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SCIENCE PARKS: ANALYSIS OF INTERNATIONAL EXPERIENCE AND DEVELOPMENT PROSPECTS IN UKRAINE

The object of the research is the issues related to the creation of science parks in Ukraine at a new level in the process of its post-war reconstruction. In this paper, the main focus is on the analysis of the very concept of «science park» and the experience of some international ones, which are most suitable for the domestic plans for the transformation of the Ukrainian economy and its social infrastructure. Also researched the initiative of the Kharkiv city government to create the so-called «science quarter», which would absorb all the best that exists in the world in the field of science parks, and would have its own «highlight». As a result of this study, it was established that the creation and functioning of science parks is an important component of the modern world economy, which should be given serious attention in the process of post-war transformation of the Ukrainian economy. Moreover, the process of developing a strategy for the construction of such science parks should be started now, without waiting for the end of the war. A good example of this is the start of work on the project to create a science park in Kharkiv called «Science Quarter» as part of the development of a city recovery plan with the help of specialists from various international organizations, universities, banks and funds. The article analyses the activities of some similar science parks in Poland, which can be used as a guide in this process, and provides recommendations for the improvement and enhancement of certain basic elements of the future Kharkiv science park. As a result, it was concluded that thanks to the hard work of the city authorities with the support of international institutions, active work is being done to develop a city reconstruction strategy at a fundamentally new level in Kharkiv, within which a significant place is given to the implementation of the «Science Quarter» project. The success of the latter will depend not only on the experienced team of specialists implementing this project and the receipt of the necessary funding, but also, first of all, on the success of our defenders in repelling russian aggression.

Keywords: *post-war reconstruction of the country, science parks, «Science Quarter», Kharkiv science park.*

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1. Introduction

In today's economic realities, it is important not only to withstand but also to win russia's war against Ukraine, as the continued existence of the civilized liberal democratic world in its confrontation with aggressive authoritarian and totalitarian regimes depends on it. Therefore, from the very beginning of russia's aggression, Ukraine began to receive various types of military, food, financial, and humanitarian aid from many countries, primarily the United States and the EU. A few months later, the country began to develop plans for post-war reconstruction, involving leading domestic and foreign experts.

Among the many areas of restoration (or transformation) of the Ukrainian state and its economy, an attempt to restart the work of existing science parks and to resume the process of creating new ones at a new level is promising. The initiative of the Kharkiv city hall to create a «Scientific Quarter» is interesting from an applied perspective. Therefore, an analysis of the world's experience in science parks, the problems of similar pre-war Ukrainian projects, and the prospects for the Kharkiv project is extremely relevant from a scientific and practical point of view.

Although the world's first science park, Silicon Valley, appeared in the USA in 1951, and the rapid development of science parks worldwide began during the 1960s to 1980s, in Ukraine, attention was paid to them only at the beginning of the 21st century. Among the scientists and practitioners who began to study the issues of creation and functioning of science parks and continue to do so today are the authors of [1–5]. In their works, they studied the theoretical issues of science parks, world experience, and prospects for development in Ukraine, but mainly related to the peaceful period of our country's life. Challenges associated with russian aggression require researchers to take a new approach to this problem and to adjust some views on how the process

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of formation and development of science parks should take place during the war and post-war periods.

The aim of this research is, firstly, to analyze the concept of a «science park», to study the problems and prospects of creating and operating science parks in Ukraine, and secondly, to provide specific recommendations for implementing the strategy of building a science park called «Science Quarter» in Kharkiv. This will be based on the views of many experts on this issue and the experience of similar European projects.

2. Materials and Methods

The object of research is the issues related to the creation of science parks in Ukraine at a new level in the process of its post-war reconstruction. *The subject of research* is a set of theoretical, scientific and practical recommendations for finding optimal ways to create and develop science parks in the period of transformation of the Ukrainian economy.

The main methods used in this study were the following: scientific (or logical) abstraction with the use of modeling, analysis and synthesis, a combination of historical and logical, statistical analysis.

3. Results and Discussions

The term «science park» was first introduced into the Ukrainian legislative field in 2009 by the Law of Ukraine «On Science Parks», which has been amended several times until recently. According to this law, «a science park is a legal entity established in the form of a business entity that must have at least one higher education institution and/or research institution as a member». It is «created with the aim of developing scientific, technical and innovative activities in a higher education institution and/or a research institution, efficient and rational use of the available scientific potential, material and technical base for the creation and commercialization of the results of scientific and technical activities and their implementation in the domestic and foreign markets» [6].

Representatives of Ukrainian science provide many of their own definitions of the concept of a «science park». Thus, according to the authors of [2], «a science park (science and technology park, technopark) is a scientific and production complex that includes a research center and an adjacent production area, where high-tech firms are located under lease or other conditions. Science parks, as a form of integration between science and industry, belong to the category of territorial scientific and industrial complexes. Today, science parks embody innovative urban planning ideas, stimulate urban development in regions, become the hallmark of the country of countries, and contribute to their economic development».

The team of authors in [7] argues that «science parks are created around a research center – a research institute, and less frequently – a university. They are focused on the development of research and development, their commercialization, and bringing them to the market. The result of the activities of science parks is the formation of specialized, technologically advanced areas as «incubators» of innovation, centers for «nurturing» new technological industries and markets that can gradually but fundamentally change the «technological landscape of the region», elevating it to a higher technological level» [7].

The author of [8] provides the definition of the term «science park» by various international organizations. Thus, «according to the position of the International Association of Science Parks, a science park is an organization established by a higher education institution or a research institution on the basis of a cooperation agreement for the purpose of transferring scientific knowledge to enterprises. Directorate General XIII of the European Commission defines a science park as a territory characterized by such properties as proximity to a research center or higher education institution, favorable conditions for the establishment and operation of new enterprises, and the ability to transfer developed technologies to real sector enterprises located within the territory». Finally, «according to UNESCO, the term 'science park' refers to the entire property complex created to support and group knowledge-based enterprises for the purpose of commercializing the results of scientific research and technology. Science parks aim to promote the development of a knowledge-based economy by bringing together scientific institutions with government organizations and their business support and development programs in one physical location» [8]. Summarizing all these definitions, the author considers that «in the world practice, there is no clear distinction between the definition of a technology, science and research park. As a rule, each country uses one of the formulations. In practice, the terms «science park», «technology park», «research park», «innovation center», «center for the development of advanced technologies» can generally be considered synonymous» [8].

From a scientific point of view, it is advisable to distinguish between these concepts. For example, a technopark in its classical definition is a research and innovation center that unites organizations and firms that cover the *entire cycle* of innovation activities from the generation of new ideas to the production and sale of knowledge-intensive products. And the first world technoparks (for example, the same Silicon Valley based at Stanford University, Western European technoparks of the 70s) generally started their activities with educational institutions leasing their land for long-term use as an office center, where only high-tech companies could act as tenants. In contrast, science parks (also in the classical definition) are not directly inherent in production and sales functions. The result of their functioning should be the creation of certain scientifically developed territories as so-called «incubators» of innovations for their further implementation in the real economy. In addition, a prerequisite for the operation of many science parks at the current stage of global economic development (including post-war Ukrainian ones) is the existence of a favorable environment, which, in addition to the development of innovations, should include support for the development of intellectual capital and appropriate social infrastructure in the form of housing, kindergartens, recreation areas, etc.

However, it is reasonable to assume that the differences in these definitions are not of fundamental importance. There are different models among the more than 400 science parks operating in the world. And each national model is based on its own principles. Even within the same country, each science park has certain features. It is fully possible to agree with the following statement: «Often the difference between science and technology parks is not clearly traced, they are identified with each other and with other innovative structures such as high-tech parks, research parks, as well as with technopolises and research campus. That is,

they may differ in name, but in fact they perform the same functions» [7]. Therefore, the main thing here is the result or effectiveness of the activities carried out by the entire structure of the science park and what it brings to the city and the people who live in it.

Before the war, 36 science parks were registered in Ukraine, founded by budgetary institutions (higher education institutions, research institutions, and state-owned enterprises); 28 of them were actively operating [8]. But, according to Vitaliy Cherniuk, former director of the Taras Shevchenko Kyiv University Science Park Corporation, former head of the expert group on communications and strategic planning of the Directorate of Innovation and Technology Transfer of the Ministry of Education and Science of Ukraine, and now head of Lugera Global R&D Solutions at the international company Lugera, both technology parks did not start working in Ukraine at the beginning of the century and the creation of many science parks after the adoption of the relevant law in 2009 did not give the desired result. This Law «stipulated that the creation of science parks was a mandatory requirement for some universities to obtain research status... This was a mistake, because many universities that applied for such status created science parks without understanding what they were supposed to do. That is, «on paper» the parks existed, but in reality, they did not. At the same time, the university reported that it had a science park and claimed to be a research university» [9].

In other words, the process of creating science parks needs to be started anew, even before the end of hostilities. An illustrative example in this regard is the initiative of the Kharkiv city hall to create a so-called «Scientific Quarter» in the city. In fact, the post-war reconstruction of Kharkiv was discussed as early as April 2022, when the russian aggressor's troops were still nearby. According to the first plan, the city's master plan was to consist of five parts: «heritage», «industry», «housing», «scientific quarter», and «rivers». Commenting on the proposed master plan, Kharkiv authorities said that it envisages the development of a «Scientific Quarter» that will house innovative enterprises, including a building designed by the British architectural firm Foster+Partners, founded in 1967. (By the way, Foster contributed to the development of high-tech architecture and introduced energy-efficient building technologies. His works are characterized by large-scale open spaces, an abundance of glass and metal, and multifunctionality. The architect worked on the design of Apple's headquarters, Apple Park in California (USA), designed the HSBC Bank in Hong Kong and the world's tallest bridge, the Viaduct de Milo in France. At the same time, he has been criticized for his cooperation with authoritarian regimes and cited for the construction of the Palace (Pyramid) of Peace and Harmony in Astana, the airport in Beijing, and the Lusail Stadium in Qatar for the 2022 FIFA World Cup.) This science park will be located near the Barabashovo market.

The idea of creating a science park in Kharkiv was further developed at the Investment Forum «Kharkiv: Restart», which took place in Kyiv on September 19, 2023, at the initiative of the Kharkiv city hall and the USAID Economic Resilience Agency (ERA). It was attended by about 500 participants, including politicians, government officials, representatives of local authorities, international organizations, domestic and foreign businesses, etc. The forum discussed the future reconstruction of Kharkiv and the need to attract investments to support it, taking into account factors such as efficiency (using the best international practices), security and potential risks due to the proximity of the border with russia.

The conference presented a city plan developed by the Norman Foster Foundation at the request of the United Nations Economic Commission for Europe (UNECE) and seven pilot projects, including creation projects:

1) a «Scientific Quarter» (on the site of the Barabashovo market);
2) a modern transport hub and a shopping and entertainment cultural center on the territory of the Levada suburban railway station;
3) a new shopping center near the Southern Railway Station;
4) Oleksiivka City, a «city within a city»;
5) smart city;
6) municipal taxi service on electric vehicles;
7) reconstruction of the Lopanska embankment.

Let's focus on the characteristics of the first project, which corresponds to the topic of this study. The «Science Quarter» will be created on the territory of the former Barabashovo market. The project aims to become a flagship for the new Kharkiv master plan, as a new neighborhood that will position the city and the country at the forefront of innovation, modern technology, and urbanism.

Barabashovo Market and the adjacent riverfront areas will be transformed into a new, iconic, revolutionary mixed-use district designed to promote scientific and technological innovations. This forward-looking project will combine the innovative potential of science parks with the most modern approaches to neighborhood development. New residential districts will be created, featuring multi-family buildings that will foster the city's economic development through innovative research. Barabashovo Market will remain in place in a modernized and compact version. Connectivity with the rest of the city will be ensured by the strategic location of the district between the «Akademika Barabashova» metro station, the «Saltivska» tram line, and the Kharkiv River. The estimated area will be approximately 140 hectares with potential for further growth [10].

A crucial factor will be the presence of universities, which will serve as the foundation for the creation of this science park, as well as the design and construction of green public spaces to promote the formation of a fundamentally new type of residential area. In this way, the problem of the presence of modern infrastructure in the science park is addressed. Vitalii Cherniuk considers the lack of infrastructure, which is almost entirely absent everywhere, to be the main issue for all science parks operating in Ukraine. According to him, most universities do not have their own infrastructure, and science parks function more as technology transfer offices rather than as science parks in leading universities around the world [9].

On December 1, 2023, experts from the Norman Foster architectural bureau presented new developments regarding the city's master plan at a meeting with Kharkiv Mayor Ihor Terekhov. «The economic factor precisely aligns with the pilot project of the research campus, which is to become a hub for attracting young talent. Entrepreneurs working there should be able to easily and quickly register their businesses and should not be burdened with excessive regulatory procedures», said Alberto Sendoya, Co-Head of the Architecture Department of the Norman Foster Foundation [11].

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Already on February 1, 2024, at the next meeting dedicated to the reconstruction of Kharkiv, with representatives from the Norman Foster Foundation, the UNECE, and experts from Oxford and Harvard Universities, the mayor noted, «It is crucial for us to create an economic model for the city right now, during the war. I like your proposal for developing science parks based on our universities. This would attract more entrepreneurs, more IT specialists, and more young people here» [12]. In turn, Alberto Sendoya stated that this year, three out of five pilot strategies, whose development is funded by Kharkiv's international partners, including the «Science Quarter» project, will be finalized. «The economic factor precisely aligns with the pilot project of the research campus, which is to become a hub for attracting young talent. Entrepreneurs working there should be able to easily and quickly register their businesses and should not be burdened with excessive regulatory procedures», he said [12].

Thus, the idea of creating a modern science park in Kharkiv remains one of the priorities in the post-war reconstruction and is continuously being refined. Currently, the park's concept is still being finalized and will need to be agreed upon with the residents of Kharkiv. Subsequently, changes to the master plan will be required (all this in wartime conditions). This means a timeline of 5–10 years (under favorable conditions), with the concept planned to be implemented in stages: housing will be built first, followed by the creation of the science park's infrastructure.Certainly, the American model of a science park, characterized by a single founder and primarily leasing land to owners of technology firms, is not relevant in our case. Examples include science parks affiliated with universities such as Heriot-Watt University in Edinburgh, Scotland, Universite de Nice Sophia-Antipolis in Nice, France, ZIRST de Meylan-Grenoble in Grenoble, France, and Li Noû Loven in Ottignies-Louvain-la-Neuve, Belgium, among others. The existing concept of the science park planned for Kharkiv closely resembles similar parks in Poland, notably the Poznan Science and Technology Park and Technopark Gliwice. Let's believe this aligns well with the city's and country's needs for the near future. Unlike Silicon Valley, whose success recipe has been impossible to replicate, or the Western European science parks of the 1970s–1980s, which were often based on neglected industrial sites (e. g., Rhein Elbe Science Park), modern Polish science parks best meet the conditions and requirements of our city. Let's explore why.

The Poznan Science and Technology Park was the first to be established in Poland back in 1995 to stimulate cooperation between science and industry to enhance regional development through innovation, technology transfer and international cooperation. Its main activities are:

– *research* (the park offers research services to companies, contract research, technology development and testing in laboratories in the following areas: biotechnology, chemical and cosmetic industries, food industry, etc.);
– *incubation of startups* based on the results of a business plan competition; the park's incubators provide coaching for startups, including entrepreneurship courses, and assistance in preparing startup developments for investment;
– *technology transfer and innovation promotion* (consultative support is offered at every stage of the innovation chain, competitive position analysis for companies, sourcing innovations and potential funding sources for innovation projects; legal consultations are provided; support for academic entrepreneurship is implemented);
– *infrastructure support* (from leasing equipped laboratories, educational and office spaces to providing park residents with all necessary social infrastructure (kindergartens, cafeteria, library, green recreational areas, etc.)) [7].

Strengths of «Technopark Gliwice» include:

1) high quality of human capital, reflected in the high level of education of the local population and concentration of highly skilled human resources;

2) concentration of strong educational and scientific centers in the city;

3) high investment attractiveness.

The activities of these science parks have allowed for a significant increase in average wages, the volume of goods produced, the creation of comfortable living conditions for residents, and a positive image for these cities, thanks to the influx of investments. Recent economic transformations have underscored the importance of small and medium-sized enterprises for the development of the Polish regional economy. For example, in Gliwice, such enterprises account for 99 % of the total number of registered businesses [7].

Analyzing these characteristics, one can conclude that the city of Kharkiv has all the conditions for the successful implementation of the «Science Quarter» project similar to these two Polish science parks, albeit with its own specifics. The city has long been renowned for its high scientific and technical potential, which still persists despite the negative processes of recent years related to the outflow of skilled personnel due to war and the lack of economic attractiveness in the region before the war. Kharkiv is a city with a concentration of many educational and scientific institutions. It has about 70 higher education institutions, including 17 universities that before the war enrolled approximately 300,000 students. Additionally, the city possesses investment potential that is being realized even during wartime.

According to Maksym Bondarenko, the head of the Investment Promotion Office «UkraineInvest», Kharkiv has the potential to become the most comfortable city in Ukraine, considering its population size and the significant labor force potential for upcoming enterprises [13].

In Kharkiv, there are companies operating in pharmaceutical, food, engineering, and other sectors of the national economy. However, they require innovative changes not only in equipment but also in organizing production processes and technologies that can be provided by the structures of the science park. The Park also needs to create opportunities for all interested legal entities to receive advisory support and guidance in legal and economic matters. There is no doubt that the Kharkiv IT Cluster will also participate in the processes of development and operation of the science quarter. This public non-profit idea-based organization, which brings together representatives of education, government authorities, and IT companies, is precisely created to develop an environment for technological business in the region.

Startup incubation, which is one of the key components of the Poznań Science and Technology Park, should also be present in the activities of Kharkiv «Science Quarter». The Kharkiv IT Cluster can also assist newcomers in developing their first IT projects through Boot-Camp, as its representatives mentioned during an online meeting with students of the Ukrainian Engineering Pedagogics Academy on February 28, 2024, using facilities of the future «Science Quarter» [14]. By the way, only two-thirds of the world's science parks include universities, with the most common

elements being business incubators (>90 %) and research institutes (>80 %).

Finally, the city's plans for residential construction in the «Science Quarter» should be complemented by the creation of modern social infrastructure, which would allow all its residents and workers to access all necessary services on-site. This would significantly distinguish Kharkiv «Science Quarter» even from leading domestic science parks such as SID City Science Park at Lviv Polytechnic National University and the Kyiv Polytechnic Science Park at the National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute».

In order to properly conduct the techno-economic justification for the Kharkiv «Science Quarter» and better define its strategic components, it is necessary to have complete and reliable information regarding Kharkiv universities, research institutions, regional economic situation, and business environment; detailed information on local and regional development plans for Kharkiv; innovation policies and support mechanisms; as well as cultural, artistic, and creative industries (Fig. 1).

This has a significant impact on the development of the economic strategy for Kharkiv, the analytical basis of which is provided in Fig. 2.

From a practical standpoint, it is necessary to identify the strategic revenues of the city and adjust the content of the management toolkit to achieve them, confirming the objective need for constructing confidence intervals of the city's strategic revenue expectations.

In this context, it is conditionally expedient to define certain basic components, namely:

– *knowledge management* – consolidation of intellectual capital as a primary type of city resources, strategic marketing, and product innovation;

– *establishing partnership networks with other market participants* – developing informational capital; process management of city activities;

– *city value* – systematic risk management, organizational structure, and culture as factors of the city's competitive advantage.

Fig. 3–5 depict isovariational ellipses of mathematical expectation for the city's strategic revenue based on the integrated indicators of «knowledge management», «establishing partnership networks with other market participants», and «city value».

The variable values of model criteria parameters enable forecasting the city's development level under conditions of external uncertainty by constructing ellipses of mathematical expectation of strategic revenues and investment portfolio efficiency, directly determined by cross-spectral properties of managerial effectiveness and strategic forecasting.

Thus, the plan for creating a modern science park in the city of Kharkiv and the main conditions for its implementation exist. The remaining open questions concern the sources of funding for its actual construction (since the strategy or construction plan is already financed by international partners) and the creation of a qualified team of specialists who will be responsible for the implementation of this project.

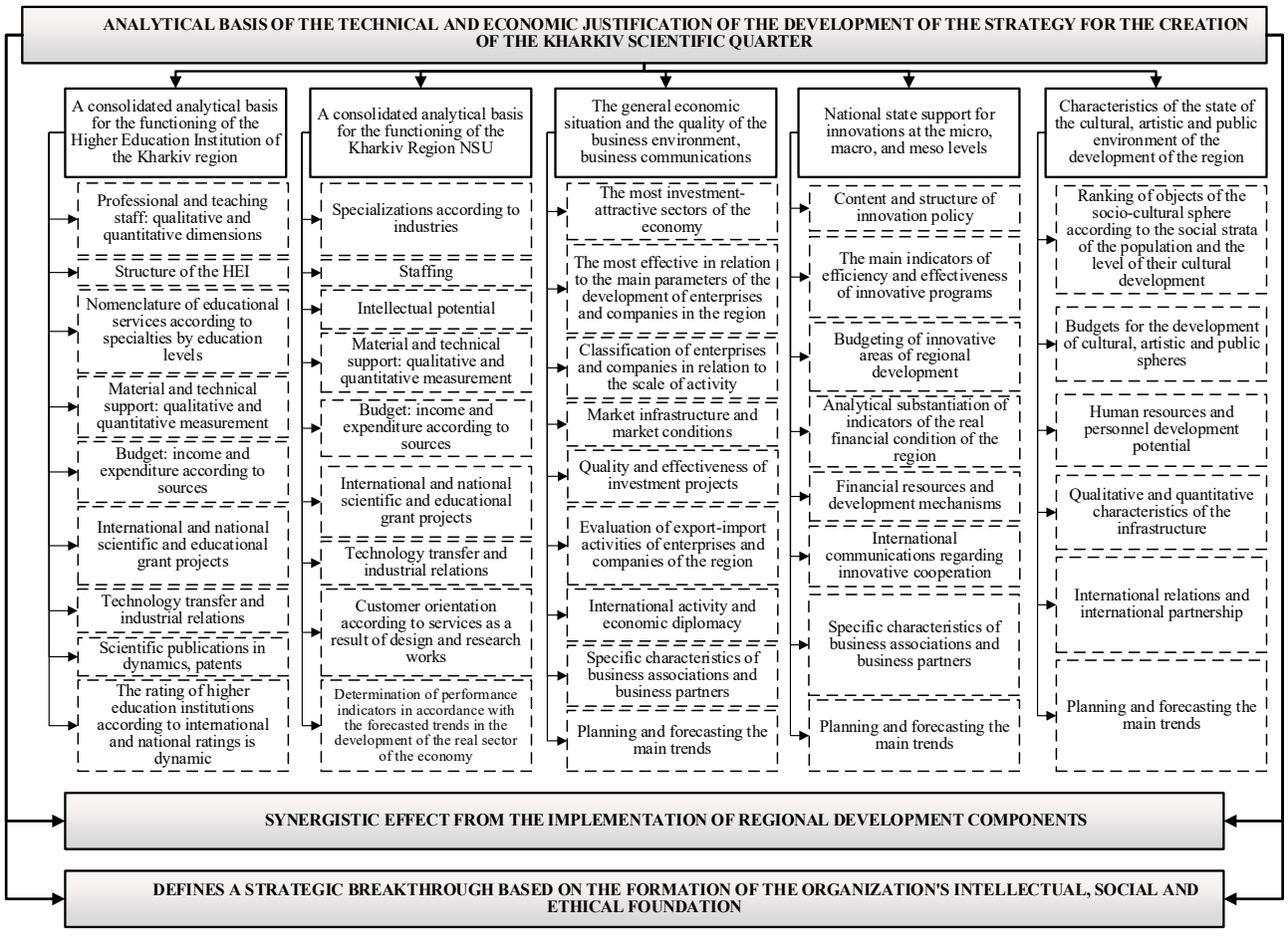

Fig. 1. Analytical basis for the techno-economic justification of the strategy for creating the Kharkiv «Science Quarter»

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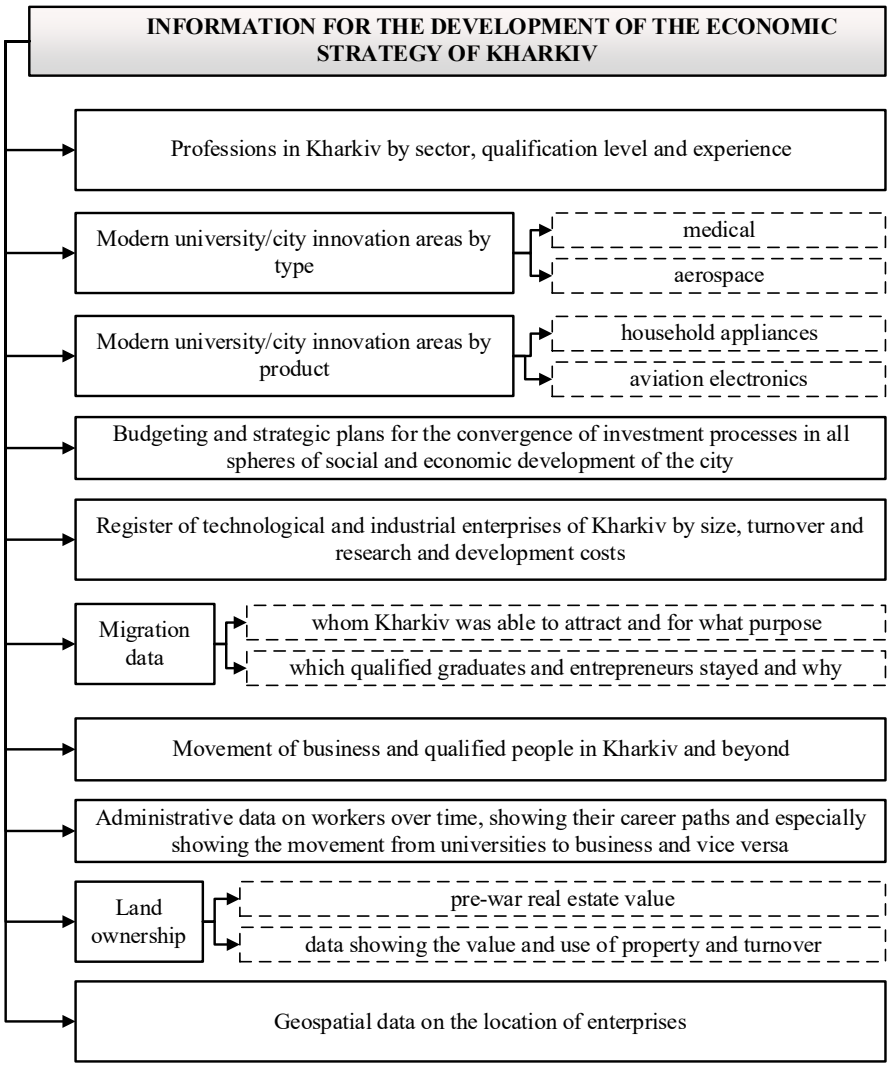

Fig. 2. Analytical basis for the development of the economic strategy for Kharkiv

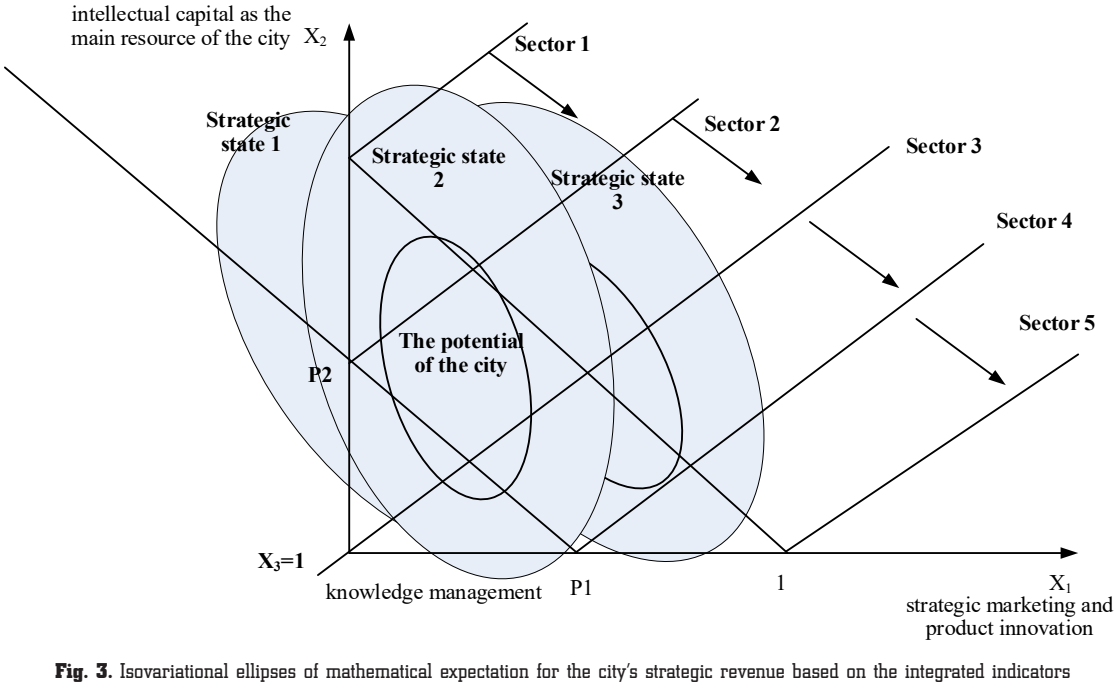

Fig. 3. Isovariational ellipses of mathematical expectation for the city's strategic revenue based on the integrated indicators of «knowledge management»

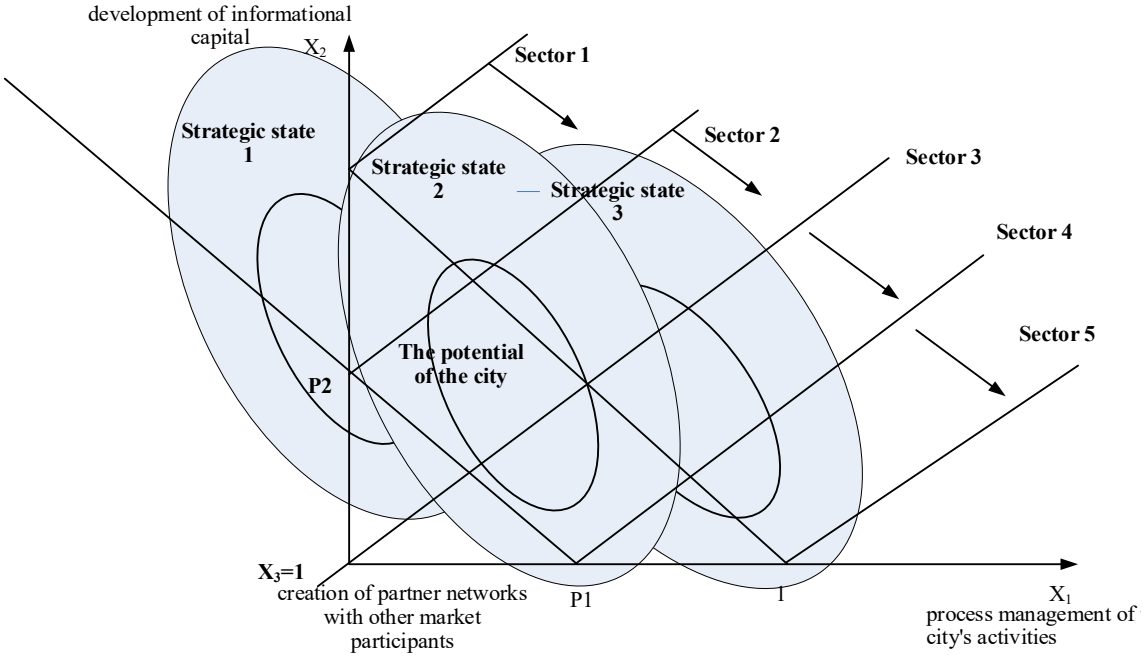

Fig. 4. Isovariational ellipses of mathematical expectation for the city's strategic revenue based on the integrated indicators of «establishing partnership networks with other market participants»

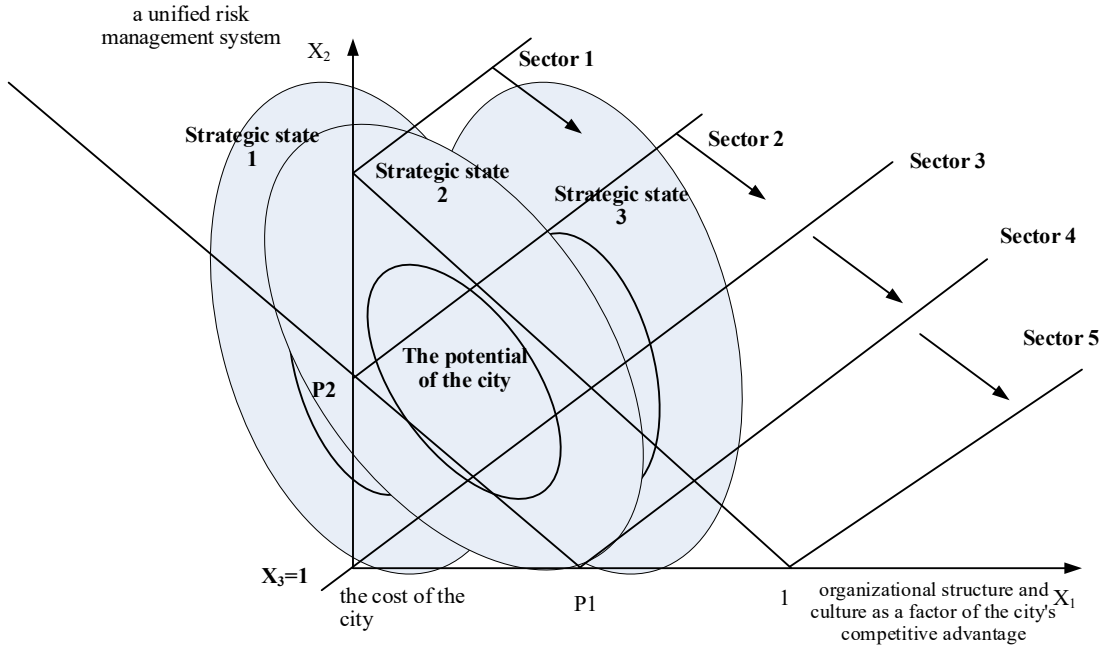

Fig. 5. Isovariational ellipses of mathematical expectation for the city's strategic revenue based on the integrated indicators of «city value»

This research will continue with a more detailed analysis of the global experience in the functioning of science parks and related entities, as well as providing recommendations for specific actions to promote their establishment in Ukraine.

4. Conclusions

The study shows that the development of science parks in Ukraine is extremely necessary. This is indicated by the entire global experience of their functioning for more than 70 years. It has shown its effectiveness in achieving significant breakthroughs in the economies of certain regions of countries that have established science parks and related entities on their territories.

The differences in the definitions of the concept of a science park, as expressed by various authors, are not fundamental. From a theoretical standpoint, each concept should undoubtedly have its specific definition. However, as the practice of creating and developing science parks around the world shows, each one is almost unique, built according to a certain model but on its own principles, which are most suitable for a particular region. The main factor is the result of the science parks' activities.

The science parks currently existing in Ukraine mostly do not fulfill their intended function. Therefore, they need to be rebooted, taking into account global experience and the realities of post-war reconstruction in the country. In this regard, the creation of a so-called «Science Quarter»

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in Kharkiv is promising. It should become a flagship for the new master plan of Kharkiv, positioning the city and the country at the forefront of innovation, modern technology, and urbanism.

For the effective implementation of this project, it will be beneficial to utilize the experience of Polish science parks, particularly the Poznan Science and Technology Park and «Technopark Gliwice». These examples are most suitable for the Kharkiv «Science Quarter» as they share many common features and foundational conditions.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

Data will be provided upon reasonable request.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the presented work.

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