poor countries remains quite large and expanding. Thus, in 1995 the governmental research intensity of rich countries was four times than of the poor ones; in case of considering the summary expenditure (i.e. private and public one), the gap is more than eight times higher, i.e. the rich countries make around 5,4 dollars of the Agricultural R and D expenditures per 100 dollars of national total output in the agricultural sector.

Eightfold difference in the full intensity of Agricultural R and D expenditures shows the research financing flow gap between rich and poor countries. However, it is not only the amount of investment in the research and innovation activities which provide a country with an increased technological capacity and better rating position in cross national comparison of agricultural productivity, but it is also the available storage of knowledge.

Current knowledge and investment of previous expenditures in this knowledge depend on the type of science, institutional structures of the scientific environment and economic context, influencing the way this knowledge is used. Some scientific expenditures are very important for local scale of the used knowledge, but the same expenditures in the societies constantly ruined by wars, institutional insecurity and obvious crisis, may have much lower effect.

According to calculations of experts, in the ending of 1990 the amortization rate was 3%, and the storage of knowledge in the USA was 11 times more than the volume of produced agricultural production. In other words, every 100 dollars of agricultural production were supported by the storage of knowledge almost equal to 1100 dollars. At the same time the actual storage of knowledge in Africa was less than the value of African agricultural production. So,the ratio of American storage of knowledge to American agricultural production was 12 times higher than the corresponding amount for Africa, and if we take the amortization rate equal to 6% instead of 3%, the gap between American and African relative indicators will be more than 14.

In the last quarter of XX century, the sponsors' initiatives on providing the agricultural information resources in the developing countries resulted in the foundation of International Agricultural Research Centers (IARCs).

In 1971 the developed countries representatives formed the Consultative Group on International Agricultural Research (CGIAR) [3]. CGIAR is a non-official association, which currently includes the developing and the developed countries, private funds, regional and international organization, co-sponsored by the Food and Agricultural Organization of the United Nations, the International Fund for Agricultural Development, the United Nations Development Program and the World Bank. This organization coordinates the system of International Agricultural Research Centers, controls the co-financing of these centers and the forum for discussions and establishment of technical research assignments.

The Consultative Group system was formed as a small one, between 1960 and 1964 it actually was one institute: the International Rice Research Institute (IRRI) [6]. Out of its start-up budget of 7,4 US Dollars Million in 1960, the total annual expenditures were 1,3 million of dollars to 1965. In 1970 four institutes within the group received the total amount of 14,8 million of dollars each year [3]. Progressing expanding of general number of centers during the next decade had resulted in a tenfold increase in nominal expenditures up to 141 million of dollars in 1980. During 1980 the expenditures continued growing, - considerably doubling in nominal values to reach 305 million of dollars in 1990. Growth rate had slowed down, but it was still considerable. However, in 1990, although the number of centers had increased from 13 up to 18, for today the number is 15 [3] – the financing did not grow enough to support the expenditure level of every centers, not to speak of growth rates.

Analysis of the available data provides some quantification on reducing of the international support for agriculture and researches, which have a direct influence on the sector's development. Thus, although the European Community had increased the support level of the developing countries in 1987–1998, the agricultural direct support had been considerably reduced. In the ending of 1980 the agriculture received 12% from the total EC expenditures, and only 4% – in 1996–1998. For the previous decades the agricultural lending proportion of the World Bank had been reduced too (from average 26% in the first half of 1980 to 10% in 2000).

The World Bank's amount of loans differed for different countries, from 0,1 millions of dollars for Argentina in 1992 and Niger in 1997, to 136 millions of dollars for India in 1998, China – 68 millions of dollars, Ethiopia – 60 millions of dollars. [8].

From the middle of 1980 to 1997 the United States Agency for International Development had reduced the amount of agricultural research financing of less developed countries by 70%. In this context, Asian countries suffered heavily: amount of financing was reduced by almost 42 million of dollars in the middle of 1980 (according to the prices of 1999) to 1,1 millions of dollars in 1997 [10].

In order to research the agricultural innovation activity, it is necessary to define its result/product. In most cases, the product of agricultural innovations is the information which often belongs to the non-rival and non-excludable goods. Valuable information product can be easily copied or used by those who did not participate in the production process; this use does not limit the availability of information product to the other users.

Non-excludability and non-rivalry increase the social value of innovation, speeding up and reducing the value of promotion for the potential users, and lowering the price for the consumers. But at the same time, lack of excludability means lack of incentives for the private manufacturers. That's why this sector requires some kind of public intervention. Historically, incentives were not enough for the agricultural innovations, so the real technological progress was slow without public intervention.

From ancient times regents and governments had always supported the expeditions, going in search of new plants and animals, and the members of American Congress in XIX century distributed for free the seed packages of new cultures [5]. In XIX century Germany, Russia, several other European countries and the USA carried out institutional innovation activity in the form of agricultural research institutes financed by the state. For the previous century, these institutional innovations had extended over the globe, and for today almost 2/3 of resources, sent for the world's research, are provided by the public sector [4].

But the political climate of developed countries has changed towards more active participation of private sector in the research, connected with agricultural production technologies. Traditionally, innovations of the private sector were considerably concentrated on the processes inputs - agricultural innovations (resource provision), such as agricultural equipment, fertilization and crop protection chemicals, or on the postharvest technologies and marketing, where the market power and intellectual property rights (such as patents, copyrights and trade marks) were available and allowed getting the income from innovations.

In 1980 the confirmation of different life forms patentability in the USA and parallel development of biotechnologies for proving of alleged infringement, had made the service patents appear, as new strong incentives for agricultural biotechnology research. Besides, Bayh-Dole Act of 1980 encouraged the expending of patents and use of governmental financing in the researches.

Over the last years the use of patent systems in the developing countries and all over the globe has become more frequent because of the necessity to fulfill the TRIPS[2] agreement, essential condition of membership in the World Trade Organization [12].

Besides, many countries have enforced their patent systems as part of internal initiatives on modernization of national innovation systems. Some observers could conclude that these events show the increased influence of economics on the policy in the intellectual property sector. For today, many people and maybe even the majority support incorporation of patent system in modern innovation systems and economic development programs. However a significant minority has a different understanding, indeed, traditionally the economists had different opinions on the use of patents as a part of national policy [4, 8].

Defense of intellectual property rights implies the right to exclude the others from: 1) production and reproduction of patented products; 2) copying; 3) delivery for sale; 4) the process of sale itself or some other marketing activity; 5) export; 6) import; 7) indirect participation in one of the abovementioned activities (article 14 of the Agreement [11]).

Plant breeders' rights (PBRs), according to the Convention for the Protection of New Varieties of Plants (more famous by its French acronym: UPOV), protect the varieties which are considered to be new, homogeneous, distinct and stable from unauthorized activity related to the support of commercialization, the innovation criteria is less demanding than for the

[2] Trade-Related Aspects of Intellectual Property Rights (TRIPS).

patents. Variety can be considered new if it has not been commercialized before, during four years in the countries-members of the Convention or during one year in the applying country.

Distinctiveness means that the variety is obviously different from the other varieties which, as it should be known, have existed during the registration. Stability and homogenous demand means that the plant variety complies with its original description and keeps its corresponding characteristics when reproducing or distribution. These criteria do not interfere with the values or importance of distinct characteristics, but display the necessity to identify an adequately protected plant variety by using the available tools of modern biotechnology. For example, cultivars species of soya bean in the USA, distinguished only by the type of its flower, was protected by the corresponding variety patent.

Repeated reproduction of the protected cultivar for commercial sales is the infringement, but it is allowed to use idioplasm in the researches in order to produce the new cultivars species. So, plant breeders are protected from reproduction of the protected varieties by the competitors.

Besides, natural parent lines of hybrid grains were protected by the UPOV from use by the competitors in commercial hybrid production. But the breeders are free to use the protected variants for reproduction in their production areas and to protect new varieties, produced from the protected variants, while the farmers can keep the idioplasm for repeated usage, distribution or reproduction. Indeed, the UPOV original model did not imply that the exchange between the farmers or sale of seeds were prohibited by the countries-participants of the Convention [9, 11].

UPOV Act of 1991 had considerably expanded the rights of breeders; it defined that the variety, « basically produced» from the patented parent-plant, is covered by the same patent's protection. The basically produced variety is defined in the UPOV Act in the article 14 (5) (b) and (c). Besides and not without contradiction, the basically produced variety can be received by transformation or a number of other methods. Thus, for example, if an agro engineer takes the protected grain variety and transforms it into the variety with a genetic construction (for example, presence of genes of insect resistance), the produced grain variety is «basically produced variety» and protected based on its origin. While the UPOV Act of 1978 accorded the rights to exclude the others from the production for commercial marketing, offer of protected variety for sales and marketing, these rights were considerably expanded in the Act of 1991. Now the rights cover arrangement of conditions, export, import and supply of the protected variety. Freedom in collaboration between farmers had also been weakened in the UPOV Act of 1991, limiting the exchange of patented seeds.

Both – the patents and the breeders' rights belong to the jurisdiction of the territory where they are registered. In search of wider geographic sphere of protection some experienced practical people have found out that the evaluation requirements in every country, including the tests and need in the local legal representation and possible translation of the documents can be equal to the price of international service patent protection [5].

Service patents are considered to be the strongest protection of intellectual property rights, including the inventions, processes and products, embodied in the material things. Basically, patent nominal premium (disclosure of an invention secret) must be equal to the amount of expenditures which could enable a person with ordinary competences in the corresponding profession to make such an invention. Usually invention information falls into the public domain in eighteen months after applying. Thus, one important advantage of patent system implies that the system facilitates the innovation information flow. Patents have a limited shelf-life, usually 20 years from the registration date and the property rights area is defined by the complaints, included in the patent which in case of litigation proceeding can be interpreted by the court, acting in accordance with common law.

Patent's issue does not mean that a patent bureau will directly protect the author's rights for the patented novelty/innovation from the infringement. It is more likely that a patent grants to its owner a legal right to *exclude the others* from inventing in the same manner as it is described in the document. Thus, the importance and power of patent systems directly depends on the effective legal system in terms of infringement prevention and penalization of infringers.

Although international agreements control the key patent aspects, the patents are issued by the national governments and have force only in a corresponding national jurisdiction. In order to protect a novelty in this country, a patent must be received in this country. Expanding of property rights over other countries are facilitated within the Patent Cooperation Treaty (PCT) controlled by the World Intellectual Property Organization (WIPO) [12].

For countries which are WTO members and which have concluded the TRIPS agreement, minimal criteria are the same.

Patents' values are extremely sophisticated. For example, while a popular licensed Cohen-Boyer patent earned more than 200 millions of dollars in license payments, most patents bring income within the limits from zero to several thousands of dollars (it is implied that the expenditures are not always higher than income). It is not a surprise then, that the majority of inventions is patented only in one or several developed countries with big markets. Even very progressive biotechnologies were protected in few developing countries, in particular, where the patents of corresponding technology type were affordable. For example, none of a number of the key technologies of Agrobacterium is patented in more than four countries outside Europe, while a very popular «CaMV 35S promoter», widely used in transformation of plants, is patented only in European countries, Japan and the USA [5].

Confidential information (for example, lists of consumers, business plans, description of production processes, genetic lines for hybrid grains production), which has a commercial value, can be protected as a commercial secret if the owner hides it from the competitors.

Information, protected as a commercial secret, can include new genetic material, experts' remarks, specialist's ideas on processes and procedures related to the property and general innovations which need to be hid before publication of a patent application. Secret (or information) is not basically a property right, but the law acknowledges it as a personal right. This right, unlike patents and author's rights, is not registered until the owner of commercial secret uses reasonable endeavors to keep the secret.

If a commercial secret is disclosed, right holder can compensate the damage through court action, including court injunction and loss. However a product or a use of process does not infringe the commercial secret, if the secret information is revealed during an independent invention or received by some other qualified means (for example, from a published paper or at a workshop).

On the other hand, revolution in analysis of genetic material had created the technologies of genetic fingerprinting, which enables to find unauthorized reproduction or production in such a manner that the commercial secret's form could be used more often in the future.

Product's identity, as far as it is understood by a client, has a very important property – it can influence this product's value. Thus, a registered trade mark, under which different plant varieties or genetic line are sold, can become a significant protection of genetic value embodied in the product. Even upon conditions that it is not possible to copy a basic novelty, the customers often pay more for a trade mark version than a copy, relying on good reputation, especially in cases when final quality or property will not be very obvious, as it stands in the situations with tolerance to herbicides or resistance to blasts. Gardeners will pay more for a trade mark variety, if this mark is known and approved by the consumers. Trade marks have an additional advantage in protection duration. Registration can be renewed for a moderate price while the trade mark is used. Also, according to Madrid Protocol it becomes easier to register a trade mark in other countries.

In spite of expanding of the intellectual property protection area, legal force and value are still a problem. It is especially obvious at the farm's level. Even in the developed institutional legal environment of the USA, farmers themselves may bring a case on property rights infringement before a court failing to post a profit, because the farmers' financial resources and assets are generally smaller than an average value of judicial process. Only restraining influence on other behavior of other people can justify such actions.

As the result, the scientists had invented new biological means to restrict the copying of idioplasm or property characteristics of biological objects, providing a chance for return on investments. A various number of technologies is considered within a general class, characterized as Genetic Use Restriction Technologies (GURTs).

GURTs are divided into two broad types: 1) *for variety level* (V-GURT); 2) *for typical characteristics* (T-GURT). In 1998 U.S. patent (5 723 765) was issued in cooperation between the Department of Agriculture of the USA and Delta & Pine Land company, American biggest cotton seed supplier by V-GURT technology. This technology enables a seed manufacturer to inoculate a seed with a specific regulator which makes a plant infertile, consequently making it impossible to economize [5].

Long before this type of physical protection could be transformed into a market technology, the prospect of producing the cultivars using V-GURT technology raised considerable objections of farmers and other non-government organizations. Although V-GURTs varieties had a potential to facilitate frequent problems of these groups related to transgenic seeds of second generation (the same yield or poor cross fertilization), critics called them «terminator's technologies», emphasizing that they could sterilize neighboring non-transgenic grain corps with drifting pollen or disadvantaged farmers, who could get the «terminator's» seeds by mistake.

On the other hand, T-GURTs technologies do not finish the variety's reproduction. Generations, cultivated from the conserved seed, will be fertile. But in order to make the protected characteristic appear this year, it is necessary to use an activator (for example, some chemical). Experts think that T-GURT could be activated by spraying the composition with certain characteristics. Gene usage could be paid as half of price from the activator's purchase. If such a technology is possible, a farmer could wait until it is obviously necessary to use such a characteristic as a resistance to a certain disease, then he could additionally buy and use the activator, following the same scheme as chemical biocide. In this case the product's characteristic offers «self-defense», instead of «self-insurance» in risk management's terms.

At the same time the following disturbing facts are known: in India it was refused to register V-GURTs technologies, and V-GURTs were rejected by The Rockefeller Foundation and by Consultative Group on International Agricultural Research (CGIAR), but accepted by the Department of Agriculture of the USA (USDA), co-developer of original technology of cotton cultivation [11].

Finally, it should be noted that it is possible to protect the rights of physical property only by concluding the agreements in order to prevent distribution of genetic and intellectual constructions, included in the limits of something characterized as physical property. It can be relevant when regulating the rights of research results where a special genome or other biological material can be considered to be the property or physical property of their producer. For example, mice parents with some particular characteristics were successfully commercialized by using the actual delivery agreement without applying for patent protection. Technology transfer university offices become more often involved in realization of such alternative actions, which are simpler and less expensive – in both areas: time and money. This alternative can be used in production where an idioplasm supplier can rent or provide plant material to a farmer according to the agreement, and directly demand to keep the identity, legally protecting produced product's physical property.

The current international public opinion on intellectual property issues relating to agriculture is the result of the continuation of the complex interactions between many agents representing many different interests in different areas.

Thus, the given above overview of the state of affairs in the innovation field of agriculture of the leading countries in the world shows that Russian agro-industrial complex today faces a serious challenge, in particular because of with Russia's entry into the World Trade Organization. At present it is rather difficult to present the potential of accumulated knowledge in the quantitative evaluation (because of methodological inconformity, in particular), but the current comparatives suggest that its value can be next smaller than that of the leading agricultural producers in the world.

Under the circumstances, there is a clear need for not only strong investment in innovation sphere of agriculture, creation of interacting regional rural innovation systems, but also creation of the appropriate institutional environment.

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