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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

DEVELOPMENT OF MODELS AND METHODS FOR EFFECTIVE ORGANIZATION AND MANAGEMENT OF ACTIVITY OF TECHNOPARKS

Speciality: 3338.01 – “System analysis, management and information processing” (by fields)

Field of science: Technical sciences

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GENERAL CHARACTERISTICS OF WORK

Relevance and level of development of the topic. Execution of works has started to increase the efficiency of modern management processes based on knowledge, ICT and innovation. Science and innovation centers and high-tech parks are the main driving force for the transition to an innovative and knowledge-based economy in the context of building an information society. The Development Concept[1] and National Strategy[2] of Azerbaijan set out the development of new management mechanisms, the establishment of innovation centers, technological complexes, technoparks and the organization of their activities in order to strengthen the interaction between science, education and industry.

Implementation of the Perspective Roadmaps [3] of the Azerbaijani economy in accordance with the concept of the 4.0 Industrial Revolution[4] will ensure the transition of the economy from an efficiency-based model to an innovation-based model. At the same time, the analysis of relevant scientific publications shows that the problems of creating technoparks, applying international experience in the organization of their activities to the emerging technopark structures in Azerbaijan and improving the efficiency of its management have not been studied in a comprehensive enough way.

To solve the existing problems in this area, it is very important to develop appropriate models, methods, tools and recommendations using mathematical modeling and modern achievements of information technology.

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[1] Azerbaijan - 2020: Vision for the Future "Development Concept // - Baku: December 29, 2012, - 39 p. URL:https://president.az/files/future_az.pdf.

[2] National Strategy for the Development of the Information Society in the Republic of Azerbaijan for 2014-2020 // - Baku: April 2, 2014. URL:https://president.az/articles/11312.

[3] Strategic Road Map on the prospects of the national economy of the Republic of Azerbaijan // - Baku: December 6, 2016, - 111 p. URL:https:// president.az/articles/21953.

[4] Schwab K. The Fourth Industrial Revolution, Limited, 2017, 192 p.

The purpose and objectives of the research. Development of relevant models and methods, algorithms and recommendations for the effective organization and management of the activities of technoparks in the conditions of information economy.

The following issues were considered and resolved in order to achieve the goal set in the dissertation:

1. Study of the stages of formation, specific features of technoparks as an object of scientific-technological environment and socio-economic infrastructure and identification of its scientific-theoretical problems as a result of systematic analysis of international experience in this field;
2. Research of problems of management of innovation processes in technoparks;
3. Development of an effective organizational and management model of innovative technoparks based on the synthesis of existing forms of activity;
4. Development of information support system, its main indicator block and architectural-technological structure on effective organization of technoparks activity;
5. Development of indicators, criteria, models and algorithms for complex analysis and comparative assessment of management and innovative activity of technoparks;
6. Definition of indicators, criteria for selection and implementation of innovative projects in technoparks and development of models and algorithms for evaluation of innovative projects;
7. Identification of the main factors affecting the production of innovative products and services in technoparks and multifactor modeling of relevant processes;
8. Development of recommendations on improving the efficiency of innovative activities of technoparks in Azerbaijan and their development prospects on the basis of the analysis of the proposed models and methods and the experimental results of algorithms.

Research methods. Systematic analysis, mathematical programming, multi-criteria optimization methods, computer modeling, fuzzy set theory, etc. were used to address the issues raised in the dissertation.

Processes of improvement of management system of innovative technoparks are accepted as **the object of research** in the dissertation.

The subject of research is the selection of innovative projects for the effective organization of the activities of technoparks, a comprehensive assessment of the activities of technoparks and the production of innovative products and services.

The main provisions of the defense:

- modern innovative organizational and management structure of technoparks as a socio-economic infrastructure;
- architectural-technological structural model of the improved information provision system of technoparks;
- conceptual models of management system and innovative development of activity of technoparks;
- indicators and criteria for innovative projects to improve the operation of technoparks;
- system of indicators and composite indicators for the management of technoparks;
- method of comparative assessment of complex activity of technoparks;
- multi-factor models of innovative product/service production processes in technoparks.

Scientific novelty of the research. The scientific innovations obtained in the dissertation are as follows:

- Modern innovative organizational and management model of technoparks as a complex structured socio-economic infrastructure has been proposed;
- The architectural-technological structural model of the improved information provision system of technoparks has been developed;
- Conceptual model of management system and innovative development of technoparks activity have been developed;
- Indicators and criteria of innovative projects selection in technoparks have been identified, method of their comparative

assessment is developed;

- A system of indicators and composite indicators for the management and comparative evaluation of the performance of technoparks was proposed;
- Based on the composite index of technoparks, a method of comparative assessment of their complex activity was developed;
- Multifactor models of innovative product/service production processes in technoparks have been developed.

Theoretical and practical significance of the study. The indices, criteria, as well as models, methods, proposed in the dissertation can be applied to other field technoparks. The management models and methods used in this work can be used in the activities of innovative enterprises.

The scientific and practical results obtained on the basis of the proposed methods and models allow to increase the efficiency of the results of the activities of various technopark structures.

Approbation and application. The main scientific-theoretical and practical results of the dissertation were presented at more than 20 international and national conferences in Osaka (Japan), Moscow, Novosibirsk, Astana, Vinnytsia, Baku and others.

Materials of 13 international conferences are indexed in foreign scientific databases.

The scientific-theoretical and practical results of the dissertation were regularly used in the implementation of the State Program on Socio-Economic Development of the Regions (2012-2019), in the implementation of the State Program on Poverty Reduction (2012-2019). It was also used in the implementation of the Action Plan of the National Strategy on Information Society (2014-2019), the Action Plan of the Strategic Roadmap (SRM) for the Development of Telecommunications and Information Technologies (2016-2019).

The results of the work were regularly included in the annual reports of the Institute of Information Technologies of ANAS for 2012-2020 and presented to the relevant organizations.

Published scientific works. A total of 24 scientific works of the author on the topic of the dissertation were published, including 6 international and 7 republican journal articles, 8 international and 3 republican conference materials. Of these, 4 were indexed in the Web of Science and Scopus database, and 10 in other international scientific databases. The rest are other scientific publications recommended by the Higher Attestation Commission.

Name of the organization where the dissertation work is performed. The dissertation was completed at the Institute of Information Technology of the Azerbaijan National Academy of Sciences.

The volume of structural units of the dissertation. The dissertation consists of 175 pages including an introduction, four chapters, a conclusion, a bibliography of 146 titles, an appendix, 43 figures and 12 tables. The main part of the work is commented on 142 pages.

The total volume of the dissertation in symbols. The total volume of the dissertation in symbols is 283644.

243179 characters, excluding figures, tables, graphs, bibliography and appendices.

The volume of the dissertation by chapters:

- Chapter 1 - 48470,
- Chapter 2 - 49151,
- Chapter 3 - 68777,
- Chapter 4 - 55088.

The total volume of the abstract with the sign is 45907 characters.

The bibliography is 39809 characters.

MAIN CONTENT OF THE WORK

The **introduction** identifies the relevance of the dissertation, the purpose of the research and the issues to be addressed. The scientific novelty and practical significance of the obtained results are shown.

The first chapter is entitled "Study of innovative features and management problems of technoparks". In this chapter, technoparks are characterized as a management object, being a complex system. Its specific characteristics and management parameters have been identified. The purposes of creation of technoparks, the main directions of activity [2], stages of formation, organizational forms, various aspects of the organization of activity, initial socio-economic conditions of formation, characteristic technological features are analyzed.

Technopark, which is of a scientific-technological purpose and is a complex of product/service production, mainly implemets the effective organization of turning the results of scientific research activities into commercial products and their marketing [5]. Both different and similar features of technoparks can be noted [4, 7, 16, 17]. Technoparks have many management problems that need to be addressed.

As a result of research and synthesis of organizational structural models of scientifically innovative technoparks of different profiles, their exemplary organizational structure is proposed in [1, 2, 24].

Technoparks are available in American, European and Japanese models [11]. There are about 4,000 technoparks in the world. The process of innovation in technoparks, as of time, is a process that covers the entire period of transformation of scientific

[5] Lecluyse L., Knockaert M., Spithoven A. The contribution of science parks: a literature review and future research agenda // Journal of Technology Transfer, 2019, volume 44, issue 2, pp.559-595.

knowledge, scientific ideas, discoveries and inventions into commercial products, in other words, innovation [6, 14].

The combination of elements such as innovation production, innovation movement, economic efficiency of innovation, innovation diffusion in a successive chain at different innovation stages forms the structure of the innovation process, as shown in figure 1.

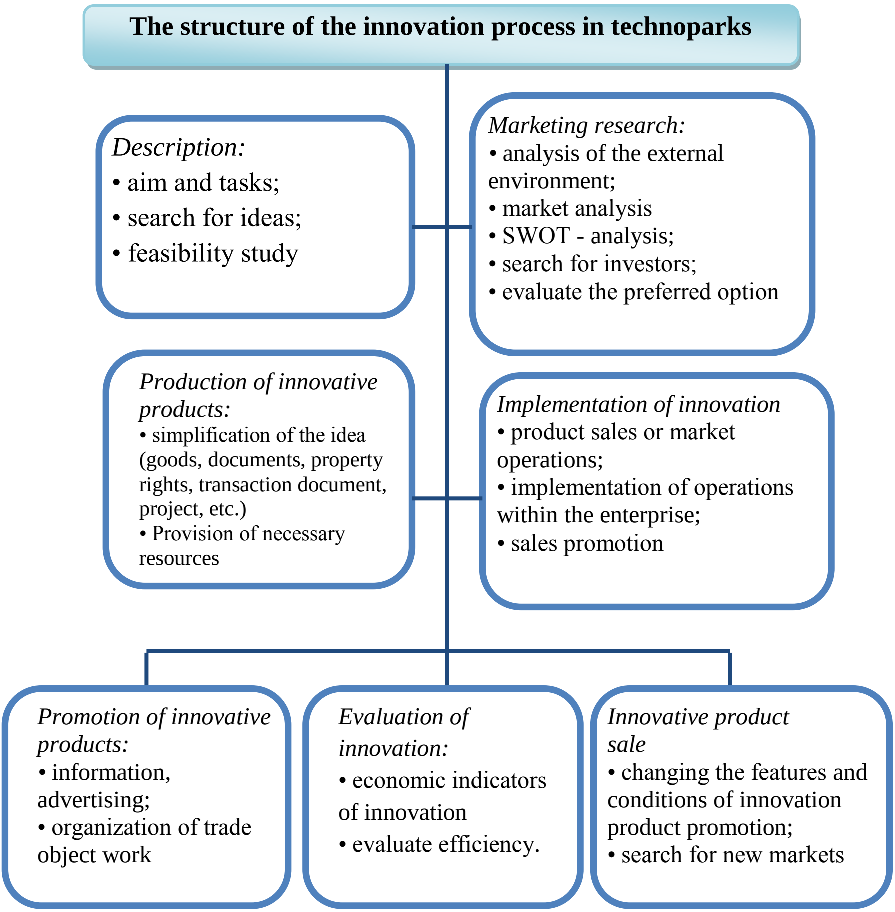

Figure 1. The structure of the innovation process in technoparks

Innovation processes in technoparks are dynamic, organically complement each other and are aimed at obtaining the final product of innovation [14]. Their effectiveness directly depends on their ability to respond quickly to rapidly changing market conditions.

This chapter also analyzes foreign experience in the complex operation of technoparks [11, 4, 7], identifies problems in their creation and management.

The second chapter, entitled "Models and methods of effective selection and evaluation of innovation projects in technoparks" provides a comparative analysis of the essence of innovative projects implemented in the process of creating and operating of technology parks, methodological aspects of the formation of content, structural indicators. The stages of classification, development, implementation stages and selection criteria for innovative projects have been determined. Appropriate models for managing innovative projects have been developed. Algorithms that will be used in calculation the weight coefficients of criteria for the project evaluation and the final project evaluation have been developed [23, 24].

Based on the directions of evaluation of innovative project, management of innovative projects in technoparks, their selection and evaluation criteria were proposed. The formation of these criteria depends on a relevant number of other indicators.

In the case of a multi-criteria assessment, if it is possible to determine the relative importance of the criteria in any way, including through expert assessment, the issue can be converted into single-criteria. That is, the general criterion of the process (GC) of local criteria $(lk_i, i = \overline{1,n})$ with appropriate weight ratios (c_i) is equal to the sum of the products:

$$GC = \sum_{i=1}^{n} c_i lk_i, \text{ here } 0 \le c_i \le 1; \quad \sum_{i=1}^{n} c_i = 1 \text{ terms are paid.}$$

An agreed average value of weights is found, taking into account the level of expertise of the experts and the elimination of inconsistencies in their prices. The algorithm for determining the weights of the criteria for innovative projects consists of the following general steps.

1)The importance of the criteria in relation to each other is determined by means of a Saati table.

2)After determining the n-1 relational values of the criterion k, it is possible to construct a General Relationship Matrix (GRM) according to a known rule and perform some other calculations using table 1.

Table 1. Elements of the general relationship matrix

Column N / Line N	1	2	...	n	The sum of line elements	Extraction of string elements
1	lk_{11}	lk_{12}	...	lk_{1n}	$\sum_j lk_{1j}$	$\prod_j lk_{1j}$
2	lk_{21}	lk_{22}	...	lk_{2n}	$\sum_j lk_{2j}$	$\prod_j lk_{2j}$
...	...	...	...	...	...	...
n	lk_{n1}	lk_{n2}	....	lk_{nn}	$\sum_j lk_{nj}$	$\prod_j lk_{nj}$
The sum of the elements column	$\sum_i lk_{i1}$	$\sum_i lk_{i2}$	...	$\sum_i lk_{in}$	$\sum_{ij} lk_{ij}$	
Product of the elements column	$\prod_i lk_{i1}$	$\prod_i lk_{i2}$	...	$\prod_i lk_{in}$		

3)Relevant calculations for Saati's different approaches to the calculation of this vector are analyzed.

4)The maximum specific value of the matrix for better results and for checking for discrepancies (λ_{max}), the consent index (CI) and the consent attitude (CA) must be calculated. These parameters are calculated by the sum of the row and column elements of the relationship matrix and the weight ratios with the appropriate formulas:

$$CI = \frac{(n-1)\lambda_{max} - n}{n-1}; \quad CA = CI/CL \qquad (1)$$

Here depending on the CL size, the relationship matrix is the random consent limit and is defined in the relevant known tables.

5) Inspection is carried out. If the consent attitude CA≤0,1 the agreement process is considered normal[6]. In other cases, the process is repeated with appropriate corrections and adjustments to the expert's assessment or to the expert.

Thus the j-th expert ($j=\overline{1,m}$),on the i-th criterion $(i=\overline{1,n})$ project evaluation l_{ij} if so, then the final sum of the i-th criterion

$$K_i=\sum_{j=1}^{m} l_{ij} \qquad (2)$$

The final sum (K) for all criteria will be as follows.

$$K=\sum_{i=1}^{n} K_i=\sum_{i=1}^{n}\sum_{j=1}^{m} l_{ij} \qquad (3)$$

In this case, the weight coefficient of the i-th criterion (b_i) can be calculated as follows:

$$b_i=K_i/K=\sum_{j=1}^{m} l_{ij} \Big/ \sum_{i=1}^{n}\sum_{j=1}^{m} l_{ij} \qquad (4)$$

Thus, in the calculation of the weight coefficients of the criteria, first of all, the weight coefficients of the experts themselves are determined. In the next stage, according to the weight coefficients of the experts, their assessments are taken into account in the final assessment [23].

The third chapter, entitled "Development of models and methods of effective management of scientific-technological and production/service processes of technoparks" provides methodological approaches to assess the effectiveness of technoparks. A conceptual innovative development model of technoparks has been developed [13]. A system of indicators and criteria for evaluating their effective management and performance

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[6] Saati T.L. Making decisions with dependencies and feedbacks. M., URSS. 2019, 360 p.

has been proposed [8]. The information model of the technopark is based on different levels of indicators is built [9, 16, 19, 21].

Given that the ingredient of the activities of technoparks is an innovative process that covers the entire period of transformation of scientific knowledge, scientific ideas, discoveries and inventions into new products/services, in other words, into the innovation its conceptual development model is proposed to increase innovation degree (figure 2).

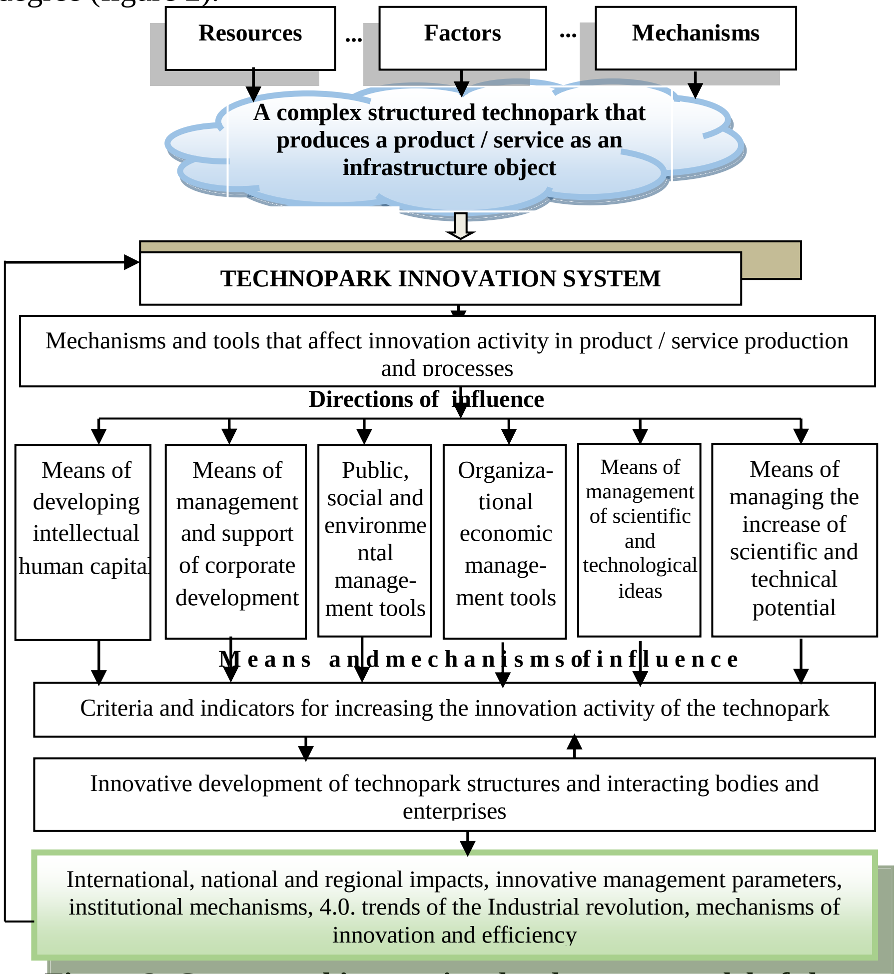

Figure 2. Conceptual innovative development model of the technopark

The model is based on the technopark infrastructure, its innovation system and the interaction of technopark entities. The main focus here is on innovative development directions and mechanisms [1, 7, 24]. Based on the interaction of technopark elements and increasing the intellectual level of their decisions, a conceptual structural model of the intellectual management system of complex activities of technoparks [13] was proposed (figure 3).

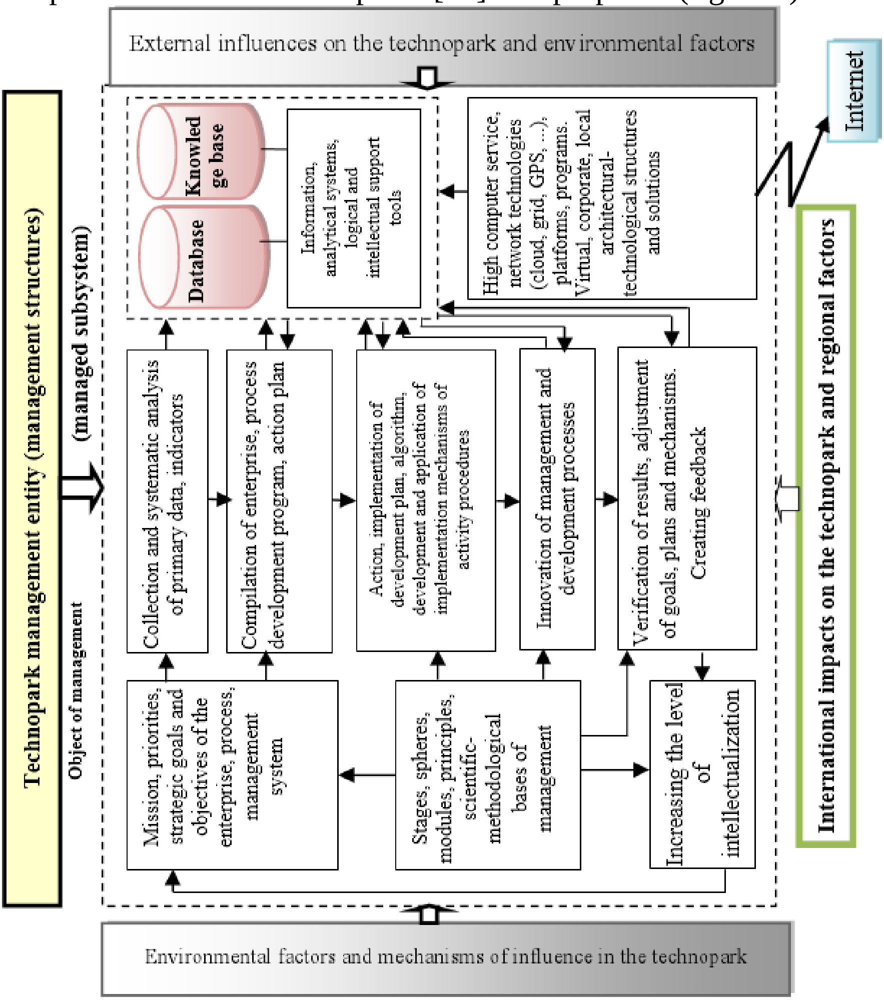

Figure 3. Conceptual structural model of the intelligent management system of activity of technoparks

In this section, a system of composite indicators for comparative assessment of the technopark's activity is proposed. On the basis of the composite index, a method of comparative assessment of the complex activity of the technopark was developed [3, 20, 15]. A generalized mathematical model for the effective organization of the management and operation of technology parks in the context of an incomplete information environment is given. Multifactor mathematical statistical models of science and innovation based production/ service production of technoparks have been developed.

Since it is necessary to use multidimensional optimization in the process of building a complex model of effective management of technoparks activity, it is expedient to fill the places of indefinite data and form the decision-making problem in the form of a vector problem of mathematical programming.

The general picture of this issue can be given on the condition that the activity of any technopark depends on the parameters, each of which is within certain limits. These parameters characterize the physical infrastructure, financial-investment (venture) resources, scientific and technological level, innovative environment, impact factors:

$$X = \{x_i, i = \overline{1, N}\}, \quad x_i^{\min} \le x_i \le x_i^{\max}, i = \overline{1, N} \qquad (5)$$

The results of the work of technoparks can be described by a set of criteria that functionally depend on them

$$F(X) = (f_1(X), f_2(X), ... f_k(X)) \,. \qquad (6)$$

The mathematical model of the technopark as a whole, which solves the problem of choosing an effective management decision in an innovative environment, can be described as follows:

$$F(X) \to \min \,, \qquad (7)$$

$$G(X) \le 0 \,, \qquad (8)$$

$$X^{\min} \le X \le X^{\max} \,, \qquad (9)$$

where $G(X) = (g_1(X), g_2(X), ... g_m(X))$ – is a vector-function of restrictions on the work of the technopark. They are determined by technological and similar processes in the technopark and can be described by functional limitations:

$$f_k^{\min} \le f_k(X) \le f_k^{\max}, k = \overline{1,K} \quad (10)$$

It is assumed that, $f_k(X), k = \overline{1,K}$, $g_k(X), i = \overline{1,M}$ functions are continuous,

$S = \{X \in R^N \big| G(X) \le 0, X^{\min} \le X \le X^{\max}\}$ given with limitations (8)-(9), most of the possible points are not empty, but compact.

(6)–(9) formulas form a generalized mathematical model of the technopark's activity. It is required to find a parameter vector $X^0 \in S$ such that each component of the vector function F(X) would get a minimum value. Methods based on the normalization of criteria can be used to solve this problem. They allow to solve this problem both in the case of equally valuable criteria and given the priority of the criterion.

Based on this approach, initial indicators for the establishment of a multifactor mathematical statistical model for the analysis of innovation and science-intensive product/service production in the activities of technoparks were first identified [17, 10].

The integrated efficiency criterion (TEC) of the technopark can be defined as a function of the relevant criteria. So that,

$$TEC = F(K_1, K_2, \ldots K_n),$$
$$K_i = F_i(K_1^i, K_2^i, \ldots K_{L_i}^i), \quad (i = \overline{1,n}) \quad (11)$$

In a special case, if we define the functions F and F_i as a linear function defined by the values of the relevant criteria as the product of their relative significance coefficients, then the result can be defined as follows:

$TEC = \sum_{i=1}^{n} k_i K_i$. For the i-th criterion, the result is defined separately as follows: $K_i = \sum_{l_i=1}^{L_i} k_{l_i}^i K_{l_i}^i$, $(i = \overline{1,n})$ (12)

The structure of the Composite Indicators and Indices System (CIS), which forms the basis of the information model of technoparks, is proposed in a multi-level form (figure 4). The main level integrally reflects all the lower levels that follow it, and the parameter that characterizes it is called the composite index of the technopark (CIT) [20]. The composite index is formed as a result of the assessment and has a leading position in the comparative analysis. So, as a result of this value, the technopark receives an appropriate rating. The value of the composite index can vary on a scale of (0.100).

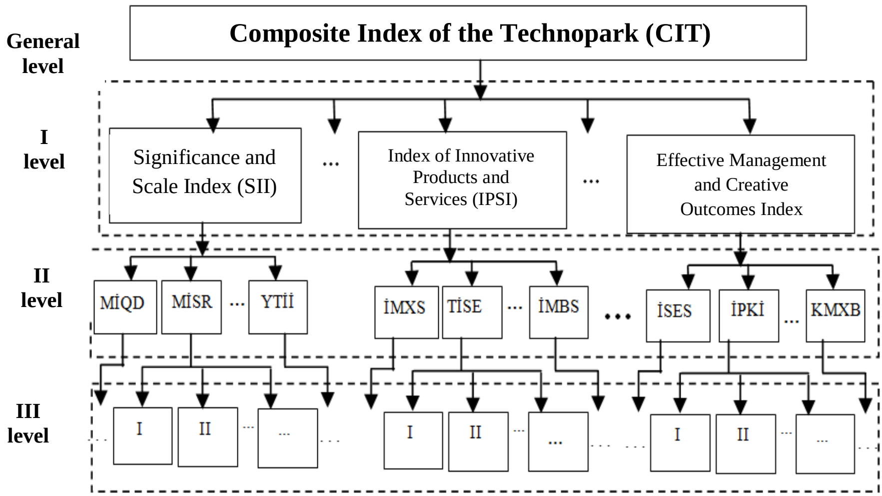

Figure 4. Hierarchical structure of composite indices and indicators of the technopark

The calculation of the CIT can be functionally stated as follows:

$$CIT = FI\ (SIS, INF, FBE, IMR, IPA, HRS, SEI, IPS, ETC, SED) \qquad (13)$$

Here indices are expressed such as SIS-Significance and scalability index, INF-İnfrastructure and information provision index, FBE-Feasible business environment, IMR-Investment-financial reserves and materialtechnical resources index, IPA-Innovative potential, activeness environment index, HRS-Human resources and professional staff training index, SEI-Scientific-research, experimental developments and innovative projects index, IPS-Innovation products and services index, ETC-Effective management and creative results index, SED-Socio-ecological development index.

In order to determine the impact (weight) coefficients, the expert group should achieve the following sequence by comparing the indices based on the degree of significance and importance:

$$K_1^* \geq K_2^* \geq K_3^* \geq K_4^* \geq K_5^* \geq K_6^* \geq K_7^* \geq K_8^* \geq K_9^* \geq K_{10}^* \quad (14)$$

If in this process significant differences and contradictions between the assessments of experts are revealed, such cases are eliminated on the basis of the intervention and advice of decision-makers.

The fourth chapter, entitled "Analysis of experimental results of models and development of recommendations on development prospects of technoparks" examines the experimental testing of models, methods, algorithms and mechanisms proposed in previous sections, reviews practical evaluation of results and giving the appropriate recommendations. The positive results of the impact of the creation of technoparks on the development of the innovative economy and increasing of its efficiency were analyzed.

In this section, architectural-technological model of technoparks has been developed to improve the information provision of the effective organization of their activity [21, 9, 16] (figure 5).

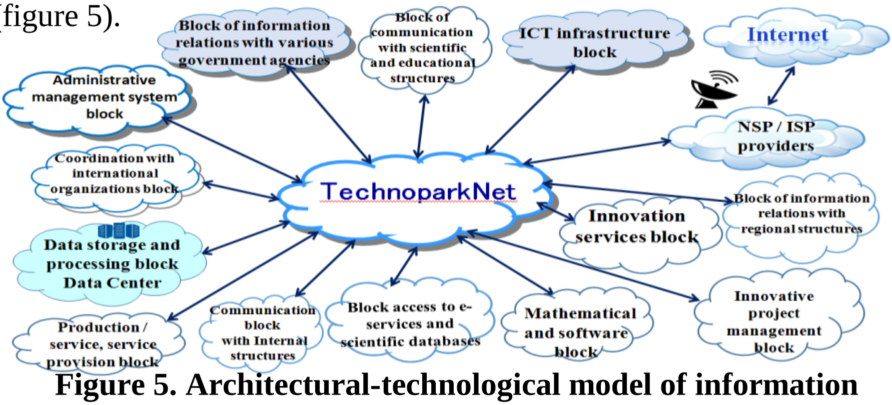

Figure 5. Architectural-technological model of information support system of technoparks

Application prospects of modern ICT tools and information technologies (soft computing, cloud computing, Big Data, The Internet of Things (IoT), cyberphysical systems, 4.0 Industrial Revolution, e-library, etc.) to improve information provision on the platform of information system formation[7] in technoparks have been taken into account [22, 12, 19].

This section also offers an expert evaluation scale for innovation projects in technoparks based on open information used to evaluate projects in various organizations.

As an experiment, 10 projects that any science and technology park that implements a competition of innovative projects wants to examine in the relevant field were considered. The projects were evaluated by experts according to 8 criteria and weight coefficients in accordance with the requirements of the implementing organization, i.e. the decision-maker [23]. Following this process, a mathematical relationship was established between the decision maker's comprehensive assessments of the projects and the criteria assessments that affected that assessment.

In the same way, the weight ratios given by the experts to the selected indices to form the proposed Composite Index for the comparative assessment of the performance of technoparks were studied accordingly. Then the final score was calculated for each index. As a result of the expert assessment, the impact (weight) coefficients of the selected indices were assessed as follows:

Experimentally, the activity of 15 different technoparks was evaluated on a scale of 10 indices (0, 10) and relevant calculations were made according to the known rule. They were ranked according to the value of the composite index obtained for each technopark, and the final estimates were as follows:

Technopark 1-140, Technopark 2-170, Technopark 3-160, Technopark 4-150, Technopark 5-175, Technopark 6-162,

[7] Farat O., Bets M. Formation of the information support for the entities of management by the development of innovation clusters // Baltic Journal of Economic Studies, 2018, vol.4, No.2, p.249-253.

Technopark 7-125, Technopark 8-135, Technopark 9-230, Technopark 10-169, Technopark 11-190, Technopark 12-180, Technopark 13-168, Technopark 14-145, Technopark 15-148.

These results are presented in formal and graphical form (figure 6), as well as in the form of estimates of statistical parameters characterizing the results (figure 7).

$$\boldsymbol{CIT\_\_Y = 0.97*KRT1\_X_1 + 1.88*KRT2\_X_2 + 4.47*KRT3\_X_3 + 3.09*KRT4\_\_X_4 + 2.82*KRT5\_\_X_5 + 4.10*KRT6\_\_X_6 + 4.83*KRT7\_X_7 + 4.61029805143*KRT8\_X_8 + 6.97081747774*KRT9\_X_9 + 3.99*KRT10\_X_{10} - 3.71} \quad (15)$$

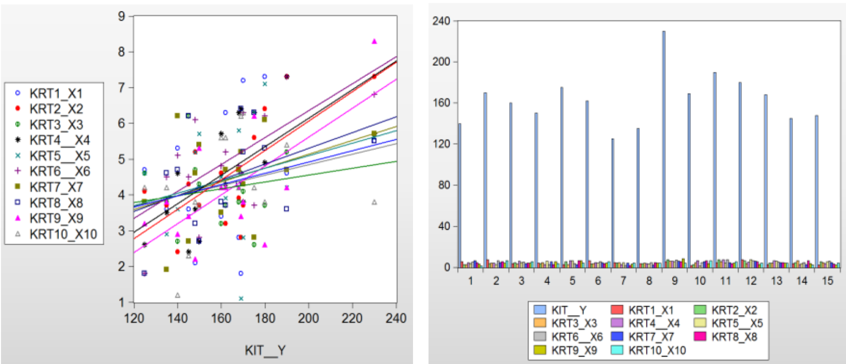

Figure 6. Dependence and distribution graphs of variables for estimating the composite index of the technopark

Dependent Variable: KIT__Y
Method: Least Squares
Date: 04/24/18 Time: 17:10
Sample: 1 15
Included observations: 15

Variable	Coefficient	Std. Error	t-Statistic	Prob.
KRT1_X1	0.970363	0.575365	1.686517	0.1670
KRT2_X2	1.879834	1.185521	1.585660	0.1880
KRT3_X3	4.473462	1.221823	3.661303	0.0216
KRT4__X4	3.094790	0.948002	3.264541	0.0309
KRT5__X5	2.816139	0.916481	3.072773	0.0372
KRT6__X6	4.100548	0.763130	5.373332	0.0058
KRT7_X7	4.831663	0.811730	5.952303	0.0040
KRT8_X8	4.610298	0.603848	7.634861	0.0016
KRT9_X9	6.970817	0.532072	13.10127	0.0002
KRT10_X10	3.993420	0.617019	6.472117	0.0029
C	-3.707510	7.437603	-0.498482	0.6443

R-squared	0.997484	Mean dependent var	163.1333
Adjusted R-squared	0.991195	S.D. dependent var	25.69843
S.E. of regression	2.411419	Akaike info criterion	4.743219
Sum squared resid	23.25976	Schwarz criterion	5.262455
Log likelihood	-24.57414	Hannan-Quinn criter.	4.737688
F-statistic	158.5996	Durbin-Watson stat	2.190690
Prob(F-statistic)	0.000094		

Figure 7. Estimates of statistical parameters of the model for estimating the composite index of the technopark

In formula (15), X_1, X_2,...X_{10} characterize the indices in formula (13) respectively. The results of the evaluation were considered appropriate by the expert group.

Experimentally, the activity of 3 types (scientific, service, production) of the technopark was evaluated by experts on 3 groups of indicators (indices). Indicator groups are marked as 1) "Production resources", 2) "Development resources" 3) "Innovative resources".

The first and second groups included 5 indicators, and the third group included 3 indicators.

On the basis of statistical and expert assessments, mathematical statistical modeling and assessment of the dependence of the volume of product (service) output on the indicators of this group in all 3 types of technoparks was carried out. In all three cases, the coefficients of the mathematical statistical regression model were as follows.

Regression model 1 (Scientific technopark).

$$TUMB\_Y = -4.099*IER\_X_1 + 3.115*MTR\_\_X_2 + 0.840*YKM\_X_3 - 0.362*EFI\_X_4 + 2.083*EMF\_X_5 + 1.229*INV\_X_6 - 2.008*ETT\_X_7 + 18.398*EKO\_X_8 - 2.114*SMI\_X_9 + 6.4881*ITA\_X_{10} - 1.9354*BTM\_X_{11} - 1.3898*INV\_X_{12} - 150.415*SAG\_\_X_{13} - 343.834 \quad (16)$$

Regression model 2 (Service technopark).

$$TUMB\_Y = -13.150*IER\_X_1 + 8.291*MTR\_\_X_2 + 2.129*YKM\_X_3 + 0.275*EFI\_X_4 + 0.503*EMF\_X_5 - 1.111*INV\_X_6 - 8.900*ETT\_X_7 - 12.548*EKO\_X_8 - 8.281*SMI\_X_9 + 2.225*ITA\_X_{10} + 391.847*BTM\_X_{11} + 275.9508*INV\_X_{12} + 600.324*SAG\_\_X_{13} + 700.825 \quad (17)$$

Regression model 3 (Production technopark).

$$TUMB\_Y = 22.209*IER\_X_1 - 37.556*MTR\_\_X_2 + 0.0852*YKM\_X_3 + 1.1360*EFI\_X_4 - 1.205*EMF\_X_5 - 0.688*INV\_X_6 + 182.265*ETT\_X_7 + 49.801*EKO\_X_8 + 3.802*SMI\_X_9 - 93.799*ITA\_X_{10} - 1992.726*BTM\_X_{11} + 9231.7415*INV\_X_{12} - 3085.686*SAG\_\_X_{13} + 4049.476 \quad (18)$$

In formulas (16)-(18) characterizes Gross Product Release in Technopark (TUMB-Y) and the volume of services (man), IER-X_1 - heat and energy resources costs, man., applied to the product -service launch, MTR-X_2 - material and technical resource costs, man., YKM-X_3 - costs of semi-finished and complementary products, man., EFI-X_4 – costs of fundamental funds and infrastructure elements, man., EMF-X_5 - Salary fund, man., INV-X_6 - Investment incentives, man., ETT-X_7 - Scientific research and education costs, man., EKO-X_8 - Environmental protection and ecological balance costs, man., SMI-X_9 - Social protection and public development costs, man., ITA-X_{10} - Innovative research and perspective research costs, man., BTM-X_{11} - efficiency degree of "Resource-production-sales" business environment on the assessment of the expert group on the (0, 10) scale, INV-X_{12} - Innovative degree of cycle "Science-education-research innovation-production" on the assessment of the expert group on the (0, 10) scale, SAG-X_{13} - The ecological and health level of production and environment on the assessment of the expert group on the (0, 10) scale.

In group I, the output of service technoparks was highly dependent on 5 indicators (IER-X_1, MTR-X_2, YKM - X_3, EFI-X_4, EMF-X_5) belonging to the group of "production resources".

5 development resource indicators (INV-X_6, ETT-X_7, EKO-X_8, SMI-X_9, ITA-X_{10}) play an important role in the activity of service profile **technoparks in group II.**

The activity of group III scientific and technological innovation parks depends on 3 institutional environmental indicators (BTM-X_{11}, INV-X_{12}, SAG-X_{13}) from the group of “innovative resources”. In this group, all 3 indicators are evaluated by an expert group on a scale of (0, 10).

The statistical parameters and graphical representations of the variables on the regression model of the activity of the scientific technopark are presented below (figures 8, 9).

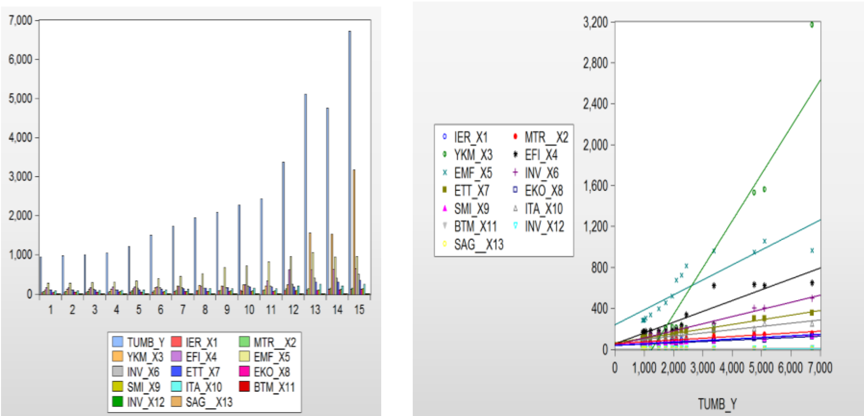

Figure 8. Dependence and distribution graphs of variables to assess the performance of the scientific technopark

Dependent Variable: TUMB_Y
Method: Least Squares
Date: 04/16/18 Time: 14:28
Sample: 1 15
Included observations: 15

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IER_X1	-4.099902	0.372183	-11.01581	0.0576
MTR__X2	3.115335	0.058479	53.27263	0.0119
YKM_X3	0.840203	0.004698	178.8242	0.0036
EFI_X4	-0.362758	0.041016	-8.844347	0.0717
EMF_X5	2.083203	0.035825	58.14966	0.0109
INV_X6	1.229792	0.082460	14.91378	0.0426
ETT_X7	-2.008108	0.106678	-18.82399	0.0338
EKO_X8	18.39887	0.480650	38.27914	0.0166
SMI_X9	-2.114452	0.235010	-8.997275	0.0705
ITA_X10	6.488172	0.068342	94.93750	0.0067
BTM_X11	-1.935422	4.502301	-0.429874	0.7415
INV_X12	-1.389832	4.372606	-0.317850	0.8041
SAG__X13	-150.4157	2.936373	-51.22500	0.0124
C	-343.8344	12.10828	-28.39663	0.0224

R-squared	1.000000	Mean dependent var	2475.907
Adjusted R-squared	1.000000	S.D. dependent var	1758.864
S.E. of regression	1.197720	Akaike info criterion	2.357333
Sum squared resid	1.434533	Schwarz criterion	3.018180
Log likelihood	-3.679998	Hannan-Quinn criter.	2.350294
F-statistic	2322409.	Durbin-Watson stat	3.095771
Prob(F-statistic)	0.000514		

Figure 9. Estimates of statistical parameters of the model for assessing the performance of the scientific technopark

Among the 13 indicators characterizing the activity of the technopark, 8 variables with the highest density were taken and included in the next stages of modeling.

8 indicators characterize the increase of efficiency of science, service and production technoparks as a whole. These results are presented in formal and graphical form (figure 10), as well as in the form of estimates of statistical parameters characterizing the results

(figure 11). The coefficients of the regression model of this result were as follows.

$$TUMB\_Y = 0.033*YKM\_X_3 + 1.467*EFI\_X_4 - 0.046*EMF\_X_5 - 2.039*INV\_X_6 + 20.654*ETT\_X_7 + 6.104*ITA\_X_{10} - 1501.013*BTM\_X_{11} + 6144.369*INV\_X_{12} - 16608.758 \qquad (19)$$

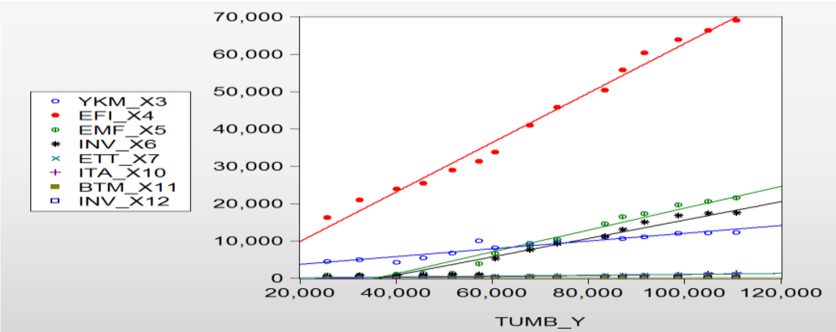

Figure 10. Dependence and distribution graphs of variables to assess the performance of the technopark

Dependent Variable: TUMB_Y
Method: Least Squares
Date: 05/03/18 Time: 15:36
Sample: 1 15
Included observations: 15

Variable	Coefficient	Std. Error	t-Statistic	Prob.
YKM_X3	0.032766	0.935005	0.035044	0.9732
EFI_X4	1.467085	0.411603	3.564321	0.0119
EMF_X5	-0.046151	0.882064	-0.052321	0.9600
INV_X6	-2.039275	1.054318	-1.934213	0.1013
ETT_X7	20.65496	29.44870	0.701388	0.5093
ITA_X10	6.104179	10.73139	0.568815	0.5901
BTM_X11	-1501.014	1567.298	-0.957708	0.3752
INV_X12	6144.369	2974.148	2.065926	0.0844
C	-16608.76	8604.589	-1.930221	0.1018

R-squared	0.998688	Mean dependent var	68826.21
Adjusted R-squared	0.996939	S.D. dependent var	26821.27
S.E. of regression	1483.802	Akaike info criterion	17.72631
Sum squared resid	13210014	Schwarz criterion	18.15114
Log likelihood	-123.9473	Hannan-Quinn criter.	17.72179
F-statistic	571.0506	Durbin-Watson stat	2.663018
Prob(F-statistic)	0.000000		

Figure 11. Estimates of statistical parameters of the model for assessing the performance of the technopark

Directions for improving the activities of modern technopark structures have been developed on the basis of the "Enterprise of the Future" Concept [18, 22]. The main trends and challenges of the IV

Industrial Revolution Platform were also taken into account (figure 12).

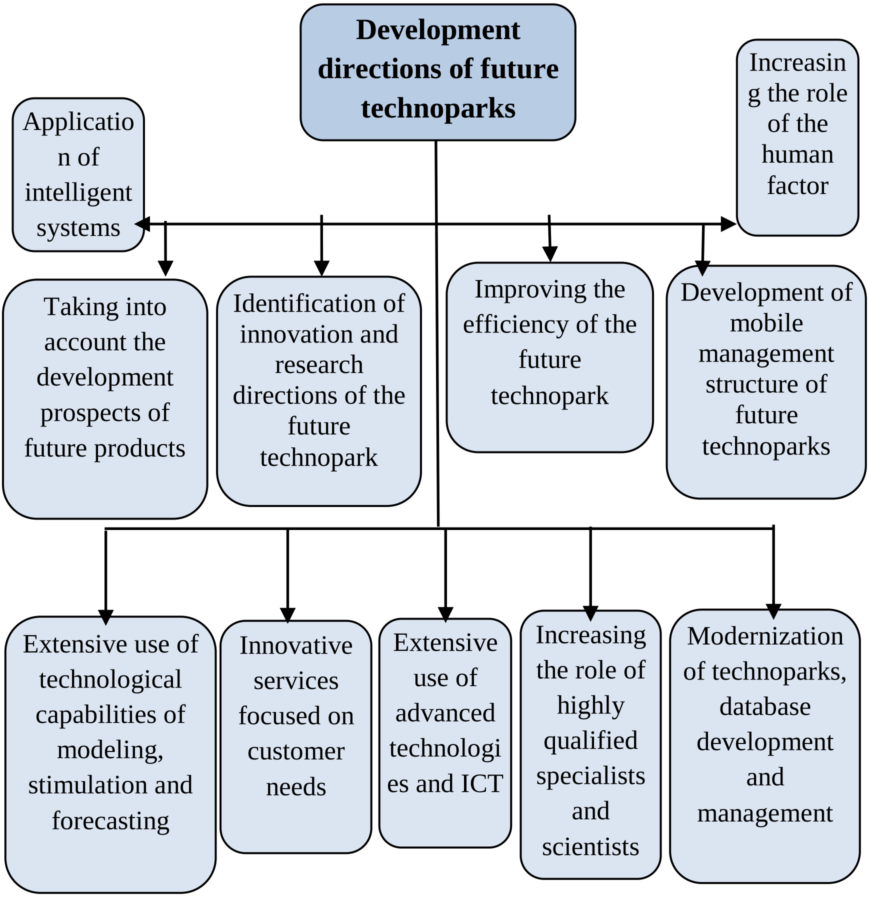

Figure 12. Development directions of future technoparks

The model of activity of modern innovative scientific and technological parks, taking into account the trends of the 4.0 Industrial Revolution, may consist of the following components [18, 22, 24]:

1)additive technologies and structures, 2)adaptive technologies and structures, 3)increasing the role of the human factor, 4)taking into account the development prospects of innovative products and services, 5)customer-oriented logistics, e-commerce, blockchain technology and marketing, 6)flexible management structure, 7)application of robotics, artificial intelligence and intelligent systems, 8)modern ICT, IoT, cyberphysical systems, grid, cloud, fog and other technologies, etc.

In addition, it is important to take into account a number of long-term major trends in the technopark, such as 1)natural development based on a "green" and sustainable economy, 2)constant contact between producer and consumer, 3)the merge of other enterprises in a chain and 4)the formation of brain centers there.

CONCLUSION

The following main results were obtained in the dissertation:

1. The main characteristics, different features, initial socio-economic conditions, characteristic technological features, management parameters and problems of technoparks as an object of management as a complex system are defined [4, 7, 13, 14]. It has been confirmed that the technopark, which is a complex of science-intensive products and services, has a special significance in the development of an innovative economy as a key structural element. It was noted that the activities of technoparks are mainly characterized by the organization and development of the transformation of scientific and innovative results into commercial products and their introduction to the world market.
2. As a result of research of stages of formation, principles, features of technoparks and comparative analysis of the existing international experience in this field, systematic analysis of the situation, their scientific-theoretical problems were revealed [6, 11, 14, 22]. A structure of innovation process covering the entire period of transformation of scientific ideas, discoveries and inventions into commercial products has been developed.
3. Based on the synthesis of existing models of activity of technoparks as an object of scientific environment and socio-economic infrastructure, their innovative modern organizational-managerial structural model was developed [2, 11, 18, 22, 24]. The components of this model are modern, and the structural analysis of the model allows to identify many problems that arise in the development stages of the technoparks. It allows to take into account the American, European and Japanese models of technoparks, elements of the 4.0 Industrial Revolution, other requirements for modern innovative science and technology parks and the application features of international trends.

4. The main indicator block and architectural-technological structure of the information support system for the management system and conceptual models of innovative development of technoparks and the effective organization of its activities have been developed [8, 9, 13, 16, 18, 19, 21, 22]. In order to increase the level of innovation in the activities of technoparks, its conceptual development model is characterized by international, national and regional impacts, innovative management parameters, institutional mechanisms, 4.0 Industrial Revolution structural elements.
5. Indicators, criteria, models, methods and algorithms for improving innovative project management processes by modeling in technoparks and evaluating, selecting and implementing projects have been developed [23, 24]. Determining the evaluation criteria for the selection of innovative projects, the weight coefficients of the project evaluation criteria and the development of the final evaluation algorithm provide scientific support to increase the efficiency of innovative project management processes.
6. Indicators, criteria, models and algorithms for complex analysis and comparative assessment of the management and innovative activity of technoparks have been developed [3, 5, 10, 12, 15, 17, 20]. The method of comparative assessment of the complex activity of the technopark on the basis of the composite index, the development of multifactor mathematical statistical models of science and innovation-intensive product-service production of technoparks will have a stimulating effect on the development of technoparks.
7. A multifactor mathematical statistical model of production processes has been developed by identifying the main parameters that affect the release of innovative products and services production in technoparks [3, 5, 10, 12, 17]. Assessment of the activity of technoparks on 3 groups of indicators will support the consideration of the most important parameters affecting the release of innovative products and services in technoparks, planning the production

of innovative products and services, the development of appropriate forecasting options.

8. Based on the results of the experimental implementation of the proposed models and methods, algorithms and systematic analysis, recommendations were developed to increase the efficiency of innovative activities of technoparks and their development prospects in Azerbaijan [8, 18, 20, 22, 24]. The requirements for various, different level innovative structures, as well as the mechanisms formed to stimulate and regulate their activities have been systematized, generalized and scientifically and theoretically substantiated and improved in an integrative manner. This creates additional opportunities to determine the direction of development of future technoparks, the formation, development and increasing the efficiency of the development model of modern innovative science and technology parks based on the trends of 4.0 Industrial Revolution, increase the level of scientific, theoretical and practical use of the results, ensure sustainable development.

Taking into account the methodological, scientific-theoretical and practical results of the dissertation and the proposed recommendations in both scientific circles and at different levels of management and the implementation in appropriate conditions can create new opportunities to achieve more important and useful results in high-tech economic development.

The main results of the dissertation were published in the following scientific works:

1. Aliyev A.G., Shahverdiyeva R.O. On need for working out the models and mechanisms of establishment and management of ICT-technoparks // The second International Conference "Problems of Cybernetics and Informatics" (PCI'2008). Baku, Azerbaijan, 10-12 september 2008, pp.188-191 **(Web of Science).**
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7. Aliyev A.G., Shahverdiyeva R.O. Some aspects of development of management mechanisms of innovative technoparks // 7th International Conference on Application of İnformation and

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13. Aliyev A.G., Shahverdiyeva R.O. Conceptual bases of intellectual management system of innovative technoparks // International Journal Education and Management Engineering, 2017, No.2, pp.1-7.
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The personal role of the plaintiff in published works with co-authors

[2], [24] - development of functional organizational and economic structure of technoparks and directions of increase of activity efficiency;

[3], [5], [12] - development of methodology and algorithm for complex assessment of operational efficiency of technoparks;

[6], [14] - structural analysis of the processes of transformation of scientific knowledge into innovations, development of mechanisms for commercialization of the innovation process;

[1], [7], [10], [17] - modeling of production and management processes, development of management mechanisms and basics of management system and implementation of models;

[8], [11], [15], [20] - generalized analysis of international experience in technoparks, development of a database of composite indicators and innovations on their activities;

[18], [22], [24] - development of strategic priorities, perspectives of creation of innovative enterprises, application of requirements of the 4.0 Industrial Revolution in management of activity of technoparks;

[4], [13] - analysis of management problems and development of management system;

[9], [16], [19], [21] - development of management information support system, analysis of information supply problems;

[23], [24] - development of indicators and criteria for selection and evaluation of innovative projects, evaluation of efficiency.

The defense will be held on 23 november 2021 at 14^{00} at the meeting of the Dissertation council FD 2.25 of Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at Sumgayit State University

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