Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 19, Issue 4, 2019
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE ANALYSIS AND FORECASTING OF EFFECT FROM INTRODUCTION OF INNOVATIVE PRODUCTS IN PLANT GROWING ON AN EXAMPLE OF THE SARATOV AREA, RUSSIA

Jury POLULYAKH, **Lubov ADADIMOVA**

Volga Research Institute of Economics and Organization of Agro-Industrial Complex, Saratov, 410010, the Saratov area, Saratov, 12 Shekhurdina Str. Phone: 8(917)3090557 E-mail: adadimova@inbox.ru

Corresponding author: adadimova@inbox.ru

Abstract

General concept of the formation and functioning of a forecasting model of scientific and technological development of the region's agriculture in the digital economy, which is forming in accordance with the well-known Federal program is proposed. It can be based on summary reporting tables of production processes in crop production and animal husbandry with electronic technological maps being connected to them, through which information about innovative products is passed in order to identify the expediency of their use in forecasting the development of agriculture. The calculation blocks are connected with an extensive and versatile information database, control and forecast modules. The main array of information on the activities of agricultural organizations is formed in the form of a multidimensional database (MO - LAP) and is subjected to full-format analysis by comparing data from full tables of different years or of different entities (organizations, regions, etc.) of annual financial statements for all types (groups)) crops, animals, products. A selection of the most satisfactory innovations and a forecast of a possible level of development of organizations in a certain perspective are presented. For this purpose, parameters and target indicators from the Agricultural Development Programs and other sectors of the agro-industrial complex are used. In the process of forecasting, the optimization of the available own resources of organizations and the budget funds of all levels identified in the programs is given in order to obtain the maximum financial result through the use of the most acceptable innovations.

Key words**:** *scientific and technical development, forecasting, agriculture, full-format analysis, a multivariate optimization*

INTRODUCTION

The address to the modeling of scientific and technological development of agriculture in the region is due to the fact that at the present time there exist several rather significant of federal level documents concerning scientific, technical and technological development of agriculture, while in the regions there are only subprograms "Technical and technological modernization", "Scientific - innovative development "for 2014–2020, adjusted and prolonged up to 2025 in connection with the adoption of the "Federal Scientific and Technical Program of the Development of Agriculture for 2017-2025"[4]. Within the regional programs "Development of agriculture and regulation of the agricultural products markets, raw materials and foodstuffs", in 2018 the projects of Pilot government programs with similar names for the years 2019-2025 are developed [13]. The programs are called pilot because it was made the attempt to change the process itself of forecasting the development of agriculture and the forms of participation in it by the state. So, if before the year 2018 the production volumes were being outlined at first, then a certain amount of financial resources for them were being allocated by the government, nowadays the government is projecting the amount of funding that should ensure the achievement of certain results.

Formally this goal was achieved, as the project and the process parts of the program took place, but in reality there is no certainty that the allocated budget funds will ensure the obtaining of the specified volume parameters, and all the more so economic indicators, as it is missed the most important link - the production process with its real costs and results. Thus, in fact, the starting point for working out a program development should be a working model of ensuring the reproduction in agriculture, through which it is possible to pass over information on the innovations introduced, the intended amount of funds sizes and to obtain the final results of production in the process of solving problems on their optimization. Based on the fact that under the conditions of the digital economy which is already being formed in accordance with the Program "Digital Economy of the Russian Federation" approved by the Government of the Russian Federation (dated July 28, 2017 No. 1632), to the basis of the model it will be possible and necessary to lay the accumulated in the management bodies of the agro-industrial complex a fairly large database of annual accounting reports of agricultural organizations, peasant (farmer) farms, individual entrepreneurs.

The purpose of the study is to substantiate the principles and to work out the methodology of forming a forecasting model for the scientific and technological development of agriculture in the region, ensuring the selection of the most effective innovative products for achieving in some perspective a given level (stage, degree) of agricultural production development or to determine this level under optimal use of the available resources and innovative products.

In this paper it was presented the example of the analysis and forecasting of effect from introduction of innovative products in plant growing the agricultural organizations of the Saratov Region.

MATERIALS AND METHODS

General scientific methods of economic research (monographic, abstract logical, system analysis and synthesis, etc.), as well as correlation analysis and economic-mathematical modeling, and database management elements are used. A large array of information was used in the form of a set of annual accounting reports of agricultural organizations in the region, presented in the form of a "multidimensional cube" (OLAP) using full-format analysis of tables.

RESULTS AND DISCUSSIONS

Analysis of scientific literature on the research topics [8, 9, 6], and the authors 'own previous workings in the field of modeling [11] made it possible to build the following concept of a forecasting model of science and technology development of agriculture in the region. Summary spreadsheets of production processes in crop production and animal husbandry of agriculture organizations should be taken as the basis, the source of information for which is the reporting (actual) data, adjusted with the help of connected electronic technological maps, through which information about specific innovative products (innovations) is passed. The incoming data receive the initial assessment based on deviations from the baseline, the results received at the output from the process tables are transmitted to other reporting spreadsheets, in which the final result, including financial, of the organizations' business activities is fixed. An economic appraisal of the effectiveness of innovations is given, their impact on the development of production is given. Individual innovations as well as some of their combinations are passed through the model, the most acceptable of them are selected for application over a certain perspective, and the final results are fixed.

This is quite a general idea of a model, and the user's task of the model is to search for necessary innovations, to collect as much as possible the full information about them, and to enter it into the input block of technological maps, or directly into the calculation (process) matrices (tables) of the model, and then analyze the primary (process) and final financial and economic results. A sufficiently extensive and diversified database, which possesses mechanisms of the primary processing of information about innovative products and their selection for the use in forecasting should be attached to the design schemes. Modeling is based on the developed by the authors' method of full-format analysis and the forecast of annual reproduction cycles according to the annual reporting forms of agricultural organizations.

The fundamental part of the model is the module of product reproduction and production results, which can be obtained on the basis of two forms of the annual report of the agricultural organization: No. 9-AIC "Report on production, costs, cost price and sales of crop production" and No. 13-AIC "Report on production, cost of production and sales of animal husbandry". Its initial task is to assess reproduction processes by comparing the data of the last reporting year with the previous one or with any other year from some retrospective.

At first, the two adjacent years are compared in full scale on each table to identify the changes that occurred: areas (livestock), costs in general and individual items of expenses that at the same time characterize or show the movement of working capital (seeds, fertilizers, plant protection products, feed, etc.) and fixed assets (the cost of their maintenance), as well as the energy intensity of production (the cost of electricity and the cost of petroleum products). The results of comparisons in the form of absolute and relative deviations are recorded in four similar tables (forms No. 9-AIC and No. 13-AIC). Based on the data received, the following is established: what kind of reproduction (simple, expanded, narrowed) corresponds to the processes that have occurred during the last year in the industry, culture, type of livestock, products, etc.; which type (extensive or intensive) can be attributed to reproduction in each particular case and what factors contributed to this. Based on the correlation analysis in the "multidimensional cube" [5, p. 205] of these tables, influence factors coefficients on the results and interrelations of factors are determined, which are used further in forecasting.

For forecasting similar forecast matrix tables are created. Last reporting year becomes basic. Based on its data, standard costs are calculating in one of the tables per 1 hectare (livestock) and 1 centner of production (constants C and V), for which the resource requirements for the projected areas (livestock) and the production volumes are determined with possible adjustments taken into account.

To evaluate the effectiveness and selection of innovative products information from the "Federal Scientific and Technical Program for the Development of Agriculture for 2017–2025" is used. The foreseen events and application data are skipped through the evaluation module. The "events" of the relevant regional programs, including scientific and technological development (STD), undergo a more substantive and thorough procedure in order to determine the influence on growth and production efficiency through the use of: seeds of new domestic varieties, pedigree products (material), high-quality feed, feed additives for animals, drugs for veterinary use, pesticides and agrochemicals of biological origin, etc.

Reliable information on the development of "science and innovations" is urgently needed, and moreover, in dynamics, in order to have the possibility to identify trends in the emergence and advancement of innovations, on the one hand, and to find patterns, connections, influence and mutual influence of various components of innovative activities of organizations, on the other. No doubt, information about the branch science and innovation in the field of agricultural complex is the most important, especially at the regional level. But since it is clearly not enough, indirect estimates should be resorted to. In particular, the model provides an analytical block of basic statistical information, which had already allowed to get some of the dependencies and relationships between the indicators of innovation activity in the regions of the Russian Federation and in other areas.

The estimates of the innovation indices of the RF subjects [1] accumulated by the Institute for Statistical Studies and Economics of Knowledge of the National Research University Higher School of Economics (HSE) are very interesting and important.

Since the model is called upon not only to predict agricultural development, but also to solve more complex tasks, it is necessary to evaluate available at present innovative products and to predict the possibility of their appearance in the future, to obtain the most complete characterization and to determine the effectiveness of application in the conditions of the region, taking into account the existing soil climatic diversity. The characteristic of each innovative product should be sufficiently complete so that it can be attributed to one of the categories (groups) of innovations that improve: product quality; crop yield (animal productivity); labor productivity. The effectiveness of each innovative product is primarily evaluated by the formulas developed by the authors.

In addition innovative products (innovations) are differentiated by connection with the reproduction process. In particular, if the essence of the innovation is the replacement of ordinary seeds of agricultural crops with seeds of a well-known selection, which increase the yield of a particular crop, its effect is the increase of a yield, but it requires some expenditures for more expensive seeds. It is necessary to include additional costs for new seeds and the result of their use in the reproduction process with the help of a technological map or directly through the calculation block of Table No. 9-AIC using formula 1.

$$\sum_{j=1}^{I} Q_{sSTDj} = \sum_{j=1}^{I} (Z_{sbj} + K_{sj} * S_j * (\mathrm{P}_{\mathrm{sSTDj}} - \mathrm{P}_{\mathrm{sbj}}) * (\mathrm{N}_{\mathrm{sbj}} - \mathrm{N}_{\mathrm{sSTDj}})) \quad (1)$$

where: Zsem - the cost of purchasing seeds, thousand rubles; Ps - the price of 1 centner of seeds, thousand rubles; Nssem - seed rate, c / ha; Sj is the seeding area of the jth culture; Ks - share of the area of sowing with high-yielding seeds, units. The symbols "b" and "STD" - respectively: basic, i.e. commonly used seeds (b), seeds of better quality (STD).

It means that the costs are corrected for all (although not necessarily) agricultural crops, taking into account the proportion of the area sown with better seeds (Ks), as well as the differences in price and seeding rate. The increase in agricultural crops yields is reflected in the gross yield of products according to the formula 2:

$$\sum_{j=1}^{I} Q_{tg\,STD} = \sum_{j=1}^{I} (Q_{\mathrm{tg\,j}} + K_{S\,j} * S_j * (\mathrm{U}_{\mathrm{STDj}} - \mathrm{U}_{\mathrm{b\,j}})) \quad (2)$$

where: Qsb - gross yield of the j-th crop, c; Ustd-Ub is the yield, respectively, of the new variety (seeds are of higher quality) and the base one c / ha.

Similarly, calculations are carried out for fertilizers, plant protection products, etc.

The next group of innovations is related to the applied technology. In this case the calculations are much more complicated. They can be performed: as for individual technological operations, and as well as on an average level for the whole range of work; both in each culture and on the whole across their entirety. The third group combines innovations in the form of individual technological operations or technologies. This is true in particular, when speaking about resource-saving technologies and precision agriculture, which can be most reliably evaluated directly in technological maps, comparing the results of calculations using new and existing technologies.

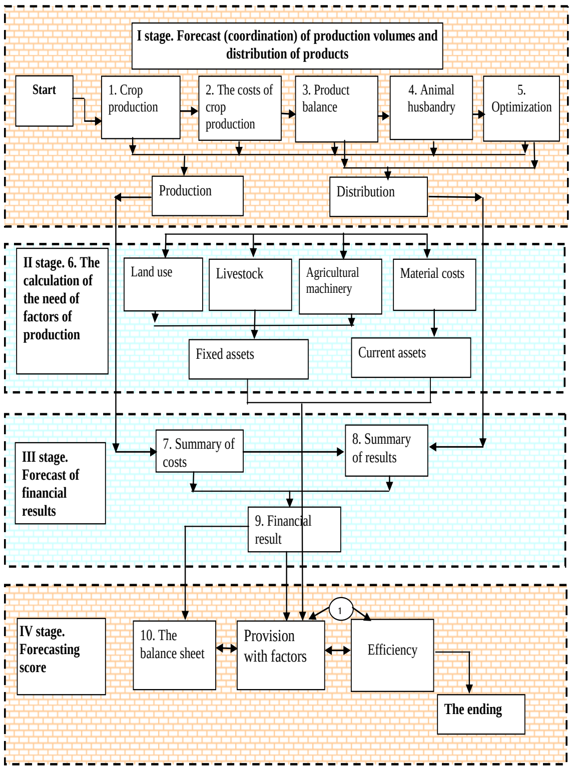

Fig. 1. A forecasting scheme of agricultural organizations scientific and technological development
Source: author's elaboration.

The most important advantage of the model is that individual innovations and/or their summations are tested for effectiveness by applying to the operating mechanism the entire economic complex of agricultural organizations. Primary estimates obtained directly in the process tables are transferred to other spreadsheets of the organizations' annual report, adjusting the final financial result (Fig.1).

According to the authors research, it is advisable to manage the scientific and technical development of agriculture in the region with the help of adaptive economic and mathematical models, which include the family of models developed earlier by the authors, based on a technological and soil-climate basis.. The task of the control module is to find the necessary innovative products, make a characteristic of each of them and connect to the design matrices. The forecast module should fulfill: to evaluate the found innovative products, to select the most acceptable ones, form some combination of them and optimize its use [14, 15] on the basis of solving direct and inverse problems.

In this case it should be assumed that, in close-up, the purpose of the model is the transfer of modern production to a higher scientific and technical stage of its development, by applying (introducing) a certain set of innovative products. Therefore, in a direct task, you need to lay a certain level or stage (step) of development on the life cycle curve of the agro-production system [2] the direct task must be to lay and to calculate the amount of additional resources and innovative products it will be required for this purpose, while in the inverse task it is necessary to determine the level or stage (step), which producers can achieve by rationally using all available resources and innovative products.

For solving of those two tasks, it is necessary to select the necessary means and apply the method of multivariate optimization [14] of resource use and the application of innovative products.

Verification of the model's performance was carried out on the materials of agriculture in the Saratov region. Annual reports of agricultural organizations in the region were used as a source base, and the "Federal scientific and technical program of the development of agriculture", as well as regional programs of agro-industrial development, served as guidelines for the prospects for the development of agricultural production served. In developing a forecast of innovative development the authors took as a base the results of scientific research of the elaboration of scientific institutions and researchers in the field of agricultural science and technology.

Within the given article it is not possible to demonstrate all the model capabilities in its practical use; therefore, only some fragments of the mechanism and results of the innovation assessment can be cited. In particular, the model envisages the introduction of precision farming technology, with taking into account the results of I.A. Petrova and N.S. Grigoryeva [10], which states that the most important component of precision farming is the differential application of fertilizers. Unfortunately, they only state that in the structure of the cost of crop production fertilizer costs make up a significant share, but do not demonstrate the structure itself, not going beyond the results of calculating economic efficiency. The imposition of all the available information, after some of its revision, on the results of winter crops cultivation in agricultural enterprises of the Saratov region in 2016 in the evaluation module showed that that the performance of differential fertilizer application operations only on half of the sown area of these crops makes it possible to reduce the cost of a unit of all production (grains of winter crops) by 31.4% due to faster growth of the crop compared to cost increases. The overall economic effect is estimated at more than 2.0 billion rubles.

The effect of cultivating winter crops improves general indicators of crop production, which in the working model spread to other sectors, primarily to livestock (in the form of №. 13-AIC), through form №. 16-AIC "Product Balance" in the column "allocated feed". Changes may occur in the processing of raw materials, both within farms and when it is delivered for industrial processing. Ultimately, all this will be reflected in the overall financial result (form № 2 in OKUD).

At the same time, the results of another study [3] show that the effect of the precision farming system expands due to cost savings when performing precise driving of aggregates, when re-processing of already processed plots (the so-called “overlaps”) is excluded and uncultivated areas are not allowed (“passes ").

The model reflects the results of a study by scientists of the Agricultural Research Institute of South-East Region (ARISER) A.I. Shibaev and Z.M. Azizov [12], who substantiate the efficiency of resource saving. In particular, attention is drawn to agricultural practices under which it is possible "on chernozem soils ... without reducing the productivity of winter and spring crops, in order to save resources, use small plowing, cultivating with preliminary stubble cultivation or subsurface cultivation, in the second link - plowing of different depths" [12, p. 30]. It is clear that this is only about not reducing yields, although, in fact, everything is not so simple. From the table given in the article, it can be seen that only in variant 3 with different tillage depths for different crops a higher yield was obtained, although not significantly (1.64 t/ha compared to 1.62 t/ha - within the statistical error) so it can be affirmed that only with such soil treatment it is possible “not to reduce yield”, and in the other three options it decreases. Moreover, in the fourth variant in the way, so that labor costs and fuel cost per 1 ton of grain do not decrease, but increase, i.e. specific resources are not saved, but, on the contrary, are not used efficiently.

Some transformation of the information provided, including with the assumption to obtain more prominent results of adopting the worst (fourth) variant as the base one, allowed us to obtain coefficients (correlations to the base), with which the results of the study [12] can be connected to a more complete assessment of economic efficiency of the model developed by the authors.

To evaluate technical and technological innovations, we used the results of the study of the sector of stimulating the development of industries of the Volga Research Institute of Economics and Organization of Agro-Industrial Complex (VRIEOAIC), described in [6]. In particular, the developed by the sector employees the technological map of the cultivation of early spring grain crops (wheat, oats, barley) in the western and central right-bank microzones of the Saratov region [7, p. 52] is presented in three versions: based on the use of the traditional domestic technology (variant I); with the inclusion of some types of foreign machines and implements (variant II); using the combined aggregates (variant III). It contains data per 1 ha of cultivated area on labor costs, density of mechanized work (conditional standard Ha), seed sowing rate, fertilizer dose and consumption of fuel and lubricants (oil products). It is characteristic that variants differ only in labor costs, density of work and oil product consumption. Information is given on the main periods of technological operations implementation and on technology in general. The difference between the second variant (with foreign equipment) and the first variant is insignificant: the reduction in labor costs is only 5.42%, in the oil products consumption is 2.29%, and there is no difference at all in the density of mechanized work.

A significant effect can be obtained if the third variant is applied with the use of combined aggregates that perform several technological operations in one pass. It is formed exclusively due to the saving of resources (labor and oil products) at the same level of productivity. In this case if to compare with the first variant, labor costs are reduced to 76.1%, the density of work is reduced to 63%, and the consumption of oil products is reduced to 41%. Depending on the density of work, the cost of repairing equipment can be reduced by 63%. The obtained data can be transferred into the coefficients of change of these indicators and input them into the developed model in order to find an economic effect of full value.

In federal and regional programs of scientific and technological development, much attention is given to the development and implementation of new domestic high-yielding varieties of agricultural crops and highly productive animal breeds, therefore, the developed model highlights the blocks of evaluating existing and newly emerging innovative products (seed varieties, animal breeds, etc.), adapted to reporting forms № 9-AIC (crop production) and 13-AIC (livestock production). Products with the highest scores are transferred to the corresponding forecast tables (Table 1).

Table 1. Forecast of the effect of introducing new varieties of agricultural crops in the form of № 9-AIC of the annual reporting of agricultural enterprises of the Saratov region (random case, variant III)

Crop	**Sown area, ha**	**Total costs, '000 rubles**	**including seeds and planting material, '000 rubles**		**Output (actually), centners**
			total	1 ha	
1	2	3	4	5	6
Winter cereals	493,483.5	6,454,751.4	588,090.5	1.19	13,252,292
Spring cereals	475,412.8	3,714,572.0	637,474.0	1.34	6,293,103
Legumes	78,685.0	950,512.0	191,711.0	2.44	711,352
Corn for grain	43,388.0	919,832.0	204,705.0	4.72	1,659,965
Soybean	16,139.0	473,142.0	50,986.0	3.16	297,020
Sugar beet	7,636.0	345,922.0	55,325.0	7.25	2,809,503
Sunflower seed	631,062.4	8,078,853.1	1,781,809.0	2.82	7,110,605
Falseflax	10,998.0	54,564.0	4,194.0	0.38	49,544
Potatoes	484.5	85,574.0	35,093.0	72.43	89,720
Open ground vegetables	1,330.6	220,476.7	43,927.0	33.01	425,574
Sheltered Ground Vegetables	84.0	1,497,172.0	40,147.0	478.18	302,465
Gourds	3,460.0	14,096.1	3,411.8	0.99	401,100
Silage corn and green feed	14,626.0	229,321.0	20,088.0	1.37	2,135,573
Silage crops	554.0	4,213.0	613.0	1.11	49,187
Total crop production	**1,938,713.0**	**24,573,443.0**	**3,757,718.3**	**1.94**	**72,072,153**

Table 1. Continuation.

Share of sown area with innovation %	**Coefficients of innovative products, units**			**The increase of seeds cost. '000 rubles**	**Output growth, centners**	**Economic effect (cost reduction)**		
	Prices	Seeding norms	Land productivity			per 1 centner, '000 rubles	total, '000 rubles	% of base cost
7	8	9	10	11	12	13	14	15
0.5	1.5	0.9	1.4	102,915.8	2,684,550.2	0.08	1,317,835.2	20.5
0.5	1.5	0.9	1.4	111,558.0	1,331,155.8	0.09	713,710.0	19.0
0.5	1.5	0.9	1.4	33,549.4	143,206.7	0.21	177,028.2	18.4
0.5	1.5	0.9	1.4	35,823.4	349,707.3	0.09	175,891.7	18.8
0.5	1.5	0.9	1.4	8,922.6	59,714.3	0.27	95,840.2	20.3
0.5	0.5	0.9	1.4	-15,214.4	574,685.4	0.03	92,601.6	28.6
0.5	1.5	0.9	1.4	311,816.6	1,438,822.3	0.17	1,490,319.1	18.1
1.0	1.2	1.0	1.1	838.8	5,609.0	0.11	6,112.7	11.3
0.5	0.5	0.9	1.4	-9,650.6	18,168.8	0.26	28,498.3	38.3
0.5	1.5	0.9	1.4	7,687.2	87,074.5	0.08	41,987.1	18.8
1.0	1.2	1.0	1.1	8,029.4	302.2	0.08	23,570.2	1.6
1.0	1.2	1.0	1.1	682.4	40,828.0	0.00	1,046.5	7.2
1.0	1.2	1.0	1.1	4,017.6	213,539.6	0.01	23,575.9	10.3
1.0	1.2	1.0	1.0	122.6	0.0	0.00	-36.0	-0.8
				203,426.9	**7,004,725.3**	**0.25**	**7,541,880.7**	**31.1**

Source: calculated by the authors according to the consolidated annual report of agricultural organizations of the Saratov region for 2016.

Table 1 shows the results of evaluating the effect of the introduction of seeds of new varieties according to a variant of the contingent example, in which the coefficients characterizing the deviations of the indicators of new varieties from those used in 2016 are placed in columns 5-8. In this case, since the calculations are demo, the coefficients for grain and leguminous crops are assumed to be the same, which is not necessary, and even, conversely, they most likely should be different. At the same time, when making comparative assessments of the reaction of various crops to an innovative product, it is better to use exactly the same coefficients, which this table confirms.

In the given example, the total scatter of the relative effect is in the range from –0.8% to +38.3%.

The table below is only a fragment of the general form (template) in which one can evaluate any innovative products and predict the possible economic results of the activity of agricultural organizations, extending them to other organizational forms of agricultural production.

CONCLUSIONS

An important result of the carried out study is the formation of ideas about the scientific and technological development of agriculture, as a set of processes: creating research and development results in the agricultural and other branches of science; their promotion and implementation in production; mastering and effective use of commodity producers, ensuring the transition of production systems to the next stage (level) of economic growth along the ascending branch of the life cycle.

The proposed model of forecasting scientific and technological development of agriculture in the region allows to accumulate volumetric parameters and target indicators from the existing agricultural development programs and other sectors of the agro-industrial sector, funds allocated for their achievement from budgets of all levels and own resources of agricultural organizations. Optimization of their use and selection of the most effective innovative products ensures obtaining the highest possible economic result necessary for the transition of agriculture in the region to a new stage (stage) of its development.

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