Planning agro-industrial complex strategies using digital technologies

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Abstract. The authors revealed the relevance of planning efficiency indicators for the formation and development of objects of the agro-industrial complex using digital technologies. Excessive strategic gaps in performance indicators and the scale of their use with the level of developed countries have been established. Planned approaches to reducing gaps based on the methodology of integration-balancing management and modeling of integration processes of methods and resources of objects in the complex are proposed. The combination of methods and resources for the development of complex objects using Big Data and Data Science tools has been substantiated. It is proposed to evaluate the impact of the instruments in the cycles of planning and investment processes for long-term strategic development. The importance of the condition for balancing the interests of producers and consumers of digital technologies has been determined. Balance is assessed by the criterion for selecting design solutions within the zone of minimum total costs for the formation and development of the complex. Such solutions make it possible to adjust the timing of the implementation of plans, the size of investments and increase the efficiency of development using digital technologies. For the correction, a methodology has been developed for predicting the elements of digital technology according to the criterion of the minimum total costs in the strategic development cycle.

1. Introduction

The needs of agriculture to improve strategic development planning in terms of sustainability of the processes of effective development of the agro-industrial complex (AIC) are growing in the context of the economic crisis. The global economic losses from the COVID-19 virus alone can amount up to three trillion US dollars, according to the Bloomberg forecast [1]. Such external factors directly affect the financial and economic efficiency and sustainability of the processes of innovative development of industrial enterprises. In 2020, the state budget deficit increased, which reduces the dynamics of positive changes in Russia in the period of 2011-2019 [2,3].

The long-term plans for high-tech transformations are determined by the project to create a national platform "Digital Agriculture" until 1924 [4]. The project plans to create a digital platform that allows integrating the capabilities of technologies and a special system for managing the digital interaction of objects and technology elements using the Internet of Things method. An analysis of business tools for creating technologies in the agro-industrial complex with an assessment of expert opinions in this area confirms the feasibility of high-tech transformations of its individual objects [5]. New organizational models and techniques are needed to implement business processes in accordance with the results of mathematical modeling. This is required to improve efficiency of the processes of ensuring results with
high added value is necessary complementary integration of diversified resources of high-tech innovation development (HTID) of objects of different purposes in the ACC.

2 The relevance of improving strategic planning in the context of digital interaction of objects of the agro-industrial complex

The need to take into account the stages of strategic planning follows from the fact that business in agriculture has a long production cycle. The results are subject to natural risks of losing part of the crop. Digital technologies in the Russian Federation are insufficiently applied in the cultivation, collection and storage of agricultural crops. Crisis events affect financial resources, opportunities to improve the competence of personnel and reduce the ability to automate biological processes. The well-known Big Dat methods are not enough for a radical increase in labor productivity and innovative technologies. Therefore, it is necessary to use digital technologies of advanced analytics such as Data Science. This trend is in line with the goals of creating a national platform. The use of complex Dat Science toolkit provides results suitable for automatic reading. This is shown by the application of a combined approach to the analysis and regulation of processes in the concept of integration-balancing regulation of processes. The increase in the efficiency of technologies by combining technical and organizational methods in a complex of objects has been substantiated [6]. The solution of the initial problems of developing tools in the specified articles of this conference (A. Alabugina and R. Alabugina) substantiated the methodology, the basic mathematical model for representing the processes of increasing the efficiency of innovative production in the agro-industrial complex. This allows you to organize the implementation of strategic planning and investment projects using the capabilities of Machine Learning. Digital technologies significantly increase the possibilities of multivariate and multicriteria analysis of decisions in complex socio-economic systems of different sectors of the economy [9-11]. It is possible to reduce the total costs for the development and examination of projects when using artificial intelligence neural networks. The use of such tools shortens the period for developing a strategy. This should also help to improve the safety of the use of innovative technologies and management solutions in other areas [7,8]. However, such a toolkit requires significant intangible resources (educational, scientific) and financial costs for investments in design and engineering preparation for the production of innovative products and services. It is necessary to disclose the content of elements of strategic planning, cost estimates for the development and implementation of methods for combining intangible and tangible resources [12] for the following stages of the full cycle: scientific (for generating and testing business ideas); project or design; technical and technological (for the design and construction of technology elements); organizational (for the formation of the agro-industrial complex with the necessary organizational structures that coordinate the interaction of objects); experimental (for the development of innovative technologies and products).

3. Planning investments in projects to improve the efficiency of the development of the agro-industrial complex

The goals of the functioning of the national platform determine an increase in the share of production of unique technologies on a post-industrial basis of innovative technological and organizational principles. This determines the relevance of accelerating the implementation of methods for digital transformation of objects of activity according to the factors-challenges of the long-term goals of agricultural development. Economic criteria are needed to minimize the imbalance of interests of the complex objects in the cycles of long-term development. It is required to regulate the zone of sustainable compromise of goals that express the interests of objects in assessing the indicators of efficiency and innovation at the stages of formation and development of the agro-industrial complex.

The processes that are carried out at the stages of research and development or technological work (R&D) [12] represent successive transformations of the same target object (for example, an element of digital technology) through the stages of the specified strategic planning cycle. This process is cyclically repeated and makes it necessary to use a special methodology and management methods for the
development of objects of the agro-industrial complex in the post-industrial knowledge economy [13-15].

The article by A.A. Alabugin shows that the structural and time frames of the stages of creating digital and other innovative technologies are significantly different. Methods of digitalization and automation of processes are needed, as new technological principles for the development of complex systems appear [16]. The principles make it necessary to change production relations. In particular, innovative methods of increasing the competence of personnel are required due to the insufficient focus of digital technologies on the client [17, 18]. The intangible nature of the new relations is manifested in the need to develop the creative behavior of the personnel of the agro-industrial complex objects according to the characteristics of innovative transformations [19]. This substantiates the features of the models and stages of the planning and investment cycles. They should be distinguished by the ability to combine modernization methods, the use of medium and high technologies based on the integration of diversified resources in the agro-industrial complex (Fig. 1). The special significance of the stages of scientific and design study of many solutions is shown due to the multiple growth of costs for eliminating inconsistencies in equipment at the stage of using high technologies in the conditions of the functioning of the agro-industrial complex. Knowledge of the specifics of the stages ensures the predominant share of "excess profits" (75%) and profit margins (up to 19%). This also corresponds to our conclusions and the results of other studies on the correspondence of the peculiarities of the development of digital technologies in the agro-industrial complex to the paradigm of investment in industry [20,21].

4. Scientific novelty

The cycle model determines the need to take into account the total costs at all stages and organize the coordination center of the complex. It should have additional functions for sales management and business relationship management. It was revealed that at stages I and II, the functions of forming creative teams such as project groups by types of digital technology elements are required. Such structures should take into account the interdisciplinary principle of attracting relevant specialists in the fields of education, science and design to develop high-tech products. The impact of sales management and the bureaucratic style of management are necessary to accelerate the achievement of the well-known technological limit of development of R. Foster [12]. The limit at stagnation stage III defines the limit for increasing the efficiency of the existing technology. This means the need to move to a new cycle of planning and investing innovation. For early detection of internal contradictions, the head of an investment project must apply transformative methods of impact investing, which are based on the use of the resources of the knowledge economy of a post-industrial type [22]. The model shows that with each subsequent stage, the influence of directive influences decreases.

The development results at each stage should be evaluated and modeled on the basis of the models proposed in other articles by A. Alabugin and R. Alabugina in the collection of materials of this conference. This is also confirmed by the results of foresight studies of the interaction of objects of the agro-industrial complex with the state, scientific and educational organizations [23-25]. A cyclical approach to assessing and regulating development efficiency determines the methodology for predicting optimal costs for the stages of digital technology development.

4.1 The amount and criterion of minimum costs

The amount and criterion of minimum costs for the indicated stages of the planning and investment cycle is represented as follows (1):

$$Z_\Sigma = Z_{\text{re}} + Z_{\text{te}} + Z_{\text{or}} + Z_{\text{expl}} + Z_{\text{dis}} \rightarrow \text{min},$$

where $Z_{\text{re}}$ – costs for research and development of personnel competencies;
$Z_{\text{te}}$ – costs for the development of prototypes of technology elements and testing;
$Z_{\text{or}}$ – costs of organizational preparation of production;
$Z_{\text{expl}}$ – costs of an element or technology during period of operation;
$Z_{\text{dis}}$ – costs of disposal of the material component of the technology.
5. Practical significance

5.1 Analysis of the dynamics of costs at the stages of the cycle by types of digital technology.
A feature of its development is the radicality of increasing the functional and consumer properties of the technology. To do this, these types of costs should vary in the degree of science intensity, novelty and areas of application of the technology. It was revealed that, as a rule, the costs of research and development work are growing. This is shown by curves 1 and 2 in Fig. 2, which show changes in costs $Z_{\text{me}}$ and $Z_{\text{or}}$ at stages I and II of the model proposed above. The rest of the costs are usually reduced even with an increase in the “ideality” of the product for the consumer in comparison with their predecessors (shown by curves 3-5 in Figure 2).

5.2 Determination of the achieved level

Determination of the achieved level of market preference for digital technology as the ratio of the actually achieved level of its recognition $K_{\text{fact}}$ (expert assessment of the consumer properties of the product) to the absolute ideal $K_{\text{i.abs.}}$:

$$K_{\text{pm}} = \frac{K_{\text{fact}}}{K_{\text{i.abs.}}}.$$  \hspace{1cm} (2)

Experts give rough estimates of costs by stages of the cycle based on the analysis of technologies that are similar in consumer properties of the developed technology. Based on the arithmetic mean values of the estimates, graphs of cost dependences on the actual coefficient of ideality recognized by

![Figure 1. Model for increasing the efficiency of technological development by stages of the investment and planning cycle](image-url)
the consumer are built. The state of the processes of applying digital technology when it is mastered by consumers on a market scale is taken as an absolute ideal. The functions of digital technology are included in the composition of specific functions of the management systems of the agro-industrial complex objects.

5.3 Determination of zone "A"
Determination of zone "A" is of the preferred level of impact of the management functions of the coordination center of the agro-industrial complex. To achieve the "ideality" of the parameters in assessing the consumer properties of digital technology according to the criterion of the minimum total costs, the formula (1) is used. Therefore, zone "A" is an area of balanced interests of the manufacturer and consumer of digital technology. At the same time, reducing the imbalance in assessing the minimum total costs is a criterion for selecting design solutions.

5.4 Clarification of the qualitative characteristics of cost management.
The plotted graph represents to a greater extent a qualitative assessment of the cost ratio. Therefore, it is recommended to refine the area for practical use. At the same time, one should take into account the prices for variable options of digital technology elements that differ in the novelty of their business idea.

The values of $K_{opt}$ in zone A, the allowable costs for further approximation to the ideal are determined by methods of increasing the functionality of digital technology.

**Figure 2.** The results of modeling the processes of formation of digital technology in the agro-industrial complex

6. Conclusion
Thus, the following scientific and practical results were obtained and reflected in the paper:

1. The urgency of improving the planning of efficiency indicators for the development of objects of the agro-industrial complex with the use of digital technologies based on the methodology of integration-balancing management and modeling of integration processes of methods and resources of objects in the complex is substantiated.
2. A combination of methods and resources was used based on the results of monitoring and evaluating enterprise development trends using Big Data and Data Science tools. It is proposed to evaluate the impact of the tools in strategic planning cycles.

3. The results of the implementation of the plans were assessed according to the criterion of balancing the interests of producers and consumers of digital technologies. The criterion for the selection of design solutions within the boundaries of the zone of minimum total costs for the formation and development of the complex has been substantiated. The solutions are implemented in a methodology that allows you to adjust the timing of the implementation of plans and the amount of investments in the coordination center for the development of the complex's facilities for a radical increase in efficiency.

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