Modeling of Scientific and Technological Development of Agriculture in the Region

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Abstract. The concept of the formation and functioning of the model of forecasting of scientific and technological development of agriculture is presented, which allows to solve a number of scientific and applied problems of forecasting of innovative development of agricultural production, of evaluating the effectiveness of existing and emerging at the market innovative products and technologies, as well as establishing already at the development level, the parameters of such products, acceptable for specific conditions of usage, to control the implementation of the “Federal Scientific and Technical Program of the development of agriculture in the years 2017-2025 ” as well as similar regional programs. The model is based on the information of the consolidated annual financial statements of agricultural producers, which characterizes production processes in plant growing, animal husbandry and the processing of agricultural raw materials. It consists of calculating and analytical blocks, reproduction, evaluation, control and forecast modules. The model can become an important component of the emerging digital economy of the agro-industrial complex, because it relies on a big multidimensional array of information, exposing it to analysis in full format by comparing data from the financial statements tables for different years, from different subjects of all types (groups) of crops, animals, products.

In the process of forecasting, the selection of the most acceptable innovations is carried out, the parameters and purpose indicators of the Programs of the development of agriculture and other branches of the agro-industrial complex are used; the optimization of existing self resources of organizations and budget funds of all levels in order to obtain the maximum financial result from the appliance of the most preferable innovations is carried out.

1. 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 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 ”[1]. Within the regional programs “Development of agriculture and regulation of the agricultural products markets, raw materials and foodstuffs”, in 2018 Pilot government programs with similar names for the years 2019-2025 were being developed [2]. The programs are called pilot ones as they have attempted to change the very process of forecasting of the development of agriculture and the forms of...
participation in it by the state. It means that if before the year 2018 at first the production volumes were being outlined, then a certain amount of financial resources for them were being allocated by the government, now the government is projecting the amount of funding that should ensure the achievement of certain results.

This goal has been achieved formally, as the project and process parts of the programs have taken place, but 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 the most important link is missed - the production process with its real costs and results. So, in fact, the starting point for working out a development program should be a working model which ensure reproduction in agriculture, across which it is possible to pass over information on the innovations introduced, the intended amount of resources and to get 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 [2, 3], 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), the basis of the model will be possible and necessary to lay 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 and enterprises which process agricultural raw materials.

2. The purpose of the study
The purpose is to substantiate the principles and to work out a methodology for 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 given level (stage, stage) of agricultural production development or to determine this level under optimal use of available resources and innovative products.

3. Materials and research 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.

4. The results of the study
The analysis of the scientific literature in the field of scientific and technological development [4–12], modeling [13–15], and the authors’ own previous workings in the field of modeling [16, 21] made it possible to build the following concept of a forecasting model of science and technology development of agriculture in the region. Summary electronic tables 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 passes the initial assessment based on deviations from the baseline, and the results obtained at the output of the tables of process are transferred to other reporting electronic spreadsheets, which record the final, including financial, result of the organizations' business activities.

An economic assessment of the effectiveness of innovations is given, their impact on the development of production is determined. 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, with the user’s task of it is to search the required innovations, collect as much information as possible about them, and 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 versatile 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 calculating 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 [16, 22].

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 the beginning, 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). According to the obtained data, it 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 it. Based on the correlation analysis in the "multidimensional cube" [17, p. 205] of these tables, coefficients of factors influence on the results and interrelations of factors are determined, which are then used in forecasting.

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

Information from the “Federal Scientific and Technical Program for the Development of Agriculture for 2017–2025” is used to evaluate the effectiveness and selection of innovative products. 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. Of course, information about the branch science and innovation in the field of agricultural complex is the most important, especially at the regional level. But as it is obviously not enough, it is necessary to betake to indirect estimates. In particular, the analytical block of basic statistical information, which allows you 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 is foreseen in the model. The estimates of the innovation indices of the RF subjects [18] 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.
5. Discussion
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 algorithms developed by the authors.

Innovative products (innovations), in addition, 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. Additional costs for new seeds and the result of their use must be included 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:

\[ \sum_{j=1}^{I} (Q_{z,STD}) = \sum_{j=1}^{I} (Z_{sbj} + K_{j} * S_{j} * (P_{STD} - P_{sbj}) * (N_{sbj} - N_{s,STD})) \]

where: \( Z_{sem} \) - the cost of purchasing seeds, thousand rubles; \( P_{s} \) - the price of 1 centner of seeds, thousand rubles; \( N_{s} \) - seed rate, c / ha; \( S_{j} \) is the seeding area of the jth culture; \( K_{j} \) - 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).

This 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, 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:

\[ \sum_{j=1}^{I} (Q_{z,STD}) = \sum_{j=1}^{I} (Q_{gyj} + K_{S_{j}} * S_{j} * (U_{STD} - U_{b,j})) \]

where: \( Q_{gyj} \) - gross yield of the j-th crop, c; \( U_{STD} \) and \( U_{b,j} \) is the yield, respectively, of the new variety (seeds are of higher quality) and the base one, centners per hectare. Similarly, calculations are carried out for fertilizers, plant protection products, etc. in crop production, as well as for feed, feed additives, etc. in animal husbandry.

The next group of innovations is related to the applied technology. Here 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. We speak in particular, 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.

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 electronic spreadsheets of the organizations' annual report, adjusting the final financial result (figure1).
Within the framework of this article it is not possible to demonstrate the possibilities of the model in the detail in its practical use, therefore, only some fragments of the mechanism and results of evaluating of innovations can be cited using the example of precision farming technology in the cultivation of winter wheat described by I.A. Petrov and N.S. Grigoriev in [23], in which, according to the authors, the most important component is the differential application of fertilizers. Unfortunately, they only state that the cost of fertilizers in the structure of the cost of plant production is a significant proportion, but does not demonstrate the structure itself, they limit themselves to the results of calculating economic efficiency. The overlay of all available information, after some of its refinement, on the results of winter crops cultivation in agricultural organizations of the Saratov region in 2016 in the evaluation module showed that performing operations on differential fertilization only on the half of the crop area of these crops make it possible to reduce unit cost of production (winter cereal grains) by 31.4% due to faster growth of the crop (1.33 times) compared with costs (1.013 times). The total economic effect is estimated at more than 2.0 billion rubles.

In the structure of the cost price of 1 centner of grain of winter crops, the share of material costs, mainly due to an increase in the application of mineral fertilizers and plant protection products, increases from 47.6% to 51.0%, and the labor costs are reduced almost 1.6 times (from 16.4% to 10.4%), with a slight increase (by 6.9%) of the cost of maintaining fixed assets. At the same time, labor productivity increases by 2.07 times, and since the labor remuneration per 1 thousand man hours did not change, although it should have increased slightly, it is possible to fix a double advance of labor productivity growth as compared to the growth of the salary.

The effect of cultivating winter crops improves general indicators of crop production.
Table 1. Evaluation of the effectiveness of introducing perspective technologies in crop production of agricultural organizations on the example of the cultivation of winter grain crops (according to agricultural organizations of the Saratov region in the year 2016 using information from I.A. Petrova and N.S. Grigorieva [24]).

| Options | Indicator | Area, thous. ha | Costs - total, million rubles | of them: salary with social contributions | mineral fertilizers | plant chemical protection products | oil products | maint enance of fixed assets |
|---------|-----------|-----------------|-------------------------------|-------------------------------------|---------------------|-----------------------------------|--------------|-----------------------------|
| 1       | Standards | 2               | 3                             | 4                                  | 5                   | 6                                 | 7            | 8                           |
|         | Winter cereals (basic values) |                |                               |                                     |                     |                                   |              |                             |
|         | Growth factors (decrease) | 0,50            | 0,284                         | 1,21                               | 1,09                | 0,93                             | 1,05         |                             |
|         | Value of the indicator | 493             | 6164                          | 508,6                              | 278,2               | 415,5                            | 979,3        | 1788                        |
| 2       | II        | 0,50            | 0,289                         | 1,47                               | 2,00                | 0,89                             | 1,17         |                             |
|         | Value of the indicator | 493             | 6540                          | 510,6                              | 311,4               | 596,6                            | 955,5        | 1889                        |
|         | In total on plant growing | 1939           | 24573                         | 2919                               | 855,5               | 1808                             | 3350         | 5941                        |
|         | In view of II var. in winter crops | 1939           | 24283                         | 2636                               | 881,9               | 1825                             | 3315         | 5986                        |
|         | In view of III var. in winter crops | 1939           | 24659                         | 2638                               | 915,2               | 2006                             | 3291         | 6087                        |

The table presents the evaluation of the effectiveness of introducing perspective technologies in crop production of agricultural organizations, focusing on the cultivation of winter grain crops. The evaluation is based on data from agricultural organizations in the Saratov region for the year 2016, utilizing information from I.A. Petrova and N.S. Grigorieva [24].
In a fully working model, the effect of crop production extends to other sectors, primarily to livestock, using Form No. 16 “Product Balance”, in the “provided feeds” column. Changes may occur in the processing of raw materials of our own, within the framework of the farms, as well as the deliveries for industrial processing and, ultimately, on the overall financial result (Form No. 2 according to OKUD).

At the same time, 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, when optimizing the use of resources in a direct task, you need to lay a certain level or stage (stage) of development on the life cycle curve of the agricultural production system [16, 21] in the form of criteria (indicators) to be achieved, and to determine how many and what innovative products, in which industries (sub-sectors) it is necessary to be implemented, as well as how much and what kind of resources for this need should be attracted by applying certain means. When solving the inverse problem, it is necessary to proceed from the fact that commodity producers have (accumulated) a certain amounts of resources for introducing a certain set of innovative products, and it is required to determine: to what level of development the production can move by applying these resources and products.

To solve the two problems, it is necessary to select the necessary means and apply the method of multidimensional optimization [19, 20] of resource use and the application of innovative products.

| Direct labor costs, thousand man-hours. | Output Total thousand centner from 1 ha, c | Cost price Total millions rubles | Production units, thousand rubles | The economic effect (cost reduction) in the calculation of 1 centner, thousand rubles. | Total millions roubles | in% to the original data |
|---|---|---|---|---|---|---|
| 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 12098 | 13252 | 27 | 6428,7 | 0,485 | 0,000 | 0,00 | 0,00 |
| 0,284 | 1,167 |
| 7767 | 15465 | 31,34 | 6139,4 | 0,397 | 0,088 | 1362,9 | 21,20 |
| 0,289 | 1,333 |
| 7797 | 17665 | 35,80 | 6514,1 | 0,369 | 0,116 | 2055,4 | 31,97 |
| 17581 | 72072 | 37,18 | 24475 | 0,340 | 0,000 | 0,00 | 0,00 |
| 14968 | 74285 | 41,31 | 24186 | 0,326 | 0,014 | 1040,8 | 4,25 |
| 15137 | 76485 | 45,77 | 24560 | 0,321 | 0,018 | 1413,3 | 5,77 |
6. Conclusion
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; development and effective use by 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, as well as 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 ensure obtaining the highest possible economic result necessary for the transition of agriculture in the region to a new stage (stage) of its development.

7. References
[1] Decree of the Government of the Russian Federation from August 25 2017 No 996 “On Approval of the Federal Scientific and Technical Program for the Development of Agriculture for 2017–2025” http://www.consultant.ru
[2] Normative regulation of the Digital economy Article on the development of normative and legal acts in the framework of the implementation of the program "Digital Economy" http://www.tadviser.ru/index.php
[3] Vaipan V A Fundamentals of legal regulation of the digital economy http://otrasli-prava.rf/article/26874, http://otrasli-prava.rf/article/26874
[4] Markova G V 2014 Sustainability of reproduction as a condition for the implementation of state program solutions for agricultural development Economics of agricultural and processing enterprises 4 39-44
[5] Kostyuchenko T N 2013 Features of the reproductive process in agriculture: monograph Stavropol: AGRUS Stavropol State Agrarian University 156
[6] The experts of the CSR stated the need for a technological revolution in Russia https://www.finam.ru/analysis/newsitem/csr-zayavili-o-neobxodimosti-v-rossii-tekhnologicheskoi-revolutsii-20171012-124757
[7] 2017 New technological revolution: challenges and opportunities for Russia Expert-analytical report 136
[8] Scientific and technical development http://www.ngpedia.ru/id361353 p1.html
[9] Rating success of regions is determined by the quality of innovation policy https://www.eg-online.ru/article/348351
[10] Order of the Ministry of Agriculture of the Russian Federation dated January 12 2017 No 3 “On the Forecast of the Scientific and Technological Development of the Agro-Industrial Complex of the Russian Federation for the Period up to 2030
http://docs.cntd.ru/document/456038646
[11] 2011 Resource-saving technologies: state, prospects, efficiency: scientific M.: Federal State Budget Scientific Institution Rosinformagrotekh 156
[12] Nureev R M 2008 Economy of development: models of becoming of market economy (the textbook. 2 edition advanced and added) M.: Norm 640
[13] Pacioli L, Sokolov I 2001 Traktat about accounts and records, with notes and additions of the Sokolov I M.: the Finance and statistics 368
[14] Kostyuchenko T N, Sidorova D V 2013 Features of renewal of production in an agriculture: the monography Stavropol: AIPYC Stavropol state agrarian university 156
[17] Polulyakh Y G, Adadimova L Y 2018 Model of maintenance of reproduction as base of scientific and technical development of agrarian and industrial complex the Scientific review: the theory and practice 1 60-68

[18] Cornell P 2006 Item the Analysis of data in Excel Simply as twice two Just like twice two, trans. with English 224

[19] Abdrakhmanova G I, Bakhtin P D, Gokhberg L M, Ditkovsky K A, Islankina E A, Kindras A A, Kovaleva G G, Kovaleva N V, Kuznetsova V I, Kuznetsova I A, Kuzmin G N, Kuzminov I F, Kutsenko E S, Martynov D M, Martynova S V, Nechaeva E G, Ratay T V, Sagieva G S, Streltsova E A, Timofeev A A, Tochilina E E, Fridlyanov S Y, Fursov K S 2017 A rating of innovative development of subjects of the Russian Federation Release 5 National research university «the Higher school of economy» 260

[20] Zhdanov I Yu Formation of investment portfolio by Harry Markowitz http://finzz.ru/formirovanie-investicionnogo-portfelya-markovica-v-excel

[21] Timirova A N Propert of model Markowitz at the task of parameters means of the theory of indistinct sets http://www.intsys.msu.ru/magazine/archive/v16 (1-4) /timirova-203-214.pdf

[22] Adadimova L Y, Kotelnikov V I, Ojdup T M, Polulyakh Y G 2017 Modelling of steady development of rural territories in view of change of a climate in geoinformation systems InterCartographical/ InterGIS - 23 The Geosupply with information of steady development of territories in conditions of global changes of a climate: materials of the International conference 1 (Yuzhno-Sakhalinsk on June 26-28th 2017) M.: Publishing house of the Moscow university 172-183

[23] Adadimova L Y, Polulyakh Y G, Belokon M V 2017 Modelling in a full format of the analysis of reproduction in an agriculture region the Scientific review: the theory and practice 6 73-86

[24] Peter I A, Grigoriev N S 2016 The organizational-economic mechanism of cost of introduction of technologies of exact agriculture The agrarian scientific bulletin 10 96-100