

Improving the Management of High-Tech Organizations Based on Digital Technology and the Use of the Economic Cross Model

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Abstract— The article proposes innovative approaches to the organization of enterprise management, taking into account the requirements of the global market and the characteristics of the economy of the 6th technological structure. Deficiencies inherent in management approaches relevant to the 5th technological order are identified, directions of the impact of digitalization on the organization of the managerial process at the 6th technological structure are identified. Based on the results of the study, a system of recommendations has been developed for solving identified management problems based on the Economic Cross model. It is found that the relevance of the economic cross method as a tool for managing a high-tech organization in Russian economic realities will grow as the market is saturated with heterogeneous domestic innovative proposals, the formation of electronic profiles of innovative organizations and the development of an import-substituting model of the economy

Keywords: *management, innovation management, digitalization, economic modeling, forecasting*

I. INTRODUCTION

Modern management theory pays considerable attention to the problems of innovation management as one of the aspects of the organization's economic activity. Most often in Russian practice, Japanese, American and German models are used [1]. Although a universal "theory of innovation management" has not yet been formed, several features characteristic of the innovation management process can be distinguished. Let's consider them in more detail.

1. Innovative activity, by definition, implies that the organization assumes significant risks. Accordingly, the management of innovation involves the use of economic and mathematical models by organizations to minimize risks and optimize utility (profit) functions already at the planning stage of the innovation process.

2. The main resource of innovative activity of an organization is its human capital. Accordingly, significant attention in the management of innovative activities of the company is paid to the development of human potential and the problems of team building.

3. The innovative activity of the organization is carried out at the junction of the external environment, offering initial information, financial and technological resources, and the internal environment, providing conditions for the processing of these resources adapted to the request of the target consumer. Thus, the innovative activity of the organization involves working with the maximum amount of information from the external environment, most often entering the organization in the form of competing projects.

The above-mentioned features of innovative activity remain relevant for high-tech organizations working in the framework of the 6th economy. At the same time, innovative projects of organizations of the 6th technological structure are global in nature, that is, focused on the use of a global innovative resource. This determines the management features of such organizations. These features are that:

- the risks of the moral aging of innovative projects begin to be given more importance, since for each of them in the global market there is an alternative oriented to the same target customers, but formed on the basis of a different prototype (technological basis);

- increased competitive pressure and the presence on the global market of similar alternative innovative solutions increases the importance of non-technological components of the innovation project, such as organization of financing and promotion;

- requirements of the global market for innovative solutions force organizations to specialize in part of the elements of the innovation project, transferring the other part to partners / competitors and forming alliances in order to create more technological and resource support for the innovation project.

These features of the activity of high-tech organizations require the process of managing them to be more mobile and adaptable to the global market, which is possible due to the restructuring of the management structure on a modular basis.

The modular principle involves the administration of each of the elements used by the organization or intended to be used elements of digital control over time. For the period

1990 - 2020 the digital management system of high-tech organizations has undergone significant changes and turned into a system of independent management services, as shown in Fig. 1.

The increasing complexity of digital management tools requires high-tech organizations to respond in a timely manner to new opportunities and / or threats that arise as a result of such complexity. Such a response, in turn, is impossible without the use by organizations of methodological tools for planning and forecasting.

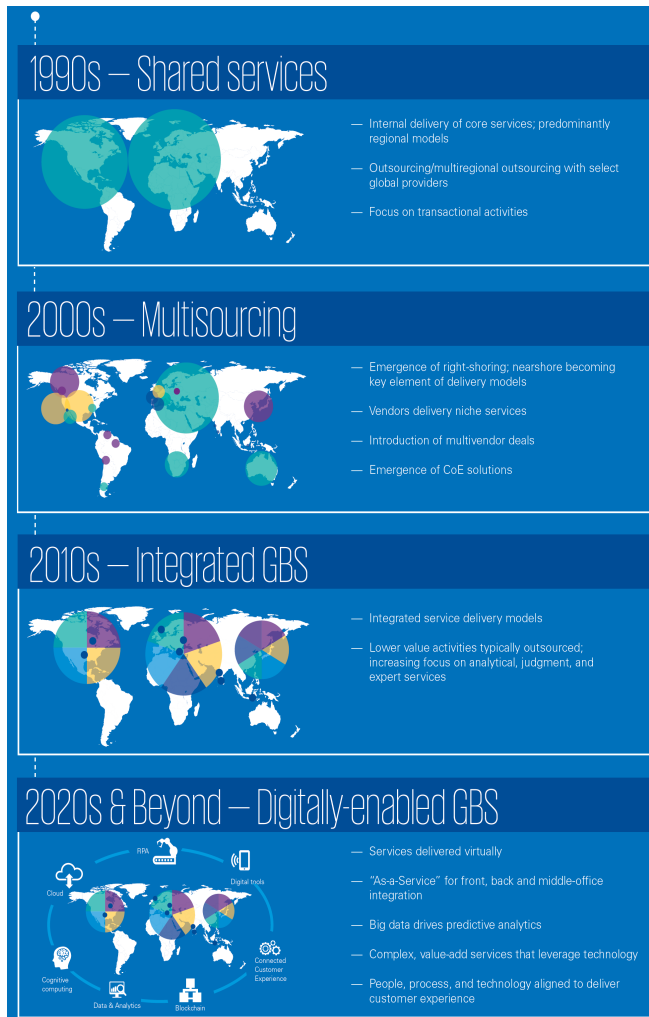


Fig. 1 – The evolution of the use of digital services in high-tech organization management systems [8, p.22]

Modern organizations of all forms of ownership are faced with the problem of identifying promising factors of innovative development earlier than such factors will be identified by competitors. At the same time, the main task facing the organization is not to select one of the proposed options, but to create a system of maximum information coverage of the proposals available on the global innovation market. Based on the results of identifying existing proposals, it is necessary to quickly rank existing options and only then make final decisions.

II. EVALUATION OF MODERN APPROACHES TO THE MANAGEMENT OF HIGH TECHNOLOGY ORGANIZATIONS UNDER DIGITALIZATION

The rapid development of the IT industry has not yet allowed to formulate a general theory of digitalization of the management process, which requires the management of organizations to respond to changes in the level of technology in real time. This circumstance necessitates the development of a methodology that allows planning to improve the management of high-tech organizations in the context of the digitalization of the economy and the uncertainty of the development of the information space.

Adaptation of management of high-tech organizations to the requirements of the 6th technological structure and the trend of globalization of innovative business is carried out through the following measures.

1. Participation (passive and active) of high-tech organizations in the processes of unification of information about potential counterparties. All types of innovative activity of high-tech organizations and their structural elements, up to individual employees, are subject to classification and monitoring of the course within each class. A significant role is played by states as participants in innovative relations, which establish certain preferences for certain forms of innovative activity. In Russia, such forms are determined by the list of critical technologies [2], [3].

2. Providing preventive competition for a global innovative resource in the form of interactions between high-tech organizations and educational institutions, including in donor countries of human capital with lower labour costs. Such interaction is carried out in the format of identifying and monitoring the development of potential employees of global high-tech companies through the implementation of a system of competitive events on a cascading basis in educational institutions.

3. Diversification of the global high-tech business in order to minimize systemic risks and increase the stage of re-export of innovative goods. In addition, country diversification of a high-tech product provides the opportunity to create platforms for testing competing business models for the development and distribution of an innovative product at the expense of foreign licensees and franchisees of global high-tech companies [4, p.65].

The above techniques have been used by high-tech companies before, in the period of the 5th - laid economy. However, the possibility of their use was limited by the maximum number of interactions of the control element with the external environment and the limits of information richness of managerial interactions, as well as the speed of response to environmental requests. The situation changed at the beginning of the XXI century with the beginning of the digitalization of the managerial process and the actualization of the use of the "big data" model in it. At present, it is digitalization that underlies the transformation of managerial models of high-tech companies, as shown in Table 1.

Analysis of the information presented in the Table 1 suggests that the process of adapting the management of

high-tech organizations to the capabilities and requirements of the digital economy has not yet been completed.

TABLE 1 – THE EVOLUTION OF CONCEPTS FOR MANAGING HIGH-TECH COMPANIES IN THE PRE-DIGITAL ERA AND THE FORECAST FOR THE PERIOD AFTER 2020 [5, p.171]

Concept domination period	The name and development status of the dominant management concept
1990 - 1910	The formation and dissemination of the concept of scientific management
1910 - 1920	The period of fragmentation of a single school of the concept of scientific management and its adaptation to the needs of the economy of innovation
1920 - 1930	Introduction of administrative-centric approaches into the management process
1930 - 1940	The dominance of relational and psychological approaches in the concept of management organization
1940 - 1950	Separation of the empirical and pragmatic approach in a single management system
1950 - 1960	Integration of previously used approaches and development of systemic approaches to organization management
1960 - 1970	Separation as an independent direction of behavioral analysis and theory of motivation of employees of innovative organizations
1970 - 1980	The development of situational analysis in management
1980 – 1990	Actualization of the question of the formation of corporate culture in high-tech organizations
1990 – 2000	The emergence of managerial models adapted to the specifics of high-tech organizations
2000 - 2010	Worldwide spreading the practice of digitalization of managerial process
2010 - 2020	Adapting the management process in developing countries to the possibilities of the digital economy

Using the extrapolation method, it can be revealed that digitalization will continue to be the leitmotif of the development of the managerial process in the medium term.

At the beginning of 2019, the hardware and software capabilities available to high-tech companies fully corresponded to their needs in terms of speed, depth of information processing and the scope of incoming and outgoing requests during information interactions with the external environment. Moreover, the currently proposed solutions to accelerate information processing, for example, through the use of quantum computers, are and will continue to be redundant in terms of management tasks for the next 20 years [6].

Along with successes in the technical sphere, it should be noted the problems associated with the introduction of digital technologies in the management systems of high-tech companies. These problems are individual for each company, however, a review of the practice of high-tech companies in the USA, Great Britain, Singapore and Australia allows us to group these problems as follows:

- problems associated with the mismatch of personnel training expected for the implementation of management models using digital technologies;
- the inability of organizations to formalize their business decisions and management decisions for developers for subsequent algorithmization and digital presentation of interaction models;
- Difficulties in combining relational (institutional) interactions and digital management models;
- Risks associated with insufficient information to translate management interactions into a digital format.

Fig. 2 shows the general scheme for assessing the degree of adaptation of the management object to the requirements of the digital management environment according to the criteria for competency coverage, management process coverage, graded at 5 levels. Depending on the position of the control object in the presented 3-dimensional space, it becomes possible to identify and implement specific measures to improve the adaptation of the control object to the demands of the digital management environment.

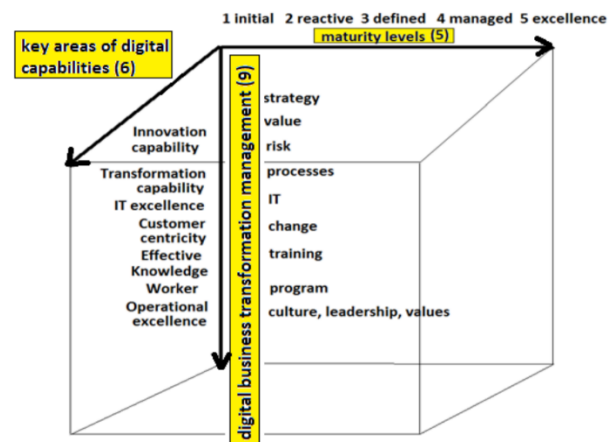


Fig. 2 - Diagram of the assessment of compliance of the control object with the requests of the digital management environment [7, p.463]

The model proposed in Fig. 2 allows, after determining the coordinates of the point of the desired optimum of the digital control object and the actual point of its state, to calculate the economic efficiency of digitalization measures. Economic efficiency can be calculated by the formula 1.

$$E = \sum_{i=1}^9 \sum_{j=1}^9 (Ri,j - Ci,j) \cdot r_{i,j} \quad (1)$$

E - average cost-effectiveness of investing in digitalization of the management system;

i - serial number of the scope of management interactions to be digitalized;

j - serial number of the business process to be digitalized;

$R_{i,j}$ - the result obtained at the intersection of the corresponding field of digitalization and the subject of digitalization of the business process;

$C_{i,j}$ - the costs incurred by a high-tech organization at the intersection of the relevant field of digitalization and the digitalization of the business process.

At the same time, in the management literature there is no algorithmized description of the processes of administering the process of adapting the managerial model to digitalization requests after identifying its current state. Existing recommendations can be classified into two groups, which include:

- general recommendations to ensure the digitalization of the organization's management system; these recommendations are relevant if the organization has not previously dealt with digitalization issues and / or the processes of digital management interactions in such an organization are absent;

- recommendations on the digitalization of individual elements of the organization's management system, which are most often based on the use of specific software and hardware solutions and may be in the nature of advertising information; such recommendations are developed by groups of analysts of companies - developers of software and hardware solutions.

The general scheme for the modernization of the management system of a high-tech organization based on digital technologies is presented in Fig. 3.

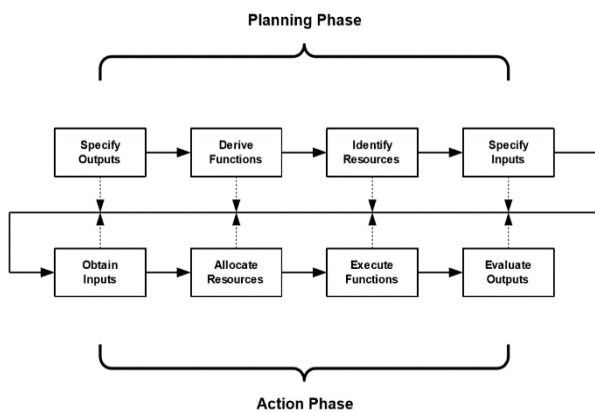


Fig. 3 - the sequence of the modernization of the management system of a high-tech organization based on digital technologies [9, P. 12]

The algorithm proposed in Fig. 3 involves the sequential implementation of changes based on the introduction of a digital technology system in the management process of high-tech organizations. However, the possibility of its use is limited for organizations in the following cases.

1. The organization already has a system of digital management interactions, but it contains obsolete hardware and software solutions integrated into the management

process at the level of communication interactions. The rejection of such hardware and / or software solutions in this case will require the restructuring of the entire system of communication interactions, which may be unacceptable for economic reasons. An example of such a dilemma is the problem of import substitution of foreign software in Russian high-tech companies of strategic importance. The use of existing domestic software analogues in such organizations is complicated by the fact that this will require retraining of specialists and amendments to the system of contractual relations with other suppliers of software and hardware solutions.

2. The use of existing software and hardware solutions in the organization's management system is determined by the specifics of the external and internal environment. In such cases, the use of standard algorithms for assessing the economic efficiency of existing solutions can be difficult. For example, the use of cloud information storages for managerial interactions may be relevant for economic reasons, but involves specific risks due to the legal uncertainty of the status of cloud storages in accordance with applicable national legislation. In addition, the use of economically efficient management decisions is often inaccessible to small innovative enterprises. Such a conflict can occur if the owners / heads of such companies are highly specialized professionals and have neither knowledge in the field of specialized management software, nor the ability to hire a specialist in the relevant field.

3. The solutions proposed in the management literature in the field of modernization of control systems based on digital technologies imply certainty of either target indicators or hardware and software proposals. A real organization operating in the high-tech market is often forced to make decisions in the face of the uncertainty of both parameters. In order to select specific proposals, it needs to formulate a concept of modernization of the control system, and to formalize the level of technology de facto represented by the global proposal.

In addition, from the point of view of the approach under consideration, the estimated timeframe for implementing changes in the management system and the period for which the introduced innovative solutions should remain relevant for the organization remain uncertain. Accordingly, the organization is faced with the need to take the risk of obsolescence of technical management decisions.

The solution of these problems can be carried out by linking the planning of modernization of management of high-tech organizations based on the digitalization of management processes and the life cycle of technologies that are critical from the point of view of the organization. For each of these technologies, a life cycle model is built, after which it is determined:

- life cycle parameters that are unconditionally dependent on the organization, conditionally dependent on the organization and independent of the organization;

- for parameters that are conditionally dependent on the organization, the budgets needed to manage the relevant parameters are determined;

- for parameters that are independent of the organization, factors are determined that affect the corresponding parameters.

Linking the corresponding life cycles is possible based on the model of the “economic cross” proposed by the authors.

III. USE OF THE “ECONOMIC CROSS” MODEL IN THE MANAGEMENT OF A HIGH TECHNOLOGY ORGANIZATION

In accordance with the model of the economic cross, all technological cycles that are systemically important for the organization are presented as sequences of economic interactions at the intersection of which the high-tech organization itself is placed. Each of the technologies used should provide for the possibility of its application independently of the other. If this is not possible, the combination of technologies should be considered as a single technology. For example, if the software is adapted to work on only one device, their use should be considered using one technology.

It is assumed that the organization itself initially owns some resource that can be used within one or more of these cycles. The degree of technological organization is defined as the number of degrees of freedom of use of a given resource within each cycle. If a resource can be used in some way simultaneously in two or more cycles, it should be considered that this creates two or more freedoms. Each use of a resource should not be correlated with another use.

In accordance with the current theory of asset management of an innovation organization, four types of management and 12 types of asset use are distinguished, as shown in Fig. 4.

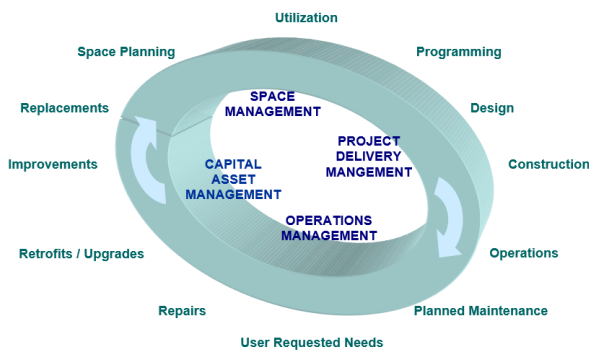


Fig. 4 – The matrix of managing the costs of using the assets of a high-tech organization as part of the technology life cycle [10, C. 5]

If a high-tech organization owns several resources, the use of which is possible independently of each other, it is considered that these are two organizations that can operate independently of each other. Thus, the model of the economic cross is no longer at the initial stage of analysis. It suggests the possibility of transferring part of the organization’s assets / businesses to outsource either their sale or division of the organization.

A geometric interpretation of the economic cross model for high-tech companies is shown in Fig. 5.

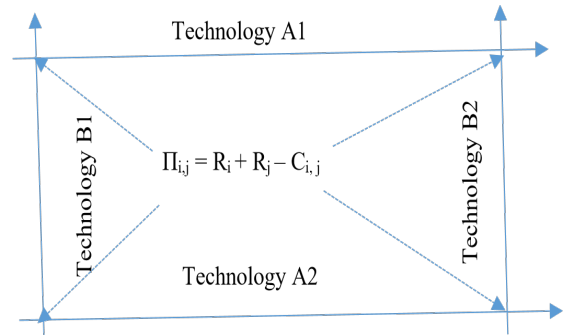


Fig. 5 – A geometric interpretation of the model of the “economic cross” as an intersection of technological cycles

Conditionally, cycles can be divided into two groups:

- production, which are focused on the use of technologies from 1 to 5 structures and can be implemented on the basis of existing infrastructure, in figure 5 they are indicated by the index *i*;

- Resource-oriented, which are focused on the use of technologies of the 6th way and require the cost of creating the infrastructure in which they can be implemented. When working with such cycles, planning the development of a high-tech company requires the development of two strategies. The first involves the choice of a wait-and-see position until one of the participants in the external environment creates the appropriate infrastructure and / or conditions are created for the emergence of positive cash flows from participation in infrastructure projects. An example of such a condition is the provision of state support to participants in an infrastructure project.

At the intersection of each of their cycles, the profit of the organization is formed, calculated by the formula 2:

$$\Pi_{i,j} = R_i + R_j - C_{i,j}, \tag{2}$$

R – positive economic result from the use of an asset at the intersection of cycles *i* and *j*. In this case, the use of an asset is understood as an innovation process, since the fact of using an asset is not predetermined in advance and represents the degree of freedom of a high-tech organization;

C_{i,j} – The organization’s total cost of sharing technology *i* and *j*. If these technologies belong to the organization itself, the value of *C* includes, among other things, the costs of refusing to use the technology in other projects and probabilistic losses due to the risk of technology disclosure. If the technology does not belong to the organization, the value of *C* includes, inter alia, the costs associated with the acquisition of the appropriate technology or license to use it.

Next, the task of managing the development of a high-tech organization is reduced to maximizing the value calculated by formula 3:

$$\sum_{i=1}^n \sum_{j=1}^m \Pi_{i,j} \tag{3}$$

Since all technologies i and j are independent of each other, the economic cross model allows you to select economically attractive intersections, i.e. intersections for which $\Pi_{i,j} > 0$, on the first step of the suggested analysis. We may see that the sum $\sum_{i=1}^n \sum_{j=1}^m \Pi_{i,j}$ is the greater, the greater is the number of technologies i and j the organization will be able to use in the innovation process.

If the resource of a high-tech organization is exclusively a technology, the number of its uses is not limited or limited only by the maximum cost of searching for technologies i and j and analyzing their intersection points. If the resource of a high-tech company necessarily includes a financial component, the task of optimizing the value of P should be addressed within the existing budgetary constraints.

The most significant obstacles to the use of additional strategies i and j by the high-tech organization are:

1. Institutional restrictions, which in Russia are most often associated with the legal uncertainty of the status of an innovator for certain types of activities or with the lack of personnel with the necessary training.

2. The problems of organizing the marketing of innovative products, which may be related both to the rejection of the market for an innovative product and to the monopolization of individual market segments that impede the entry of innovative companies into them.

3. The presence of informational barriers that impede either the free flow of information within the economic system, or distort the reliability of the relevant information. The same group should include barriers associated with the unreasonably high price of providing and the innovator of information about their own technological solution and barriers associated with the price of receiving information about other people's offers. There is still an acute problem associated with the manipulation of the information space by interested participants, which forces high-tech enterprises to work primarily with affiliates.

Table 2 presents the SWOT analysis of the use of the "economic cross" model as a planning tool for improving the management of high-tech organizations in Russia. The analysis allows us to state that the main shortcomings and threats are associated with time costs.

TABLE 2 - SWOT - ANALYSIS OF THE USE OF THE "ECONOMIC CROSS" MODEL AS A TOOL FOR IMPROVING THE MANAGEMENT OF HIGH-TECH ORGANIZATIONS IN RUSSIA

<u>Strengths</u>	<u>Weaknesses</u>
<p>1. It is effective as a tool for working with large volumes of proposals in the field of technological solutions.</p> <p>2. Provides the ability to manage the structure of innovative business.</p>	<p>1. Requires analysis of a large amount of statistical information.</p> <p>2. The possibilities of parallel analysis are limited when evaluating work at the intersection of the same technology pair.</p>

<p>3. Promising as an analytical tool with a process approach to management.</p> <p>4. Provides opportunities for adapting plans when changing the level of technology due to one or more of its new elements.</p> <p>5. Provides the visibility of the results.</p>	<p>3. It requires clarity and concreteness of the source data, ineffective when using elements of fuzzy logic.</p> <p>4. Requires substantial time costs.</p> <p>5. Does not allow the initial selection of economically promising solutions before calculating P for each intersection</p>
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<u>Opportunities</u>	<u>Threats</u>
<p>1. Promising in the globalization of the industry market.</p> <p>2. The proposed analysis technique lends itself well to formalization and digitalization.</p> <p>3. Perspective in mediation.</p> <p>4. Promising when working in related fields, for example, in valuation activities.</p> <p>5. There are opportunities to combine as an analytical tool with other techniques.</p>	<p>1. There may be risks of the technological dependence of the organization on partner companies that own technologies i and j.</p> <p>2. Considering the complexity of parallel analysis of one and the same project, there are limited risks of abuse of information obtained during the analysis.</p>

Managing the development of a high-tech organization based on the "economic cross" model seems promising in a digital environment. Consider the elements of the digital environment that are relevant in terms of increasing the technologies i and j available for the organization.

1. The presence of data banks of technological solutions of partners with unified parameters. Such data banks make it possible to represent the management of a high-tech organization as a process for managing individual modules. The optimization task for each module can be presented in the form of a formalized digital request and then offered to suppliers in one of the following formats:

- tender;
- offers;
- grant.

It should be noted that the model of the "economic cross" provides the possibility of advancing the formation of modules. Working at the intersection of technologies already discovered in the global market, the organization can simultaneously prepare modules with specified parameters for entering the market. This format is most suitable for the work of a high-tech organization with resource technological cycles, that is, cycles that, in theory, are already technically feasible, but for which the necessary infrastructure conditions have not been formed.

2. The effectiveness of using the Economic Cross model is generally dependent on two parameters: the speed at which technologies i and j are located and the speed at which economic efficiency is analyzed at their intersection. The problem of adapting the internal environment of the organization, including the training of employees, can be addressed proactively if there is a properly formed offer for the technology market. In this case, the parameters of the offer are also parameters for training employees or planning for the release of these employees during the development of the company. Digitalization of the economic environment, including the strengthening of the presence of organizations in the digital environment, standardization of formalized parameters of their presence and the development of expert online systems can significantly increase the efficiency of using the model when planning the development of high-tech organizations.

3. Under the conditions typical for Russia of the lack of data banks of innovations, the “economic cross” model allows high-tech organizations to quickly and cheaply create their own data banks through the use of digital technologies. This can be achieved through the use of special bots that analyze online profiles of innovative organizations and individual scientists for matches on key parameters of the desired technologies i and j .

IV. CONCLUSION

Thus, the “economic cross” model is a tool for managing the development of high-tech organizations based on the search for development opportunities based on the knock of existing technologies. The model involves the active use of expert systems engaged in primary online - the search for technology proposals that are promising for use by this high-tech organization. In the absence of clear coincidences with the required technologies on the market in the case when the level of technology provides the possibility of the appearance of appropriate technologies, the economic cross model can be used to formulate the corresponding online offer.

The advantages of the model is its effectiveness in assessing the economic prospects of adapting the development of an organization to a change in the level of technology. A comparison of the economic results of the organization's current development plan and the development plan taking into account the changed level of technology in accordance with the economic cross model can be represented as a comparison of the obtained economic results $\sum_{i=1}^n \sum_{j=1}^m \Pi_{i,j}$ for each of these plans at the intersection of the respective technologies.

The relevance of the economic cross method as a tool for managing a high-tech organization in Russian economic realities will grow as the market is saturated with heterogeneous domestic innovative proposals, the formation of electronic profiles of innovative organizations and the development of an import-substituting model of the economy.

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