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ASSESSMENT OF THE DEGREE OF IMPLEMENTATION OF THE RESULTS OF SCIENTIFIC RESEARCH AND INVENTIONS IN THE AGRICULTURAL SECTOR OF THE ECONOMY

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Abstract

In ensuring the country's food security, the dominant role belongs to scientific activity and the development of advanced production technologies. Moreover, the process of implementation of innovations and further stimulation of demand for the results obtained are of greatest relevance. The purpose of the study is to develop theoretical and methodological approaches to assessing the implementation of scientific developments and new technical solutions in agriculture in the context of innovative transformation of the economy. The article reveals significant interregional and intercountry differentiation of patent activity, and notes the gap between the total number of patents and the inventions being introduced into Russian agriclture. Based on a scientometric analysis of patents with text mining, trends and patterns in the formation of promising patent developments in agriculture have been identified and a bibliometric map has been generated in the direction of the relationship between areas of patent activity in Russian agriculture. The predominant clusters have been identified - agricultural engineering; soil treatment, harvest, pest control, production of herbicides and their components. The results obtained determine the need to develop effective mechanisms for supporting patent activity in agriculture and stimulating the introduction of scientific developments and new technical solutions into the production process in order to determine the most promising areas of research in agricultural science. The practical implementation of the research results is associated with the justification of the necessary incentive measures and government support for scientific developments in the context of fundamental technological changes and innovative structural shifts.

Key words**:** *agro-industrial complex, innovative development, scientific research, scientometric analysis, bibliometric map, implementation of the results of intellectual activity, differentiated approach*

INTRODUCTION

Ensuring Russia's national security largely depends on the level of development of the country's scientific and innovative potential and the wider use of fundamentally new production technologies [4].

Research confirms that economic growth in countries with developed market economies is determined by more than 80% of the materialized results of scientific and technical activities [23].

The implementation of scientific developments and new technical solutions in agriculture and other industries will improve the efficiency of using the financial, human, land, and technological resources used. [25, 26].

Russian researchers are working on the problems of breeding high-yielding plant varieties and creating a breeding base of highly productive animal breeds, developing advanced technologies and high-tech products, machinery and equipment, which will increase the competitiveness of agri-food products on the world market [6,33].

In the near future, the area of research on breeding and seed production will significantly expand.

The degree of significance of scientific research and development is determined on the basis of scientometric analysis [23].

Scientometric analysis systems provide the ability to process data sets, classify and systematize publications in various areas, and also calculate certain bibliometric indicators.

Scientometric systems differ depending on the content of information, built-in search functions, and areas of research [14].

The most common characteristics are research activity and citation, supported by such scientometric citation indicators as the Hirsch index, the maximum citation index (f-index).

To assess the effectiveness of scientific research and identify trends in the development of Russian science, the Russian Science Citation Index (RSCI) system with various versions of the Hirsch index (h-index without self-citations, h-index according to the RSCI core) is used [19].

One of the common methods for identifying trends in the formation of knowledge interests is mapping science, called the scientific landscape [11].

Currently, international information and analytical databases such as Web of Science, Scopus, Google Patents, PatSearch, ExactusPatent, The Lens, Dimensions are mainly used to build scientific and patent landscapes.

Building a scientific landscape aims to highlight priority areas of research based on topic modeling [31].

Research using scientometric analysis of patents is reflected in the scientific works of J. Thavorn. V. Muangsin, C. Gowanit, N. Muangsin. Their research was based on theoretical aspects of the concept of technological intelligence associated with the search for the necessary information on innovative activities at the micro and macro levels. The identified five technology sectors of the Chinese economy reflected different levels of patent activity [29].

Many publications demonstrate a new methodological approach to reflecting the information array about the state and main directions of agricultural science based on the construction of a scientific landscape. Its visualization is most often represented by road and bibliometric maps, forecast scenarios, and windows of opportunity. For example, the scientific landscape on the development of innovative processes in agriculture is built using information from bibliometric and patent analysis about the innovative technologies used, the state of the market for high-tech products, patent and scientific activity and development trends based on innovation, and the search for materials for monitoring the market for high-tech products. For information processing, a technology for automatic text analysis with the ability to build clusters and model promising areas of research is intended [8].

For example, a content analysis of research into the scientific and technological development of the crop growing industry with the construction of a scientific landscape revealed that the predominant part of research in agricultural science is related to the development of resource-saving technologies, the study of problematic issues of rational land use, as well as the reduction of greenhouse gas emissions [15].

In the previous studies of the authors, a bibliometric map was formed on the basis of publications of Russian scientists in foreign journals on the problems of introducing innovations and technological transformations in agriculture; the predominant clusters are identified - biotechnology and processing of raw materials, livestock farming, crop production, economic and organizational support [7].

Ensuring sustainable economic growth is largely determined by the effective interaction of science, education and business in order to implementation the results of intellectual activity [1,22].

The study of the peculiarities of the processes of innovative development in agriculture, taking into account the positive and negative external effects of the flow of knowledge, is of particular importance in the context of accelerating the international exchange of scientific and scientific-technical information. [5].

The technology gap theory considers the presence of knowledge absorption potential as the most important condition for the commercialization of acquired or acquired knowledge based on cross-country exchange. Practice shows that companies for which it is

developed, have stable connections with external suppliers of knowledge and technology. This provision is more relevant for developing countries [12,34].

Paul Romer's endogenous growth theory identifies the keyfactors of economic growth: knowledge, innovation and investment in human capital. In long-term development, priority is given to the acquisition of knowledge and its use in the production process [27].

Studies of the dynamics of R&D and innovation in US agriculture have revealed a higher innovative susceptibility of farmer-entrepreneurs included in value chains and actively interacting with food industry enterprises. The authors developed a dynamic model that allows us to identify the relationship between technological innovations in agriculture and scientific research on agricultural topics [13].

In the scientific works of domestic and foreign scientists, various methods of knowledge transfer are highlighted. These include education, scientific communications, scientific and technical databases, and joint scientific activities [3,16,18].

Scientists have proven that knowledge flows have a more significant impact on economic development compared to international trade or foreign direct investment [2, 21]. Accordingly, the country's innovative potential increases [9]. One of the common forms of knowledge transfer is the patenting of scientific developments. Patenting in agriculture helps stimulate innovation and scientific and technological progress, which results in improved product quality and food safety.

It should be noted the work of foreign scientists on the transfer and use of the results of scientific developments in agriculture through patents. For example, H. Fujii, K. Yoshida, K. Sugimura identified the highest priority factors for the growth of patent applications based on the results of the development of biotechnologies and their implementationin various sectors of the economy, including agriculture and food production.

Based on the research conducted, a conclusion was made about the relationship between the number of patents and an increase in the volume of research funding [17].

One of the main trends in patenting in Russian agriculture is the protection of developments related to the use of genetic resources and biotechnologies. The selection of new varieties of plants and animals, genome modification to increase crop yields or improve product quality have become widespread. In addition, the number of patent applications for digital technologies, monitoring and control systems is increasing, which contributes to significant savings in production costs.

Russian scientists are actively patenting their innovative achievements in the field of crop production on the topic of combating pests and plant diseases, as well as the development of advanced resource-saving technologies aimed at achieving stable growth and sustainable development of agriculture [20].

The purpose of the study is to develop theoretical and methodological approaches to assessing the implementation of scientific developments and new technical solutions in agriculture in the context of innovative transformation of the economy.

MATERIALS AND METHODS

The methodological basis of the study was regulatory documents, state legislative acts, regulations, research by domestic and foreign economists on the topics of scientific activity and patent activity. During the research process, monographic, abstract-logical, analytical, economic and statistical research methods were used. As an information base for the study, information from the scientometric system The Lens, as well as information from the ISSEK Foresight Center of the National Research University Higher School of Economics and Rosstat were used.

RESULTS AND DISCUSSIONS

A country's innovative potential is largely determined by the level of inventive activity, which is measured using various indicators.

Patent information allows you to assess the uniqueness of the technology being developed, determine the conditions and opportunities for innovation, and search for the most popular patent applications. Cross-country comparisons of patent activity indicators showed China's dominance in the total number of patent applications, which is largely determined by the presence of effective mechanisms for stimulating scientific research and supporting patenting. One of the support measures is multi-level stimulation of patent development, including the implementation stage [10].

Unlike most countries, the majority of China's patent applications are aimed at commercializing research results within the country [29].

Japan, Germany, France, and the UK also submitted a significant number of patent applications in 2021.

According to the Institute of Statistical Research and Economics of Knowledge of the National Research University Higher School of Economics, in 2021, the share of Russia in the global number of patent applications for inventions decreased by 8 thousand units. compared to 2015 and amounted to 25.5 thousand units (Fig. 1-2).

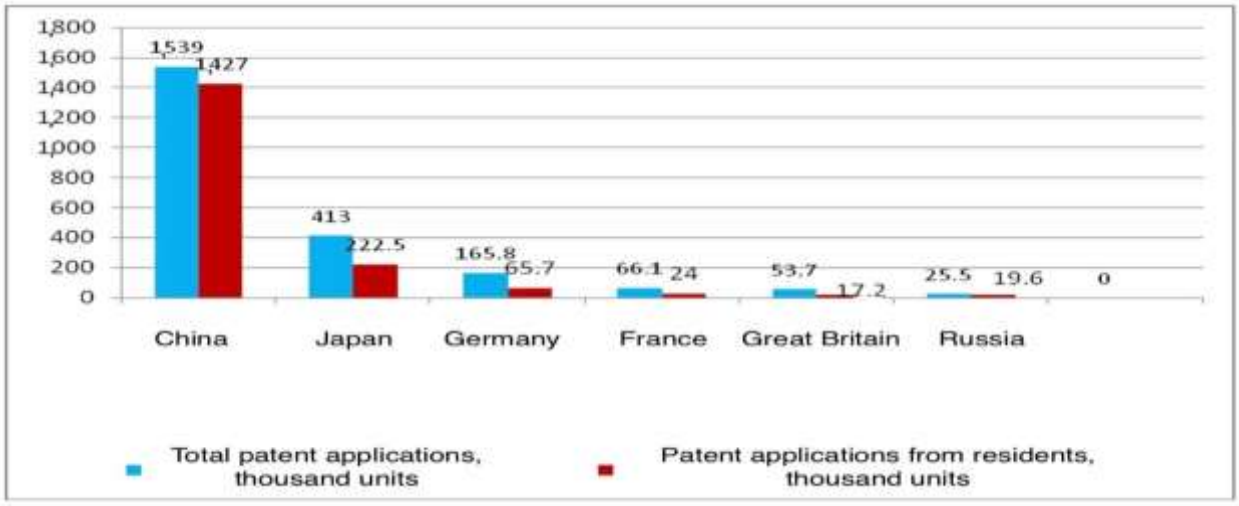

Fig. 1. Cross-country comparisons of patent applications for inventions by country of applicant and place of filing, 2021

Source: Own calculations based on data [35].

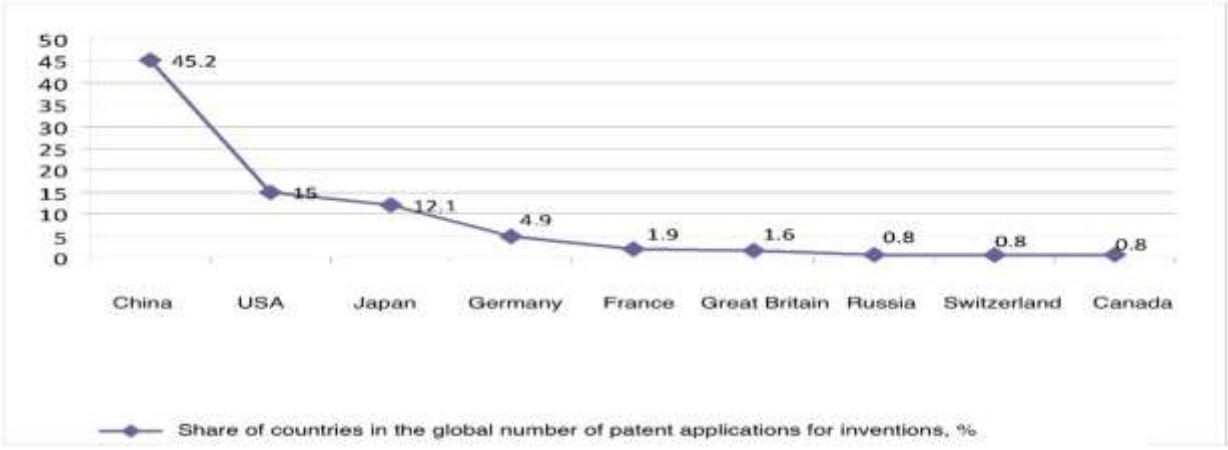

Fig. 2. Cross-country comparisons of relative indicators of patent activity, %, 2021.

Source: Own calculations based on data [28].

However, it should be noted that there is a tendency for increase in the coefficient of technological independence, calculated as the ratio of the number of domestic applications to their total number (Fig. 3).

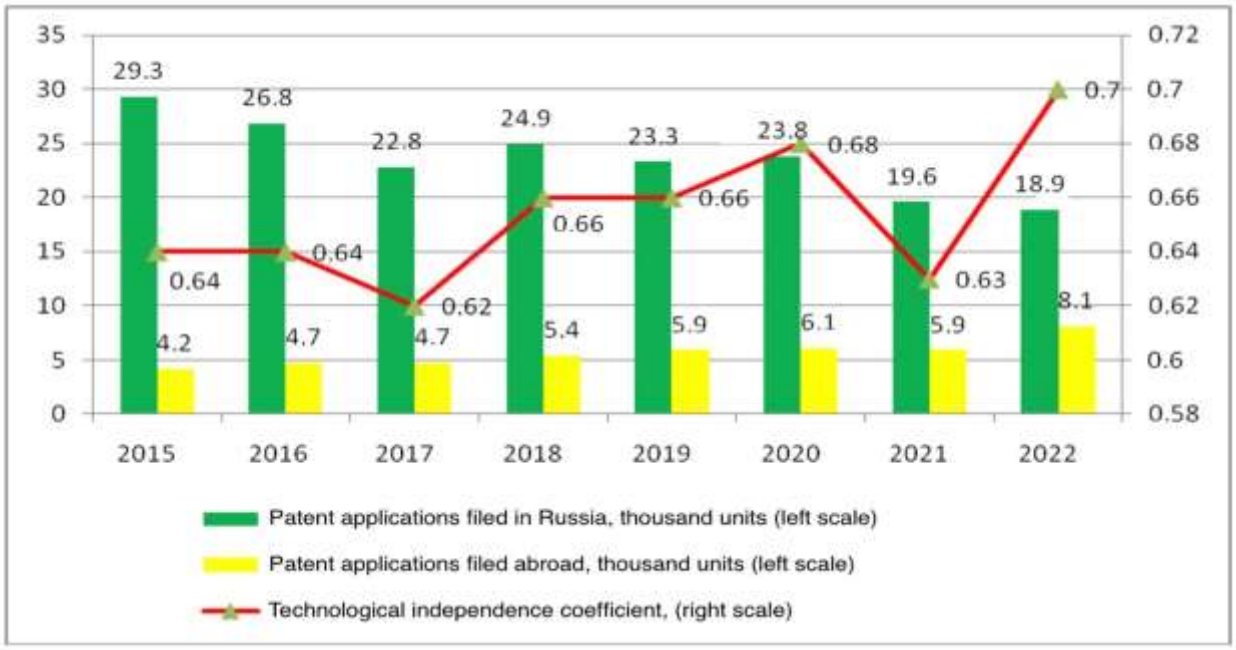

Fig. 3. Indicators of patent activity in Russia, 2015-2022.
Source: Own calculations based on data [28].

The calculated coefficients of technological independence for the countries leading patent activity showed that in 2021 the highest indicator was achieved in China (0.92). In the UK, Germany, USA, France and Japan, the figures were 0.32, respectively; 0.4; 0.51; 0.36 and 0.54. The above indicates the strengthening of the innovative vector of the Russian economy.

There is a certain relationship between the indicator of inventive activity per 10 thousand people. population and the country's innovation rating.

For example, in 2021, Korea ranked first in the world in both the Inventive Activity Ratio and the Bloomerg Innovation Index; China ranked fourth and sixteenth, respectively [10].

One of the possible reasons for the insufficient degree of implementation of knowledge and developments is the incomplete correspondence between filed patent applications and the use of these scientific results in production. As Russia's own technological base develops, an increase in patent activity is predicted in various sectors of the economy, including in the agricultural sector[24].

In 2022, agricultural organizations introduced into production 3 inventions, 2 utility models, 12 computer programs, 2 databases and 117 breeding achievements [30].

It should be noted that there is significant interregional differentiation of patent activity, which is determined by such factors as the level of specialization, natural and economic conditions, the presence of agricultural scientific potential, and the presence of vertically integrated holding-type structures. In regions with a low level of development of agricultural production, patents are almost never registered. According to research by Russian scientists, the largest number of patents was registered in Moscow, St. Petersburg, as well as the regions of the North Caucasus and the Volga region. A certain relationship has been identified between the level of innovative development and patent activity. In particular, regions with registered in 2010-2019. patents in the field of "Agriculture" in the amount of 400 and above are called "innovation centers", and regions with indicators of less than 20 are characterized as innovation periphery. The innovation periphery includes regions with unfavorable natural and economic production conditions and a low level of agricultural scientific potential [24].

The diffusion of implementation of inventions is heterogeneous in terms of space and industry. In agriculture, large investors and agricultural holdings play a significant role in the implementation of progressive

technological solutions using nanomaterials, nanotechnologies, and soil cultivation technologies.

Strengthening interregional and international exchange of results of scientific and intellectual activity predetermines the need to study the dissemination of knowledge based on the analysis of patent and scientific publishing activity.

The article provides a scientometric analysis of patents based on text mining.

To compile a bibliometric map of patent activity in Russian agriculture, we used the Lens open database, which contains information about publications and patents. The advantage of the chosen service is associated with the availability of more extensive information on publications and patents compared to other scientific databases, which predetermined the use of the above-mentioned database for research.

The search parameters were limited to the search query "Agricultural", and the term "patents" was used as filters. The search was aimed at obtaining the necessary information for Russian agriculture, taking into account the patents of only Russian scientists. The search process involved downloading 16,872 patents issued between January 1, 2001 and January 1, 2024, in Research Information Systems (RIS) format. Subsequent processing of information for clustering and graphical construction of a bibliometric map was carried out using the scientometric tool VOSviewer, which allows removing inaccuracies and typos. To cluster keywords according to the degree of their mention, the "co-occurrence" method was used, on the basis of which thematic clusters with visual differences were formed.

The results of clustering the patent activity of domestic inventors are presented in Figure 4. The resulting clusters are marked in color, and the size of the bubble of an individual keyword is directly related to the overall data matrix. According to generally accepted methodological approaches to the analysis of bibliometric maps, the number of lines and their line thickness are determined by the close connection with the general data array [32].

Recognition of the obtained bibliometric map data as one of the forms of visualization of the results of processing an array of information revealed the corresponding vector of innovative development of agriculture. Patent activity reflects the most common topics of domestic inventions.

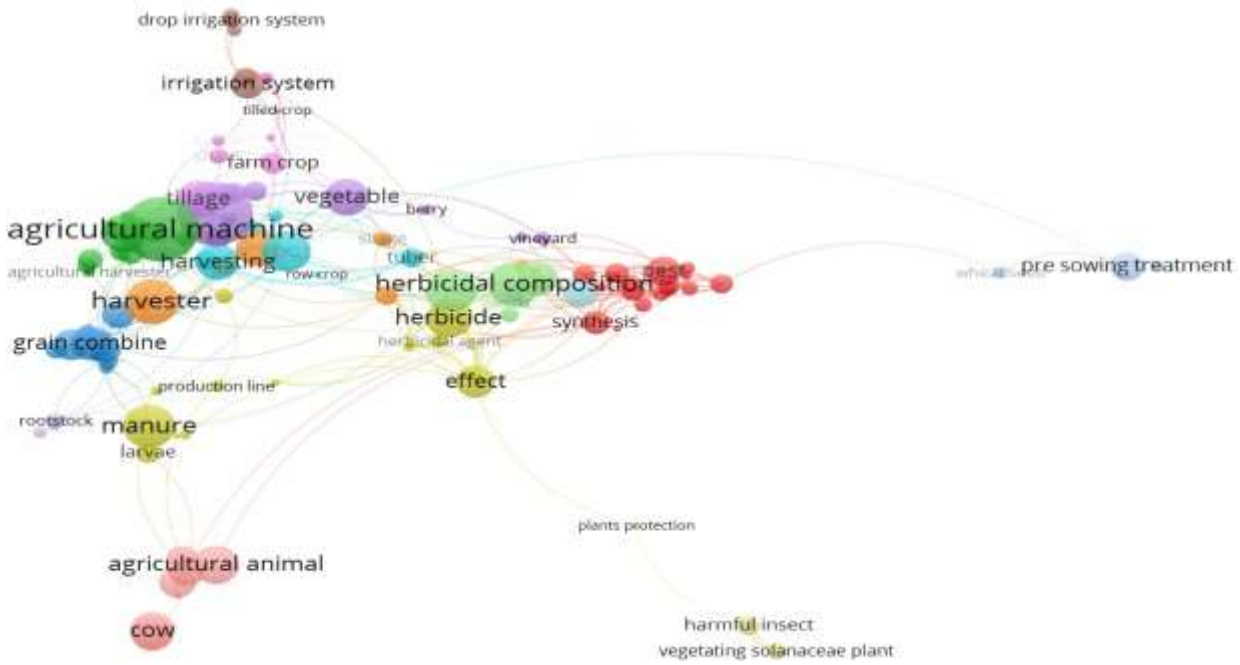

Fig. 4. Bibliometric map of the relationship between areas of agricultural science according to patent applications of Russian researchers
Source: Own calculations.

The main areas of patent activity are: innovative developments related to agricultural engineering; plant protection, soil cultivation, livestock farming, drip irrigation systems, harvesting, growing vegetables and berries.

Analysis of the constructed bibliometric map shows the presence of several clusters: dark green – agricultural engineering; purple – soil treatment; blue – harvesting; red – pest control; pistachio – production of herbicides and their components.

Patent activity in the agricultural engineering cluster is tied to soil cultivation and irrigation systems. The greatest number of references relates to the terms: mechanisms, tools, cultivators, tillage.

In the "pest control" cluster, there is a relationship with the areas of "vegetable growing" and "grain harvesting". The most significant terms in this cluster are: harvesting, herbicides, granaries.

Scientometric analysis provides systematization of indicators of large information arrays. Its use made it possible to assess the degree of patent activity in the process of forming the high-tech agricultural sector of the Russian economy.

Increasing the degree of implementation of agricultural knowledge largely depends on the measures of government support for the scientific sector, as well as stimulating the promotion and implementation of intellectual property.

The form of intellectual property support introduced by the Russian government in the form of subsidies to finance part of the costs of registration in foreign markets will help strengthen the patent activity of economic sectors, including the agricultural sector.

CONCLUSIONS

An analysis of global experience in researching scientific activity and patent activity made it possible to identify the relationship between the implementation of scientific research results and the level of innovative development. Significant interregional and intercountry differentiation of patent activity has been revealed. Compared to developed countries, in Russia there is a gap between the total number of patents and the inventions being introduced into production. Based on bibliometric analysis, trends and patterns in the formation of promising patent developments in Russian agriculture have been identified. A study of Russian patent applications in agriculture for the period from January 2001 to January 2024 led to the conclusion that the main areas of patent activity are: innovative developments related to agricultural engineering; plant protection, soil cultivation, livestock farming, drip irrigation systems, harvesting, growing vegetables and berries.

Based on the scientometric analysis of patents with text mining, a bibliometric map was formed in the direction of the relationship between areas of patent activity in Russian agriculture.

The predominant clusters have been identified - agricultural engineering; soil treatment; harvest; pest control; production of herbicides and their components. The results of the analysis showed that patent activity in the "agricultural engineering" cluster is tied to soil cultivation and irrigation systems. The greatest number of references relates to the terms: mechanisms, tools, cultivators, tillage.

In the "pest control" cluster, there is a relationship with the areas of "vegetable growing" and "grain harvesting". The most significant terms in this cluster are: harvesting, herbicides, granaries.

The results obtained determine the need to develop effective mechanisms for supporting patent activity in agriculture and stimulating the introduction of the results of intellectual activity into production, which will allow us to identify the most promising areas of agricultural scientific research.

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