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IMPROVING METHODOLOGICAL APPROACHES TO FINANCING AGRARIAN SCIENCE TO STIMULATE INNOVATIVE AGRICULTURAL PRODUCTION

Marianna VASILCHENKO[1], Elena DERUNOVA[1], Victor SHABANOV[1]

[1]The Institute of Agrarian Problems is a separate structural subdivision of the Federal Research Center «Saratov Scientific Center of the Russian Academy of Sciences» 94, Moskovskaya Street, 410012, Saratov, Russia, Phone: +78452263179, Fax:+78452264768, Mobiles: +79172036930; +79873093797, +79172068353, Emails: mari.vasil4enko@yandex.ru, ea.derunova@yandex.ru, vic35@inbox.ru

Corresponding author: ea.derunova@yandex.ru

Abstract

In modern conditions, the problem of improving the mechanism of state support for innovative agricultural production is actualized. The purpose of the study is to evaluate the effectiveness of financing agricultural science and develop a mechanism for stimulating innovative agricultural production. The article analyzes the impact of investments on the innovative development of agricultural systems based on the construction of models of the modified Cobb-Douglas production function, substantiates methodological approaches to financing agricultural science to increase incentives. for innovative agricultural production. Foreign and domestic theoretical and methodological approaches to the financing of agricultural science have been studied. Empirically, calculations were made to determine the optimal level of financing of agricultural science in order to reduce interregional differentiation. It has been empirically proven that the process of financing scientific research in the field of agricultural sciences does not sufficiently influence the dynamics of production volumes. Approaches have been developed to optimize the means of financing agricultural science on the basis of the achieved criterion of innovativeness of production. The practical significance of the results of this work lies in the improvement of tools for stimulating innovative production.

Key words**:** *government support, innovation, agricultural production, financing mechanisms, Cobb-Douglas production function, modeling*

INTRODUCTION

The current macroeconomic instability, the sanctions policy actualize the issues of reducing import dependence in the agro-industrial complex. Under these conditions, the possibility of increasing the volume of funding for agricultural science to stimulate innovative agricultural production, ensuring food security and independence of countries is limited. The strategic priority of achieving a new quality of scientific, technological and economic development is to increase the efficiency of scientific research. Successful world experience shows that the contribution of scientific achievements to the growth of gross domestic product can reach 50% [12]. Of particular importance is the search for an effective model for financing the costs associated with research and development work. The purpose of the state program «Scientific and technological development of the Russian Federation» is the renewal of scientific, technical and innovative activities. According to forecasts, is expected that by 2030 an effective system of reproduction, attraction and development of intellectual potential will be formed, subject to a significant increase in budgetary and extrabudgetary funds for research and development, the creation of an advanced infrastructure for fundamental and applied research [16].

In modern conditions, insufficient investment activity significantly limits the technological development of agro-industrial enterprises, which is confirmed by the relevant statistics: of the total number of completed, accepted and recommended for implementation of scientific and technical developments, about

4% are used; technological innovations are introduced by less than 10% of enterprises. For the possibility of growth of economic indicators in the amount of 4-5% per year, it is necessary to increase the rate of accumulation of fixed capital by 25-27%. Of particular importance in the present period is the determination of priorities for fundamental and applied research, the organization of the introduction of scientific and technical products in agricultural production, and the increase in innovation and investment activity [31].

The effectiveness of investments in agricultural science in the process of innovative structural transformations [6, 29] largely depends on the stability of ties between science, government and business [8,10]. The study of this topic has been widely reflected in foreign and domestic publications. In particular, G. P Pisano [1, 15. 17, 18]. considered the problem of optimizing financial flows in the context of individual sectors of the economy. L. Lambertini, A. Palestini [11,14], presented recommendations for improving the efficiency of investments, highlighting the investment attractiveness of the regions as the most important factor. J.Zhang, Q. Xiao [35] developed specific recommendations for improving the management of investment activity. One of the most important factors in the growth of the competitiveness of the agro-industrial complex is knowledge and scientific and intellectual capital [32]. Among Russian scientists, the most significant are the works of I. G. Ushachev, A.V. Kolesnikova, V.S. Chekalin in the direction of research on budget financing of agricultural science. According to these scientists, in order to solve the problem of insufficient funding for agricultural science and the imperfection of tools to stimulate innovation, it is necessary to increase domestic spending on research in agriculture by 5–7 times. [30]. Despite the fairly broad reflection in the works of domestic and foreign scientists-economists of the problems of financing research activities in various sectors of the economy, there is a need for more in-depth studies of the impact of investment in agricultural science on the technological development of agricultural systems.

MATERIALS AND METHODS

The purpose of the study is to evaluate the effectiveness of financing agricultural science and develop a mechanism for stimulating innovative agricultural production. The methodological basis of the study was legal documents, research by foreign and Russian scientists on improving the efficiency of research funding in order to implement innovative structural transformations of the agricultural sector; monographic, abstract-logical, analytical, economic-statistical and expert methods.

Based on the compilation of theoretical and methodological approaches of Russian and foreign authors, the author's paradigm for assessing the scientific support of the agricultural sector is proposed using the conceptual provisions of the theory of innovation diffusion and knowledge absorption.

The hypothesis of the study is the assumption that the multiplicative efficiency of financing agricultural science is achieved under the condition of higher growth rates of agricultural production compared to the growth rates of investments in fixed capital of agriculture.

The hypothesis put forward was confirmed empirically: calculations were made to determine the optimal level of funding for agricultural science in order to reduce inter-regional differentiation of innovative development of agricultural production using the methodological tools of the Cobb-Douglas function.

To confirm this hypothesis, the model was linearized by taking a logarithm; based on the results of regression calculations, the parameters of the Cobb-Douglas production function were identified. These parameters make it possible to assess the mutual influence of the volume of costs for scientific research and agricultural production.

The information base for the analysis was the statistical data of Rosstat, the Higher School of Economics, the Ministry of Agriculture on

innovation, research activities in agriculture, the financing of agricultural science; expert research materials.

RESULTS AND DISCUSSIONS

With a high scientific potential, agriculture is now showing growth and is the engine of economic growth in the economy as a whole, creating the necessary jobs and gross value added. However, in Russia there is an insufficiently stable trend of inflow of investments into agriculture. Agricultural organizations are characterized by rather low involvement in innovation processes: the development of the latest scientific and technical products was carried out by only 3.1% of organizations; for comparison, in industry, the proportion of organizations implementing technological innovations is 3 times more than in agriculture. It can be assumed that this disproportion reflects the lack of practical application of the results of innovative activities in practice, the imperfection of organizational and financial mechanisms for financing agricultural science in order to stimulate the introduction of domestic innovative products and technologies in agricultural production.

The state of development of agricultural science is assessed by numerous indicators, the main of which for the purposes of the study were chosen: internal costs for research and development, including per researcher and as a percentage of gross domestic product; the number of researchers in total and per 10,000 employees; number of organizations performing research and development.

According to departmental statistics, in 2020, 206 million rubles were allocated from the federal budget. for the performance of scientific research by organizations subordinate to the Ministry of Agriculture of Russia. Amount of funding in 2017–2020 remained relatively stable, while the number of R&D topics changed markedly (Figure 1).

In the subject of agricultural sciences, research in the field of agronomy prevails (about 60%); livestock accounts for a little over 40%.

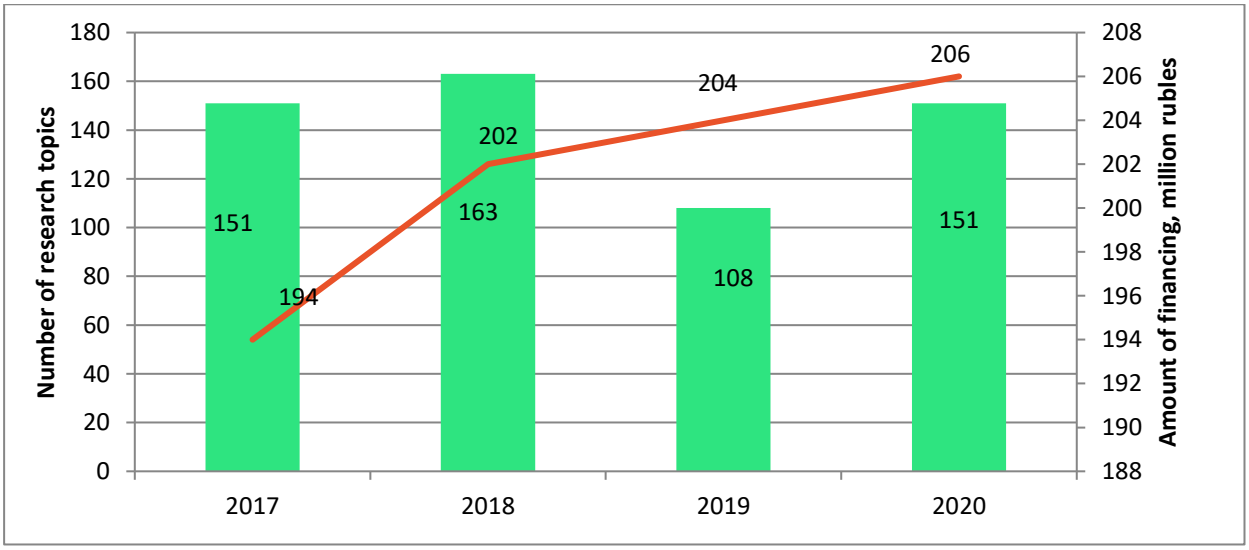

Fig. 1. Dynamics of financing of scientific activities of institutions that are in the department of the Ministry of Agriculture of Russia.
Source: Own calculations based on data [22].

The active use of elements of the precision farming system (parallel driving, informatization and monitoring, yield mapping, differentiated fertilization) allows agricultural organizations and peasant (farm) farms to create electronic field maps. It has been scientifically proven and confirmed in practice that the use of parallel driving systems increases the productivity of material and technical resources, reduces the

environmental burden on the soil, and also reduces the cost of such production resources as fuel, seeds, fertilizers, chemical plant protection products [19, 20].

Along with minimizing production costs and reducing the anthropogenic impact on the environment, the advantages of precision farming also lie in the use of new forms of production process control based on digitalization. Currently, automated production systems are widely used in large-scale production of livestock products, mainly in agricultural holdings. The introduction of modern technologies for breeding and rearing a limited number of animal breeds and poultry crosses that are in demand on the market makes it possible to achieve a reduction in resource intensity and an increase in feed conversion. The state of development of agricultural science is assessed by numerous indicators, the main of which for the purposes of the study were chosen: internal costs for research and development, including per researcher and as a percentage of gross domestic product; the number of researchers in total and per 10,000 employees; number of organizations performing research and development.

According to statistics, the share of domestic expenditure on research and development for the development of agriculture in the total volume of domestic expenditure on research and development in 2010-2019. ranged from 2.1% to 2.9%. The number of Russian organizations performing research and development has increased from 3,492 units. in 2010 to 4,175 units. in 2020 or (by 19.6%), while the number of staff engaged in research and development decreased in 2010–2020. from 73,650 people up to 67,933 people (by 7.8%); the rate of decline in the number of researchers in the period under review was somewhat lower (93.9%).

A study of the state of financial, scientific and personnel support shows Russia's significant lag behind a number of foreign countries. Thus, the ratio of domestic research and development costs to gross domestic product in 2019 was 1.03% in Russia; in Belgium - 2.68%; Germany - 3.13%; Sweden - 3.32%; Israel - 4.94%. The target parameters of the national project "Science" suggest bringing spending on Russian science to 1.2% of GDP by 2024, which will ensure only 0.15% economic growth without significant innovative transformation of most of its sectors [27].

The indicator of the number of personnel engaged in research and development per 10,000 people employed in the Russian economy (106 people in 2019) shows a lag behind advanced countries. For example, in Austria this figure was 198 people, in the UK 159, in France 174, in Germany 180 [28].

Table 1 shows the dynamics of the number of patent applications for inventions in various countries.

Table 1. Number of patent applications for inventions filed by residents at home and abroad in 2016-2019

Countries	Number of applications per 1 million people labor force, units			
	2016	2017	2018	2019
Russia	420.2	370.3	410.3	401.0
Great Britain	1,565.1	1,582.4	1,637.8	1,585.9
Germany	4,115.1	4,075.1	4,134.3	4,088.9
USA	3,211.8	3,198.8	3,113.4	3,141.5
Japan	6,829.4	6,847.7	6,734.7	6,635.4

Source: Own calculations based on data [24].

Insufficient patent activity is also confirmed by the «number of triadic «patent families» indicator, which reflects the number of patent applications filed simultaneously with the patent offices of the EU, the US and Japan. In 2010–2019 its value was in the range from 88 to 111 units, in the UK - from 1,658 to 1,825 units; in Germany - from 4,595 to 5,058 units; in the USA - from 12,743 to 14,818 units; in Japan from 17,489 to 19,295 units. The unsatisfactory state of the scientific and intellectual potential also predetermines Russia's significant lag in a number of indicators of innovative development. For

example, the level of innovative activity of Russian organizations is 7–8 than Canada, USA and Switzerland.

The proposed scientific hypothesis assumes the achievement of a multiplicative efficiency of investments in agricultural science, subject to higher growth rates of agricultural production in comparison with the growth rates of investments in fixed capital of agriculture. The calculations performed using the methodological tools of the Cobb-Douglas function confirmed the correctness of this hypothesis.

In domestic and foreign practice, the production function is widely used as a methodological tool for studying static and dynamic processes. [13, 21]. So, M. Cheng, Y. Han developed an economic growth model for the Chinese economy using a modified production function[3, 25]. Gross domestic product was interpreted as a dependent variable, and investment in fixed capital, the number of employees, and energy consumption were taken as independent variables. G.Bella, D.Liuzzi, P.Mattana used the production function apparatus to study the problem of achieving environmental sustainability at the macro level [2].

V.N. Yusim, V.S.Filippov investigated the options for using the Cobb-Dugas production function in order to build predictive models for the development of the national economy. [34].

I.B. Voskoboynikov and V.A. Bessonov substantiated the use of the modified Cobb-Douglas function to assess the dynamics of the physical volume of investments both by industry and the economy as a whole [33].

N.V. Suvorov, R. R. Akhunov, R. V. Gubarev modified the Cobb-Douglas production function to determine its dynamic parameters in the study of the development of industry in the Republic of Bashkortostan [26].

Cheremukhin, D.V. Proskura used the tools of production functions for the information array of agricultural organizations of the Nizhny Novgorod region in order to identify the impact of economic resources on the production of rapeseed, potatoes, cattle and pig meat [4].

The production function characterizes the relationship between the volume of output and factors of production. Most often in macroeconomic calculations, the two-factor Cobb-Douglas function is used, represented by the formula:

$$Y = AK^{\alpha}L^{\beta}, \quad \text{.....(1)}$$

where:

Y is the volume of output;

K and L - factors of labor and capital quantified accordingly;

A is a constant in the regression equation, which reflects the influence of hidden factors not included in the calculations and acts as an indicator of production efficiency;

α and β are parameters varying from 0 to 1 ($0 <= \alpha <= 1$, $0 <= \beta <= 1$); they characterize the elasticity of output with respect to labor and capital resources as the ratio of the marginal productivity of the corresponding resource to the average return of each unit of the resource. As a rule, the elasticity of output for each resource is a constant value.

When developing the production function model (1), new parameters were installed in the equation. For the resulting variable, the volume of agricultural output is chosen. Y - Gross agricultural output, 2019, million rubles.

The following indicators were taken as independent variables:

K - Investments in fixed assets aimed at the development of agriculture, 2019, million rubles

L is the average annual number of researchers in the field of agricultural sciences, people, 2019;

A - A constant that takes into account the influence of technical progress and other factors not explicitly represented in the model.

As an information array, data on regions - subjects of the Russian Federation were used. From the number of subjects participating in the statistical analysis, regions were excluded for which there were no separate data on indicators of investment or the number of researchers.

With the use of SPSS software products, regression models of the Cobb-Douglas

production function were built and dependencies were selected that adequately approximate the empirical material.

The scientific hypothesis was tested by linearizing the model by taking the logarithm:

$$\ln(Y) = \ln(A) + \alpha*\ln(K) + \beta*\ln(L) \quad .....(2)$$

The above formula reflects a multiple linear regression model. The variables ln(K) and ln(L) are natural logarithms of the values of the above indicators for the constituent entities of the Russian Federation.

According to the results of calculations, a model of the following type was obtained:

$$Y = 532*K^{0.45}*L^{0.23.} \quad .....(3)$$

The regression analysis parameters are presented in Table 2.

Table 2. Results of applying the regression analysis

Model	Unstandardized Coefficients		Standardized coefficients	T	Significance
	b	Standard error	β		
(Constant)	6.276	0.413		15.211	0.000
K	0.454	0.051	0.680	8.922	0.000
L	0.231	0.072	0.244	3.200	0.002

Source: Own calculations.

Determination coefficient R^2 (0.64), shows a fairly high accuracy of the selection of the regression equation and allows us to estimate the dependence of gross agricultural output on investments and the number of researchers. Calculations showed that an increase in the indicators "Investments in fixed capital aimed at the development of agriculture" and "Number of researchers in the field of agricultural sciences in the constituent entities of the Russian Federation, people" by 1% leads to an increase in the indicator "Gross agricultural output" by 0.45, respectively. % and 0.23%. Thus, an increase in investment by 1% and an increase in the number of researchers by 1% is accompanied by a slower growth in gross agricultural output, which indicates a low efficiency of investments in science [7]. The currently used forms, methods and tools of state support do not sufficiently stimulate domestic agricultural producers to use the achievements of science and technology more widely, there is no differentiated mechanism for distributing budgetary funds between organizations depending on their ability to innovate.

According to Decree of the Government of the Russian Federation of November 30, 2019 No. 1573 “On Amendments to the State Program for the Development of Agriculture and Regulation of Agricultural Products, Raw Materials and Food Markets” [5] and the development of Rules for the provision and distribution of subsidies from the federal budget to the budgets of the constituent entities of the Russian Federation to support agricultural production for certain sub-sectors of livestock and crop production are allocated compensatory and incentive subsidies, the level of which is determined according to established methods and calculations [23].

Subsidies to support new production methods are essential for sustainable agricultural development. However, at present, subsidizing is carried out without taking into account the level of innovativeness of agricultural products. It is proposed to allocate subsidies to agricultural producers, taking into account the level of innovation of manufactured products or products produced using innovative methods and technologies. However, this indicator does not take into account the level of innovation in the allocation of subsidies, depending on changes in agricultural production. Meanwhile, subsidies to support new production methods are essential for sustainable development [9].

CONCLUSIONS

In modern conditions, the task of increasing the production of agricultural products and increasing the competitiveness of products is being updated. It is necessary to improve methodological approaches to the optimal distribution of financial resources to stimulate

the introduction of scientific achievements into production. The problem of insufficient investment activity, which significantly limits the technological development of agro-industrial enterprises, involves the development of methods and tools for the optimal distribution of limited budgetary funds to finance scientific research. The results of the calculations show that in the regional context, the financing of scientific research does not affect the volume of production and the level of innovative development of agriculture. Approaches have been developed to optimize the means of financing agricultural science on the basis of the achieved criterion of innovativeness of production. The practical significance of the results of this work lies in the improvement of tools for stimulating innovative production.

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