INNOVATIVE DEVELOPMENT OF NATIONAL ECONOMIES

Collective monograph

Technology Center

2022

UDC 330.3:338.2:351
I64

Published in 2022
by PC TECHNOLOGY CENTER
Shatylova dacha str., 4, Kharkiv, Ukraine, 61165

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Innovative development of national economies: collective monograph. – Kharkiv: PC TECHNOLOGY CENTER, 2022. – 158 p.

Collective monograph contains the results of scientific research on topical issues of development of innovation systems at the National level. The problems posed are considered in several aspects: the formation and functioning of the National Innovation System (NIS), the impact of nanoeconomics on the macroeconomics of an individual state, the breaks in the innovative development of socio-economic systems in the face of emergency challenges for the state, an innovative model of regional management of freshwater resources according to environmental priorities. Such a range of issues under consideration give the monograph practical value, expressed in the possibility of implementing research results in various areas of the National Economy.
The monograph is intended for scientists and practitioners involved in solving topical issues of innovative development of socio-economic systems of national economies.
Figures 28, Tables 29, References 200 items.

DOI: 10.15587/978-617-7319-64-0
ISBN 978-617-7319-64-0 (on-line)

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ABSTRACT

Collective monograph contains the results of scientific research on topical issues of development of innovation systems at the National level. The problems posed are considered in various aspects, so the results of the research are of practical interest, and their use can contribute to the formation of a policy for the development of regional economies.

Section 1 presents the results of a study of the formation processes and features of the functioning of the National innovation system (NIS), its main components and the links between them. In particular, Investment and innovation systems (IIS) are studied as key institutions of the NIS, characterized by a pronounced system-forming function. A block diagram of the National innovation system has been developed, which includes four main institutional subsystems and subsystems of specific links, which, in fact, ensure the functioning of both institutional subsystems and the entire NIS. The algorithm of their functioning is defined on the basis of its representation by means of a system of inequalities of criterion conditions.

Section 2 analyzes the impact of nanoeconomics on the macroeconomics of an individual state based on the characteristics of the nature of nanoeconomics, its tangible and intangible forms, regularities, and evolution. The system of households as cells of individual consumption is characterized and it is shown that the structure of the national economy as part of the service sector, industry and the agro-industrial complex forms an entrepreneurial sector with active individuals. A close relationship has been established between the indicators of the development of nanoeconomics of the macroeconomic situation in a particular country and the relevance of the individual systemic factor for the development of national economic systems has been proved.

Section 3 discusses the problem of identifying and leveling the breaks in the innovative development of socio-economic systems on the example of Ukraine in the face of new challenges for the state in the process of developing relations with the EU. An assessment of the level of innovative competitiveness of the Ukrainian economy is made and the most important factors for leveling interruptions in its innovative development in the conditions of association with the EU are identified. Recommendations are given for scheduling breaks in the innovative development of Ukraine. Among them: increased foreign investment and public funding; improvement of legal acts, reduction of corruption, institutional improvement; technology support through regional cluster programs or "smart specialization"; integration into the European Research Area.

In Section 4, within the framework of the study of an innovative model of regional management of freshwater resources, environmental priorities, innovative investment dominants, targets and a model of environmentally balanced management of freshwater resources at the regional level are identified. This provides a more objective and balanced assessment of possible schemes and tools for managing the territory's freshwater resources. The conceptual approach presented in the paper is a rather flexible tool with a free choice of elements of analysis depending on the goals and objects of management.

KEYWORDS

National innovation system, NIS institutions, investment and innovation systems, nanoeconomics, baby economics, nanotechnology economics, breaks in the innovative development, Global Innovation Index, high-tech products, freshwater resources, regional management, innovative model.

CIRCLE OF READERS AND SCOPE OF APPLICATION

The monograph is intended for scientists who study the problems of innovative development of socio-economic systems of national economies either at the level of theoretical approaches, or at the level of practical implementation of measures aimed at determining priority areas for innovative development. It can be useful for practitioners in the field of state regulation, specialists and managers of various levels of industry, agro-industrial complex, services, etc., who solve practical issues of increasing the competitiveness of National Economies.

The monograph can also be useful to graduate students and masters of universities in the relevant educational and scientific profile.

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The formation of priority directions for the development of national economies in the context of unstable political situations and social changes caused by such changes is becoming relevant and requires scientific research on a wide range of issues. These issues are related to the need to respond to external challenges that can lead to a loss of stability in the socio-economic systems of the state. The use of modern science-based solutions based on the search for factors of influence will help improve the state of National Economies and create conditions for ensuring their competitiveness. In this context, the problems of the functioning of innovation systems should be considered through the prism of the maximum efficiency of all resources available in the state.

The presented results of the study of the processes of formation and features of the functioning of the National innovation system open up the possibility of determining the main structural links of such a system and searching for the conditions for their effective functioning.

An analysis of the impact of nanoeconomics on the macroeconomics of an individual state, based on the characteristics of nanoeconomics, its material and non-material forms, its main patterns and evolution, makes it possible to determine an individual systemic factor as a factor influencing the development of national economic systems.

Identification of breaks in the innovative development of socio-economic systems in the face of new challenges and identification of the most important factors of influence make it possible to develop recommendations for leveling interruptions in the innovative development of the state. In particular, among such factors it should be noted the increase in foreign investment and public funding, the improvement of regulations and the reduction of corruption, the support of technologies through regional cluster programs and the development of integrative solutions in the European Research Area.

The importance of studying an innovative model of regional management of freshwater resources and the formation of environmental priorities, innovation and investment dominants of targets is to determine models and rational management decisions for the use of freshwater resources as an important strategic resource value of the state.

All these issues are reflected in the monograph, and the results of solving these issues can form the basis for the implementation of practical solutions for the development of national innovation systems.

Therefore, the results presented in the monograph can be considered in terms of practical usefulness and the formation of materials for further in-depth theoretical studies of the innovative development of national economies.

DOI: 10.15587/978-617-7319-64-0.CH1

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CHAPTER 1

CHAPTER 1

INVESTMENT AND INNOVATION SYSTEMS (IIS) – THE KEY INSTITUTIONS OF THE NATIONAL INNOVATION SYSTEM (NIS)

ABSTRACT

Research has been carried out on the processes of formation and features of the functioning of the National innovation system (NIS), its main components and the links between them. A separate direction, within the framework of this topic of this scientific work, was the study of investment and innovation systems (IIS) as key institutions of the NIS, characterized by a pronounced backbone function. At the same time, the main general scientific methods of this study were scientific abstractions, analysis and synthesis, induction and deduction, scientific modeling, and the scenario method.

The integrated use of these research methods made it possible to schematically present the structure of the National innovation system, highlighting four main institutional subsystems and subsystems of specific links that ensure the functioning of both institutional subsystems and the entire NIS. In addition, the use of the scenario method for business entities of all categories of the national economy engaged in innovative activities, in order to clearly identify investment and innovation systems among them, made it possible to determine the algorithm of their functioning, presenting it as a system of inequalities of criterial conditions.

KEYWORDS

National innovation system, NIS institutions, investment and innovation systems, regulating relations, innovation climate, innovation culture, migrating institutions, inter-innovation period.

"Ukrainians do not know what innovations are, they are constantly not ready for their implementation, while they are sure that they know and know how to deal with them, which they suffer from in their history, paying for this inadequacy with mass casualties and destruction" (Datsiuk, S. "Getting Ready for Innovations" Ukrayinska Pravda, 08.06.2018).

While agreeing with the author of these words regarding such an assessment of knowledge about innovations in our country "on average for the chamber", one cannot, however, agree with such a generalization of all Ukrainians.

We believe that the source of this inadequacy between "do not know" and "know", for which "mass casualties and destruction" are paid, is, first of all, the heads of public authorities, industries, regions, communities responsible for these areas of activity of Ukrainian society, institutions, enterprises and organizations that "...are sure that they know and are able to deal with them", but in fact, not knowing "what innovations are", they ignore and neglect their importance for the development of society, since, according to Charles Darwin "Ignorance more frequently begets confidence than does knowledge".

The national innovation system of Ukraine today exists and functions – or rather, some of its individual elements that cannot create a systemic effect, and therefore the results of their "existence-functioning" are far from desired, and, as from the beginning of the 90s, so and in the mid-2000s, as well as to the present. And this despite the fact that domestic scientists do not get tired of proving the need for an innovative direction in the development of the economy of our state, substantiating and formulating theoretical concepts and models that develop recommendations, programs, plans and strategies. However, their discoveries, inventions, utility models, samples of equipment and technologies never became innovations, did not benefit either their authors, or society, or the world.

Realizing that the process of formation of the national innovation system of our country continues to move into the future under the influence of the so-called "path effect" or "dependence on the past path" (path dependence problem), we offer our vision of organizational, structural-functional and human-oriented capabilities and ways of its real transformation into an integral system, designed to change the "bureaucracy from innovations" (which, according to Datsiuk, S. should be characterized by a total rejection of such thinking, for which "innovations are not a value") to humanocracy, with concentration "...on people – real carriers of innovations".

The presented results of the analysis and assessment of the state of management of the innovative development of socio-economic systems, the national innovation system as an object of necessary changes, supplemented by a subsystem with investment and innovation functions, can and should become the basis for radical, properly justified and managed changes in the entire system, which "...at the mental and organizational level" will change the modern "systematized pseudo-innovative activity" to new approaches to the formation in society of the necessary set of domestic "risk innovative corporations" and "personal and corporate innovators".

1.1 NEW APPROACHES TO MANAGING THE INNOVATIVE DEVELOPMENT OF SOCIAL SYSTEMS

Although the place and role of intelligence in the development of human civilization has always been undeniable and generally recognized, only in the 21st century the intellectual characteristics of a person, like many other abilities and skills acquired in the process of continuous changes in all spheres of social activity, including knowledge and experience, science and technologies, economics and behavior in it have received a new and powerful impetus for further development.

The declared paradigm of "intellectualized society – intellectualized management" [1] has become a certain result and result of the analysis of the period of the avalanche-like generation of new knowledge and experience, the development of science and technology, intellectual and digital technologies based on them, the intensification of the use of natural intelligence (NI) by its carriers with resources with simultaneous use of the latest opportunities and potential of modern achievements in the field of artificial intelligence (AI) according to the formula:

$$NI+AI, \tag{1.1}$$

as well as the creation and effective use in the future of an even more powerful tandem of natural and artificial intelligence according to the formula:

$$NI \times AI. \tag{1.2}$$

At the same time, such large-scale and dynamic changes in the human, technical and technological characteristics of modern society in all its possible components would have to correspond to adequate changes in the principles, methods and structures for managing its proper functioning and development. After all, as the founder and head of the World Economic Forum Klaus Schwab quite rightly asserts, the neo-industrial paradigm of development singles out among the criteria for the development of economies such an undoubtedly important value as management, on which the culture of changes and the conditions that should be formed for their implementation are based, and since these changes transform humanity, they must be learned to manage [2].

At the same time, according to the same author, today's "degradation of global governance" has led to the fact that "institutions and their leaders have ceased to fulfill their purpose", and the "new model" should be distinguished by a number of "fundamental aspects" [3].

Therefore, in the light of unprecedented challenges and, as follows from the above positions, poorly managed changes, the need to "...change bureaucracy to humanocracy" gradually arose and was finally realized, formulated in the recommendations of Hamel, G. and Zanini, M., authors of the well-known bestseller in the field of management, known as "Humanocracy" [4].

At the same time, however, attention should be paid to the fact that the need to eradicate the traditional bureaucracy was not the first to be noticed by these authors. A number of other researchers addressed the obvious problems of the current state of management and management in the world. After all, the traditional theoretical foundations, methodological approaches and practical recommendations have long lagged behind, did not take into account and did not keep up with the dynamic changes in the values, moods, needs and desires of society and required the search, testing and implementation of adequate changes in the practice of management and management.

This is evidenced, for example, by the newspaper article "The Death of Management" by Samuelson, R. in Newsweek [5] in 1993, and by Adam Gale's article of the same title in Management Today [6], which was published only 26 years later.

The principles, approaches, models and recommendations for theoretical substantiation, testing and practical implementation of the necessary changes in practical management and management in all areas of activity were discussed, for example, in the book "The Death of Modern Management" [7] by Owen, J. in 2009, and 10 years later in the book "Transnational Management" by Bartlett, C. and Beamish, P. [8]. At the same time, in the Boston Consulting Group article "The End of Management as We Know it" [9], its authors Beauchene, V. and Cunningham, M., based on the results of surveys of 5 thousand employees (of which 30 % are managers), stated that "Traditional management has reached a turning point", 37 % of respondents believe that the "layer" of managers will disappear and only ≈10 % "want to become a manager".

It is quite obvious that in such a situation, both theoretical scientists, and practicing managers, and business consultants in all, without exception, spheres of life of modern society, today are asking the question "Quo vadis management?" and are actively looking for answers for a variety of areas of practical management and management. Examples include articles on such specific types of management as knowledge management [10], talent management [11], change management [12], project management [13], innovation management [14, 15], investment management [16], management of innovation and investment activity [17], public management and management [18] and many others.

At the same time, many researchers generate recommendations for a certain modernization of management and management processes. However, the authors of the above-mentioned book "Transnational Management" [8] Bartlett, C. and Beamish, P. believe that, until recently, the changes taking place in the field of management theory and practice "leave some problems unchanged". At the same time, Professor Buffington, J. argues that the management we know "needs to be replaced" because it "is beyond repair" [19].

Thus, it can be argued that today the system in which management was born, developed and improved for a long time, having reached a certain system of principles, laws, rules and conditions for the relationship and interaction of many people in the process of life creation, today requires steps for radical rethinking and improvement taking into account the new conditions of relationships and interaction between people. After all, the times when most of the world was ruled by tyrants have passed and today already billions of people live in democracy, in conditions of a different capitalism, which is also dynamically changing.

In this context, it should be noted that Stiglitz, J. the Nobel Prize winner in economics, stated in his article "After neoliberalism" that "...neoliberalism should be declared dead and buried" [20], and in his book "People power and income Progressive capitalism of the era of discontent" [21] in the first place he proposed "progressive capitalism" he has already placed people, and not any other resource components of the economic life of society.

Salesforce Chairman and Co-CEO Benioff, M. is thinking along the same lines, pointing out that "It's time for a new capitalism – a more just, equitable and sustainable capitalism that truly works for everyone..." [22], and the founder and managing partner of Inclusive Capital Partners, Rothschild, L. is calling for cooperation between private and public sector leaders and creating the Coalition for Inclusive Capitalism (CIC) [23], which includes all stakeholders in its management.

All this, however, indicates that any possible future modifications and changes in the economy of any progressive, inclusive, humane, etc. capitalism will require the planning and implementation of adequate and anticipatory changes in management and management. After all, according to the professor of the European Institute of Business Management (INSEAD) Petriglieri, G. management "…should become good and humane", develop and use "…not only our strengths and skills, but also our mind" [24]. That is, new modifications of capitalism already need new management and management, which will be focused on a person as a carrier of intelligence, as a source of innovation and harmonized development and effective cooperation of such components of society as people in power, people in business and people in society.

Consequently, all the above and far from exhaustive proposals of many authors from the possibilities of improving management and management processes for the economy of modern capitalism, which continues to develop and improve, are characterized by a general trend – attempts to involve in the management of economic activity of any segment of society those people who stages of the emergence, formation and development of traditional capitalism were used exclusively as a labor force and remained exclusively objects, and not participants in the management and management processes.

It is obvious that all new solutions in the theory and practice of management and management, aimed at their humanization and intellectualization, will also be relevant for specific areas of their use, among which, obviously, there is the domestic economy, the growth potential of which, according to professor Sheremet, P., 85 % is determined by innovations and the conditions for "pulling in resources" for investing in their implementation [25]. However, when the country's economy is "the least free economy in Europe", it is quite obvious that the greatest problems of its future development in all sectors of the national economy without exception are concentrated in the field of innovation and investment management, since the level of innovative development is determined by the level of investment support and investment attractiveness.

At the same time, the determining factor in the successful innovation and investment activities of industries and enterprises is management and management, which in the country of the "oligarchic, post-socialist economy" with a "deficit of economic freedom" [25] continue to remain not even on the traditional for market countries, but on the "post-socialist" level.

And then, when the majority of domestic researchers of the problems of the investment-innovative model of development of the economy of Ukraine consider the legal, economic, organizational and other conditions for its implementation in the context or in the economy as a whole [26–28] or in the context of its individual sectors [29, 30] or individual enterprises [31], or they explore these opportunities from the standpoint of introducing modern technologies of digitalization and design management [32], etc., while leaving the problems of humanization and intellectualization of the management of these processes at the level of the national economy and its industries without attention and necessary changes, the state of the country's innovative development and its investment support will remain at the old positions. Therefore, according to the quite appropriate opinion of professor Sheremet, P. "…the economy will need to be developed and developed in the way we are fighting now. And we are fighting with smaller forces, but very innovative, very motivated" [25].

Therefore, it can be stated that the formation of modern systems for managing the development of society in the era of the information economy should be based on the model of innovative development of its national economy, the key element of which is the National Innovation System (NIS). Moreover, it is the level of "formation" (or "unformedness") of its own National Innovation System in a particular country today that is one of the determining factors of what position it occupies in world rankings, and how much this country influences or can influence – really – those processes that are taking place very dynamically in today's globalized world.

1.2 NATIONAL INNOVATION SYSTEM AS THE BASIS OF THE MODERN MODEL OF INNOVATIVE DEVELOPMENT OF THE COUNTRY'S ECONOMY

A characteristic feature of the beginning of the 21st century is the constant growth of the dynamics of changes taking place in all areas of public life. At the same time, such changes, which have already been noted above, are a direct consequence of the "intellectualization" of modern society, which is manifested through the rapid development of science and technology, the accelerated generation of new knowledge, the creation of the latest "intelligent-intensive" technologies, and an increase in the share of processes using artificial intelligence.

It is obvious that the most active part in shaping the processes of global intellectualization of modern society is taken by the states that today are rightly considered the leading countries of the world economy. After all, it is they who, constantly generating the latest knowledge, introducing "intelligent-intensive" technologies, spreading the "standards" of the sixth technological order, act as a kind of "locomotive of change" in the modern world.

It is important to note that the further growth of the influence of such countries on all processes taking place in the world may also carry a certain threat – an increase in the level of their dominance in the world economy may contribute to increased differentiation between the levels of development of these and other countries of the world, which directly affects the further "stratification" of the world community and thus creates the prerequisites for the emergence of new conflicts between states. At the same time, and this is very important, globalization and its consequences can act as an effective and efficient tool to curb the possible further rapid polarization of the world (according to socio-economic criteria) in this situation. Since globalization processes contribute to the integration of "all" countries of the world (including those countries that are not world leaders today) and at the same time are directly related to the processes of "intellectualization" of modern society (and, consequently, to all components of the processes of development of science, the generation of new knowledge, the creation of new technologies), then in this situation globalization acquires the function of not only a kind of "compensator" for the possible further polarization of the world, but also creates prerequisites for reducing the differentiation that currently exists between these countries.

An analysis of the main characteristics of the countries that are today the world leaders also indicates the existence of differences (in some places considerable) between such countries.

So, they may differ from each other in the state structure, the size of the territory, the population, the political system, the form of government, the type of economic system, the model of its financial system, the country's belonging to different superstate formations, etc.

However, despite all the possible differences between the main classification features of the leading countries, they all have one common (the same for all) characteristic – the socio-economic development of each of these countries is based on the model of its innovative development. At the same time, the very model of innovative development can rightly be considered a defining feature of the current stage of civilizational development.

In other words, today the basis of various models of the national economy of each (without exception) successful country in the modern world is certainly the model of its innovative development, covering all spheres of public life. At the same time, all the differences that exist between the national economies of such leading countries (as mentioned above) are expressed only in the form of the country's innovative development model itself, and the specificity of this form of the model ensures its maximum efficiency for its national economy.

Thus, it can be argued that the national economy of each modern economically developed country is based on its own model of innovative development, which differs from the development models of other countries of the world leaders, first of all, in the features of its national economy. (Obviously, this statement is also true for countries that today are not world leaders, but in their development are guided exclusively by the principles of a market economy and are guided by a model of sustainable development). At the same time, the basis of such a model of innovative development of each country of the modern world is its National Innovation System (NIS), which is designed not only to create and provide the most favorable conditions for the implementation of innovative activities by all its business entities, but also to directly participate (in various forms) in the processes generation, production, implementation and dissemination of innovations in all spheres of life of modern society. Moreover, the level of development (development) of the NIS of the country determines the level of efficiency of the model of its innovative development.

The term "National innovation system" was first formulated by Freeman, C. [33], in his study of the technological policy of Japan (1987), and a few years later (in particular in 1992) Christopher Freeman's thesis about the objective need for the formation (and functioning such a system in the national economy of each country was supported and developed in the scientific work "National Innovation System" edited by Lundvall, B. [34].

It should be noted that in the above works, to define such a system, the term "National Innovation System" was used ("direct" translation of the English term National System of Innovation (NSI)), in contrast to the modern term "National Innovation System". Moreover, in scientific publications in this area at the end of the 20th and beginning of the 21st centuries, this formulation of this term is predominantly found, that is, the "national system of innovation" (NSI), and not the "national innovation system" (NIS). Moreover, this was typical for most publications of that time, regardless of whether the authors were foreign or domestic scientists.

However, later the term "national innovation system" began to be used more and more often. Such changes in the wording of the name can be explained by the fact that such a terminological construction – "innovation system" (rather than "innovation system") – corresponds to the construction of other currently generally accepted terms, in particular, such as "economic system", "financial system", "social system", "mechanical system", etc.

Thus, during this period, in the area related to innovation and innovative activity, there was a gradual "displacement" of the term "NSI" by the term "NIS". The adoption (in 2009) by the Cabinet of Ministers of Ukraine of the "Concept for the Development of the National Innovation System" can be considered a kind of "final stage of institutionalization" in our country of the term "National Innovation System" [35].

It should be noted that at present this document has lost its force, as a result of the adoption of a new action plan for 2021–2023 for the implementation of the Strategy for the development of the sphere of innovation for the period up to 2030 [36]. At the same time, the main definitions of the National Innovation System, formulated in the NIS Development Concept (2009), remain relevant today, despite the fact that the document itself has become invalid.

Conducting a further comparative analysis of the use of the terms "NSI" and "NIS" – both in their form and in their content – based on studies of English-language publications in the field of innovation and innovation activity, made it possible to identify characteristic trends, respectively, in two areas:

– in the English-language scientific literature today, two terminological forms of the definition of the National Innovation System are quite common:

1) National System of Innovation (NSI);

2) National Innovation System (NIS).

At the same time, there was no significant difference in the number of publications in which the first or second terminological form was used;

– the essence, main features and description of the categories NSI (National System of Innovation) and NIS (National Innovation System) in English-language publications are not characterized by systemic fundamental differences. This means that categories such as NSI and NIS can be considered identical categories.

Thus, on the basis of the study, an intermediate conclusion can be drawn. The categories "National system of innovation" and "National innovation system" are identical in their content. At the same time, in further research, it seems appropriate to survive the term "National innovation system" because:

1) in the documents of a regulatory nature (these are the above-mentioned relevant orders of the Cabinet of Ministers of Ukraine), such a wording was defined;

2) in scientific publications of domestic authors, this terminological form is used much more often. Obviously, this can be explained by the presence in the domestic regulatory and legal field of the above-mentioned orders of the Cabinet of Ministers. In addition, it is this terminological construction that is more unified for the Ukrainian language.

Despite the fact that foreign and domestic researchers have been actively engaged in the problems of NIS for the last 30 years, today it has not been possible to formulate a single approach (or at least a few "generalized" approaches of an applied nature) regarding the essence of the National Innovation System and the features of its formation and functioning. In modern scientific literature, one can find dozens of different interpretations of NIS, which were offered (or were offered earlier) by Ukrainian and foreign scientists.

In order to systematize the conduct of further research on the category "National innovation system", it seems appropriate to present in tabular form the most common definitions of it, while grouping them according to the structural-functional criterion (**Table 1.1**) and the criterion of the institutional-system approach (**Table 1.2**).

● **Table 1.1** The most common definitions of the category "National innovation system" in the scientific literature (according to the structural and functional criterion)

Author (authors)	Definition, source
1	**2**
Cabinet of Ministers of Ukraine	NIS is a set of legislative, structural and functional components (institutions) that are involved in the process of creating and applying scientific knowledge and technologies and determine the legal, economic, organizational and social conditions for ensuring the innovation process within national borders and ensure the growth of the competitiveness of domestic organizations and enterprises by increasing their innovative activity. At the same time, the main components of the Ukrainian national innovation system are five subsystems, in particular: 1) state regulation; 2) education; 3) knowledge generation; 4) innovation infrastructure; 5) production [35]
Varblane, U., Dyker, D.	NIS is all parts and aspects of the economic structure and institutional structure that affect both learning and search and research – the production system, the marketing system and the financing system are subsystems in which learning takes place [37]
Yaremko, L.	NIS is a set of interconnected organizations (structures) engaged in the production and commercialization of scientific knowledge and technologies within national borders. It consists of two elements: 1) research and production, represented by various enterprises, universities, state laboratories, technology parks and incubators; 2) infrastructure-providing, including institutions of a legal, financial and social nature, which in turn provide innovative processes [38]
Pobirchenko, V.	NIS is a system, the main structural blocks of which are: 1) a creative block or a block of knowledge generation (universities, research institutes, individual specialists, complex social networks that provide informal interaction between researchers from different institutes and universities); 2) technology transfer block; 3) funding block; 4) production block; 5) training block [39]

Continuation of Table 1.1

1	2
Yanenkova, I., Samarska, V., Alfiorova, A.	NIS is a complex system, which is simultaneously a process of interaction between various subjects of innovative activity and the result of this interaction. The main subsystems of the NIS are: 1) public policy; 2) science; 3) education; 4) business; 5) organizational and financial institutions of development [40]
Marchenko, E.	The main components of the NIS are four elements: 1) knowledge generation – a set of organizations that carry out fundamental research and development, as well as applied research; 2) education and training; 3) the production of products and the provision of services covering the production of science-intensive products produced by corporations, representatives of small and medium-sized businesses, whose labor vector is directed to science; 4) innovation infrastructure containing business innovation, telecommunications and trade networks, technology parks, business incubators, innovation and technology centers, consulting firms, financial structures [41]
Fedulova, L.	The structure of the NIS includes subsystems: 1) a subsystem which activities are focused on providing the innovation process with intangible resources; 2) a subsystem, the elements of which are directly involved in the innovation process; 3) a subsystem which function is to provide innovative activity with material resources [42]
Demchishak, N.	NIS is a set of relations about the creation, dissemination and use of innovations within a certain country, determined by national socio-cultural specifics, geopolitical features and economic development strategy. At the same time, its key elements (components) are: 1) knowledge generation is a set of organizations engaged in fundamental research and development, including research institutions, leading universities, etc.; 2) production of innovative products are the production of science-intensive, high-tech products, as well as the provision of services, the commercialization of new organizational and marketing solutions, and other activities carried out directly by innovators; 3) innovation infrastructure is technology parks, business incubators, innovation centers, science parks, etc.
Bagrova, I., Cherevko, O.	NIS includes two subsystems: a subsystem for generating and disseminating knowledge and a subsystem for innovation infrastructure [44]
Karpun, I.	The main structural elements of the NIS are: 1) knowledge generation, education and training, production of products and services; 2) innovative infrastructure, including financial and information support [45]
Griga, V.	The main subsystems of the NIS are: the system of knowledge generation and the system of its application (business, industry), which are the main participants in technological development; state and innovation infrastructure. At the same time, the knowledge generation system is responsible for the emergence of new knowledge and, to a certain extent, for its application in the country's economy. The system of application of knowledge directly consumes new knowledge obtained in the process of interaction with the system of its generation [46]

● **Continuation of Table 1.1**

1	2
Tsybulev, P.	NIS is a system consisting of three interconnected subsystems: 1) the subsystem of the innovation process, which embodies the model "from an idea to the implementation of innovative products on the market" and consists of four stages: research; development; production; implementation; 2) the subsystem of state assistance to innovation activity (the impact of the state can significantly change the final result, despite the "self-sufficiency" of the subsystem of the innovation process as such); 3) a subsystem of international relations in the field of innovation, which influences institutions and represents the indicated four ways [47]

● **Table 1.2** The most common definitions in the scientific literature of the category "National innovation system" (according to the criterion of the institutional-system approach)

Author (authors)	Definition, source
1	**2**
Freeman, C.	NIS is a network of institutions in the public and private sectors whose activities and interactions are aimed at initiating, importing, modifying and disseminating new technologies [33]
Lundvall, B.	NIS is a set of elements and their interrelations that ensure the creation, dissemination and use of new and economically useful knowledge localized within the boundaries of the nation state [34]
Nelson, R.	NIS is a set of institutions whose interaction determines the innovative productivity (efficiency) of national firms [48]
OECD Experts, Oslo Management	NIS is a set of institutions of the private and public sectors, individually and in the process of interaction determining the development and dissemination of the latest technologies, creating prerequisites for the development and implementation of state innovation policy [49]
Metcalfe, S.	NIS is a set of different institutions that jointly and individually contribute to the development and dissemination of new technologies and form a framework within which governments form and implement policies to influence the innovation process [50]
Galli, R., Teubal, M.	NIS is a historically established subsystem of the national economy, in which different organizations and institutions interact and influence each other in the process of implementing innovative activities [37]
Nelson, R., Rosenberg, D.	NIS is a number of institutions whose interaction describes the innovative activities of Russian companies [37]
Patel, P., Pavitt, K.	NIS is national institutions, their incentive structures and their competencies that determine the speed and direction of technical training (or the volume and composition of the change in activities) in the country [37]
Edquist, C.	NIS is all important economic, social, political, organizational, institutional and other factors affecting the development, dissemination and use of innovations [37]
Yim, D.	NIS is government, research institutes and other research organizations, universities, research and development enterprises, financial institutions [51]

● **Continuation of Table 1.2**

1	2
Fedulova, L., Pashuto, M.	NIS of the state is a set of interconnected organizations (structures) engaged in the production and commercialization of scientific knowledge and technologies within the national boundaries of small and large enterprises, universities, laboratories, technology parks and incubators as a complex of legal, financial and social institutions that ensure innovation processes and have national roots, traditions, political and cultural features [52]
Shapovalova, L.	NIS is an integral set of institutions interconnected within one country, whose activities are aimed both at implementing innovative transformations in the national economy as a whole and at creating favorable conditions for organizing innovative activities [53]
Bilozubenko, V.	NIS is a complex of interrelated institutions of organizational and legal nature, connected by a special structure, ensuring the flow of the national innovation process, its individual stages, as well as the participation and regulatory role of the state in the field of innovative development [54]
Sharko, M.	NIS is an economic mechanism based on the development and exploitation of new knowledge, an entrepreneurial approach, integration into foreign markets and the accelerated development of the competitiveness of the country and its regions [55]
Kuzmenko, O.	NIS is a historically, culturally, economically, scientifically, technically and informationally conditioned set of relations between the subjects of innovative activity regarding the creation, dissemination and use of innovations, which takes place within a certain country [56]
Kavtysh, O., Grechko, A.	NIS is a dynamic, open, structured subsystem of the international innovation system, consisting of interconnected actively collaborating institutions and supporting institutions involved in the process of creating, accumulating and implementing scientific knowledge, techniques and technologies, taking into account the legal, economic, organizational, socio-cultural conditions of the innovation process within the national economy and based on the strategy of scientific and technological development, the main goal of which is to increase the competitiveness of the economy and the standard of living of the population [57]
Shabelnikova, E.	NIS is a complex of legislative, structural and functional elements that are directly involved in the process of formation and implementation of scientific knowledge and technologies, thereby providing economic, organizational, social and legal conditions that ensure dynamic innovative development [58]
Ponomarenko, V.	NIS is characterized by three main features: 1) is identified with the innovation infrastructure; 2) are special integrated structures that have the characteristic of innovation and whose functions are innovation; 3) is based on the mechanism of the relationship between the elements of the system [59]

A detailed analysis of the interpretations of the definition of "National Innovation System", given in **Tables 1.1**, **1.2**, allows to draw the following conclusions:

1. The definitions given in the two tables are only a part of the totality of the most common interpretations of this definition, which are offered by domestic and foreign researchers of the NIS problem. At the same time, the formation of just such a selection of definitions of this category took place directly in the process of "filling" the indicated tables, while observing the basic principles of ensuring the maximum representativeness of this selection. In other words, the definitions

presented in the tables fully reflect the entire range of the most common interpretations of the definition "National innovation system".

2. Despite the existing "visible" differences between the definitions of the NIS category based on the structural-functional approach (**Table 1.1**), they all single out, one way or another, four main subsystems, which can be generally characterized as:

– knowledge generation subsystem;

– production subsystem;

– financial support subsystem;

– subsystem of innovation infrastructure.

In other words, the vast majority of scientists in the field of innovation consider these four subsystems as integral (or "mandatory") components of an integral and effective National Innovation System. At the same time, "significant" differences in the number of NIS components (and, consequently, in the functional purpose of each of them), cited by the authors in their formulation of the essence of this definition, can be considered as a consequence of a certain "extreme" in approaches (or "overly generalized", or "overly detailed") to the classification of the main structural elements of the National Innovation System.

3. Most scientists in their research focus on identifying the key components of the NIS and their functional classification. At the same time, the question of the "system of links" between these components basically remained outside the main attention of researchers. Only a small number of scientists in their works tried to outline and characterize such links, while noting their functional nature [38–40, 42, 43, 47]. Obviously, inadequate attention to the study of the system of links between the main components of the National Innovation System is a significant problem, since such an approach does not reveal the essence of their interaction with each other, which ultimately makes it impossible to understand "how exactly does the NIS function?" (in other words, only a set of NIS components, without a system of interconnections between them, is not a "functioning active system").

4. Almost all are given in **Table 1.2** definitions of the National Innovation System based on the institutional system approach, outline it quite fully, complete and at the same time are characterized by a certain scientific significance in the theoretical aspect. However, almost all of them define the NIS too generally, without revealing its essence as an "active system", and do not characterize the features of its formation and functioning. In other words, from the applied, practical side, such an approach cannot be considered sufficiently informative.

Thus, the intermediate conclusions formulated above make it possible to determine the direction of further research to determine the key components of the NIS and the system of relationships between them. At the same time, the next stage of the study will be based on the structural-functional approach, which is quite natural, taking into account the results of the analysis already mentioned above. (Observing the principle of objectivity of research, it should be noted that only in domestic specialized publications there are more than ten different scientific approaches to the definition of the category "National innovation system". Thus, in her dissertation work, the Ukrainian researcher Nosovets, A. identifies and classifies such scientific approaches to the definition of NIS:

macroeconomic and mesoeconomic approach, American and European (and additionally within each of them – broad and narrow) approach, as well as systemic, institutional, object-subject, historical-empirical, knowledge and relationship approaches [60]. It is quite obvious that such a systematic and detailed classification of the currently known definitions of the category "National innovation system" is important, first of all, for studies that have a theoretical orientation or study the features of the semantics of such interpretations. At the same time, such a detailed classification of scientific approaches is usually not used in applied research, since they do not reveal the "physics of the processes of a certain phenomenon" or "the mechanism of functioning of a certain process").

The next stage of this study, as noted above, is to identify the key elements of the National Innovation System, as well as the relationships between them. The analysis of the main NIS components, according to which scientists in this field reveal its essence in their works and single them out as key elements of an integral system, made it possible to identify the following four subsystems of the National Innovation System according to the structural and functional criterion:

1) knowledge generation subsystem;

2) production subsystem;

3) financial support subsystem;

4) subsystem of innovation infrastructure.

Obviously, the proposed structure of the NIS based on four subsystems (this does not yet take into account the subsystem of interconnections between them) requires additional explanation regarding the essence (or content) of each of these subsystems. At the same time, it seems quite logical that such content of filling the main components of the National Innovation System can be revealed based on the characteristic functions that each of these subsystems should provide for the formation and functioning of the entire NIS.

Thus, the knowledge generation subsystem – as a set of various institutions that produce, use, transfer and disseminate the knowledge necessary for the process of innovation – includes: universities, educational and research centers, academic and industry research institutes, scientific laboratories, training and retraining organizations personnel in the field of information technology management, institutions for patenting, licensing and consulting (on issues of protection, protection, evaluation and use of intellectual property, as well as evaluation of the commercialization of scientific results), information system objects (analytical and statistical centers), innovative business incubators, business accelerators, start-ups and various public associations of innovators and inventors.

The composition of the production subsystem – as a set of business entities that produce innovative products, provide services and (or) are consumers of technological innovations [35] – includes: all enterprises engaged in innovative activities (regardless of their size or organizational and legal form), scientifically – production enterprises, production and technological structures (technoparks, technology hubs, innovation and technology centers, pilot production), as well as all enterprises in the IT sector.

The subsystem of financial support – as a set of various financial institutions directly involved in the process of innovation by financing operations related to the creation (production), implementation and dissemination of innovations – includes: banks and various credit institutions, services

provided in the field of innovation, investment, venture and insurance funds, other funds for supporting innovation (usually industry or specialized), credit guarantee organizations of the non-banking sector, financial and industrial groups that systematically finance innovation, as well as various crowdfunding platforms financing startups.

As for the innovation infrastructure subsystem, its content is identical to the definition of "innovation infrastructure", which is defined by the Law of Ukraine "On Innovation", according to which it is "a set of enterprises, institutions and organizations, their associations that provide services to ensure innovation (in particular, financial, consulting, marketing, information and communication, legal, educational)" [61].

The above definitions of the key subsystems of the National Innovation System, as well as the presented list of the main institutions that make up each of them, are designed to clearly outline the structure of the NIS and characterize the specific functions of each of its components.

At the same time, further analysis of the entire set of these institutions as "primary" (or "basic") elements of the National Innovation System revealed the lack of validity of this approach to identify just such structural and functional subsystems of the NIS. Yes, almost all the elements related to the subsystem of the innovation infrastructure of the NIS are part of its other three subsystems. Moreover, these institutions cannot be considered "characteristic" elements of the fourth subsystem, since each of them is already a "characteristic" element for "its own", respectively one of the other three subsystems of the National Innovation System.

In other words, enterprises, institutions and organizations that provide services to ensure innovation activity are characteristic institutions, first of all, of the production subsystem of the NIS (and therefore they are not part of the innovation infrastructure); accordingly, educational and scientific institutions, as well as consulting, marketing and information and communication structures in the field of innovation are characteristic elements of the knowledge generation subsystem, and financial institutions, which activities are related to the processes of generating, producing and implementing innovations, are characteristic elements of the financial subsystem.

So, based on the identification of all the "basic" elements of the NIS according to the criterion "characteristic"/"not characteristic" for each of the four previously identified subsystems, it is possible to conclude that only three of them are "unique" – the knowledge generation subsystem, the production subsystem and the financial support subsystem. At the same time, the fourth functional component of the NIS, the innovation infrastructure subsystem, is actually not unique, since all organizations and institutions that, according to many domestic scientists, constitute its content, are actually part of the other three subsystems of the NIS.

At the same time, it should be noted that the scientific approach, according to which the innovation infrastructure is singled out as a separate subsystem of the entire National Economy, is sufficiently justified. Its obviousness is as follows:

1) all institutions that are part of the domestic economic system can be conditionally divided, according to the criterion of their level of innovative activity, into two sets – "innovatively active" and "ordinary" (or "innovatively inactive");

2) in the process of implementing the model of innovative development of the national economy of the country, the entire set of "innovatively active" (regardless of the scope of their main activity – educational and scientific institutions, manufacturing enterprises, financial and credit institutions, etc.) can be considered as an innovative infrastructure of the entire economic country systems. At the same time, it is advisable to group the set of "ordinary" institutions according to the sphere of the main activity of the institutions included in this set.

The correctness of this approach is obvious. However, it cannot be used to classify the components of an effectively functioning National Innovation System, since all of them, without exception, must be innovatively active (otherwise, it is impossible to form a real functioning NIS). Moreover, the very concept of "innovative infrastructure of the NIS" (i.e., "innovative infrastructure of the innovation system") seems to be not entirely correct: after all, if it is interpreted literally, then all three other functional components of the National Innovation System that were described above can be considered also as separate components of the innovation infrastructure of the NIS (since their "basic" elements are characterized by innovatively active institutions), which loses the meaning of such an approach.

Thus, based on the analysis carried out, it can be concluded that it is unreasonable to single out the innovation infrastructure as one of the key functional components of the National Innovation System. At the same time, this does not mean that the other three subsystems described above, the validity of identifying which as the main functional components of the NIS was confirmed by the results of the study, form the "completed" structure of the National Innovation System.

The main argument in favor of the assertion that the structure of the National Innovation System can be formed by more than three of its functional subsystems listed above is the fact that the input data for the analysis of the main components of the NIS were only well-known results of previously conducted research by scientists in the field of innovation. That is, the most common approaches to determining the structure of the NIS by institutional or functional criteria were taken into account (as noted above). At the same time, the results of some recent scientific publications regarding the presence in the structure of the National Innovation System of special institutions that are "characteristic" exclusively for the NIS have not yet been taken into account at this stage of the study.

One of such modern approaches to the formation and functioning of the National Innovation System is the approach that justifies the presence in its structure of such elements as "investment and innovation systems" (IIS) [62], which are integral components of the NIS. Moreover, according to some researchers, IIS are characteristic components exclusively for the National Innovation System, and therefore, one of its key elements [63]. At the same time, the obvious confirmation that investment and innovation systems are a characteristic component of the NIS is precisely the definition of this definition: "an investment and innovation system is such a socio-economic system that, as a result of the implementation of innovation activity, forms "new" investment resources with the aim of use for the production of "new" innovations" [63].

In other words, "an investment and innovation system is a system that provides the possibility of permanent and cyclical transformation of investments into innovations and vice versa with

a constant increase in their value" [64]. The above definition of the IIS category is fully consistent with the main goals of the creation and functioning of the NIS – ensuring consistency in the processes of generating, producing, implementing and distributing innovations in the national economy of any developed country in order to achieve maximum efficiency in the field of innovation.

So, based on the above results of the analysis, as well as the materials of previous studies, it can be concluded that the functional structure of the National Innovation System consists of four subsystems: the knowledge generation subsystem, the production subsystem, the financial support subsystem, and the investment and innovation systems subsystem. In this case, the "characteristic" elements of the fourth subsystem are exclusively IIS, i.e. regardless of their economic activity and industry affiliation. (It should be noted that the main issues affecting the essence of the IIS, as well as the features of their formation and functioning, will be considered in the following subsections of this study. At the same time, at this stage of the analysis of the structure of the NIS, the use of previously published results of the study of investment and innovation systems to argue that they are a characteristic component of the National Innovation System seems quite reasonable and sufficient).

The identification of the four main functional subsystems of the NIS cannot be considered the final stage of this stage of the study, since the question of how exactly the interaction between them occurs remains unanswered. In other words, in order to reveal the essence of an effectively NIS functioning, it is not enough just to identify its key components, but it is also necessary to identify all the links that exist between them and characterize them. (It should be noted that in systems theory there is a scientific approach, according to which in complex systems all links between their main functional subsystems are singled out into one subsystem of links and, at the same time, it is considered as another functional subsystem [65]).

The results of the study of the main publications on the issues of NIS revealed an insufficient level of attention to the study of the system of links between the main components of the National Innovation System (this was already noted above). Therefore, to identify the existing links between the specified functional subsystems of the NIS, it is advisable to apply a different scientific approach based on the results of earlier studies of the "system of links between the main participants in innovative activity" [66]. (It should be noted that this approach is described in detail in the guidelines for the study of regulatory factors in the formation of the innovative climate of enterprises [67], the author's monograph [66], as well as some other scientific publications).

Thus, earlier studies based on the above approach made it possible to single out (at the micro level) three categories of participants in the innovation process – an idea generator, an enterprise and an investor in an innovation project, as well as three categories of links that exist (or may exist) between them – information, regulatory and financial relations [66, 67].

Obviously, these three components of the process of innovation activity (at the micro level) do not require any additional explanation. Moreover, they can be considered as a kind of "responders" to the main subsystems of the macro level, that is, the functional subsystems of the NIS. That is, the "idea generator" component (at the micro level) conditionally "corresponds" (at the macro level) to the knowledge generation subsystem, the "enterprise" component conditionally "corresponds" to

the production subsystem, and the "innovation project investor" component to the financial support subsystem.

At the same time, the above three categories of links between the main components of the innovation process require a detailed explanation.

To define all three categories of relationships (at the micro level), it is advisable to use their definitions formulated in the results of previous studies.

So, information links are links that "provide: the search for "ideas", "generators of ideas", as well as potential investors of an innovative project; conducting their rating and comprehensive assessment; choosing the best option.

Regulatory links provide: participation (legal and economic) of each of the parties in the process of implementing an innovative project; development of technical and economic documentation of an innovative project; formation, regulation and observance of the rights and obligations of each of the parties; amending existing agreements; resolution of disputes between the parties.

Financial ties provide a financial opportunity to implement an innovative project" [66]. (It should be noted that the wording of the above definitions of the categories of links, as well as their qualitative assessment, carried out on the basis of such criteria of links as the "importance" and "value" of information, are based on the results of studies previously conducted by the Ukrainian scientist Vovkanych, S., in science-intensive economy of an innovative society [68]).

Thus, taking into account the conditional similarity of micro- and macro-level systems (according to the criterion of the main activity of these systems – the generation, production, implementation and dissemination of innovations), as well as the fundamental similarity of the functions of their main subsystems (with the exception of the IIS subsystem, which does not have its own "respondent" on micro level), it can be stated that the above definitions of the three categories of links between the main components of the innovation activity process (at the micro level) can serve as a kind of basis for formulating definitions of the categories of links between the functional subsystems of the National Innovation System (at the macro level).

Therefore, on the basis of the studies carried out, it is possible to formulate the definition of three categories of links (at the macro level) that exist between the characteristic subsystems of the NIS and thereby ensure its functionality and viability.

Information links are links that create and/or provide the possibility of joint participation of all functional subsystems of the NIS in the processes of generation, production, exchange, distribution, accumulation and preservation of new knowledge necessary for the implementation of innovative activities. The main object of this category of links is "information", which is characterized by "the third level of importance (this is information of a creative nature)" [66] and a high value of its "value", i.e. it is "considered as an investment in the innovative development of the future and is described by the inequality: "the value of information $\gg 1$" [68].

Regulatory links are links that create and/or provide the possibility of legal regulation of the joint participation of all functional subsystems of the NIS in the processes of innovation. The main object of this category of links is "information" of a legal and/or economic orientation, which is

characterized by "the second level of importance (this is specialized typical information that allows solving complex typical production issues)" and the average value of its "value", i.e., information is valuable for solving specific urgent problems and is described by the inequality: "the value of information ≥1" [66].

Financial links are links that create and/or provide the possibility of direct participation of all functional subsystems of the NIS in the processes of innovation. The main object of this category of links is cash flows in any of their forms (targeted receipts, investments, loans, grants, equity participation, etc.).

Thus, having outlined all the functional subsystems of the National Innovation System, as well as the characteristic links between them, it is possible to visualize the block diagram of the current NIS (**Fig. 1.1**).

The block diagram of the national innovation system shown in this figure makes it possible to explain the algorithm and the basic principles of its functioning. Thus, the interaction between the main subsystems of the NIS begins primarily through the formation of direct information links between the individual elements of these subsystems. It is obvious that such links are conditionally "primary" (i.e., they can be formed between different economic entities without the presence of links of other categories between them – regulatory or financial). Moreover, the "primacy" of information links is also manifested in the fact that their effective functioning between specific elements of various NIS subsystems is a necessary condition for the formation of regulatory links and a partial prerequisite for the formation of financial links between these subjects of management.

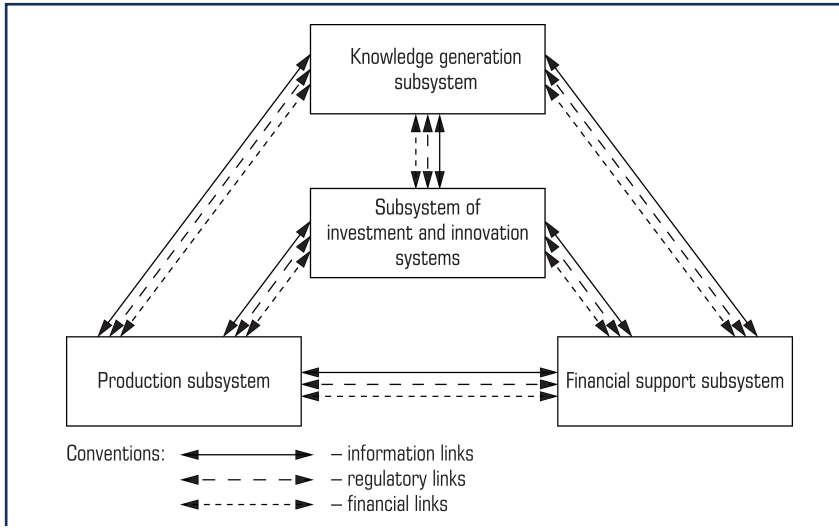

Fig. 1.1 Structure of the National Innovation System (NIS)
Source: author's development

Further analysis of the presented scheme allows to formulate another important statement: the totality of information links between the individual elements of the key components of the National Innovation System form stable information links between the most functional subsystems. At the same time, the quantity and "quality" of such links – that is, the volume and "quality" of information, the transfer of which they provide at the stage of existence of only this category of links – characterize the level of the innovation climate of the entire socio-economic system [66], i.e. in this case, the level of innovation climate of NIS.

Regulatory links between individual elements of different components of the National Innovation System can be formed only after information links have already been formed between them, but there are no financial ones yet. Therefore, regulatory links can be considered conditionally "secondary", since, firstly, they are formed on the basis of an already functioning set of information links between individual elements of the key components of the NIS, and secondly, they are a prerequisite for the emergence of financial links between these elements. At the same time, the number and the "quality" of the totality of information and regulatory links – that is, the volume and "quality" of information, the transfer of which is ensured by the interconnected functioning of the set of stable links of these two categories between the key subsystems of the NIS – characterize the level of innovation potential of the National Innovation System (in the general case, the totality of information and regulatory relationships characterize the level of innovation potential of any socio-economic system [66]).

Such changes, the "transformation" of the innovative climate of the NIS into its innovative potential, are primarily due to the fact that the formation of regulatory links changes the "level of functioning" of already existing information links: they develop, their characteristics (both quantitative and qualitative) improve significantly, and the "quality" of information (primarily of a creative nature) is growing dramatically.

It is obvious that financial links between the functional subsystems of the National Innovation System can be formed only after an interconnected set of stable information and regulatory links has already been formed between them. As a result, an integral subsystem of the necessary links is formed, which, providing the interaction between the other four key subsystems, turns a simple set of main components into a capable and efficiently functioning NIS.

Thus, summarizing the results of the study, it can be stated that the outlined and designated main four components of the NIS are its functional subsystems, and the effective interaction between them, which occurs through the use of a set of information, regulatory and financial links, ensures the consistency and systematic nature of the generation processes, production, implementation and dissemination of innovations in society, which in fact is the main goal of the formation and functioning of the National Innovation System.

At the same time, it should be noted that among all the above functional subsystems of the NIS, investment and innovation systems occupy a special place in it. They are the defining elements of the NIS and characteristic institutions of exclusively economically developed countries of the world.

The note indicates the need for further research on the features of the formation and functioning of IIS.

1.3 INVESTMENT AND INNOVATION SYSTEMS: THEIR ESSENCE AND FEATURES OF FUNCTIONING

As already noted, investment and innovation systems are institutions that are characteristic only for those countries whose economy corresponds to an innovative development model. Otherwise, if the national economy today is based on the principles of the traditional development model, the emergence of IIS in the economic space of such states seems unlikely or premature (i.e., in a non-innovative economy there are no prerequisites either for the creation of such institutions or for their effective functioning).

This means that the absence of this type of institutions among all types of business entities in a non-innovative economy makes it impossible for such a country to form its own NIS. Therefore, it should be considered fair to say that investment and innovation systems are the defining elements of the National Innovation System (and, accordingly, their combination forms the defining subsystem of the NIS) and characteristic institutions exclusively for the economically developed countries of the modern world.

It should also be noted that the other three functional subsystems of the NIS – the knowledge generation subsystem, the production subsystem and the financial support subsystem – are integral components of the National Innovation System, necessary for its formation, effective functioning and development (as mentioned earlier). However, they cannot be considered "characteristic exclusively for NIS", since all elements of these subsystems exist and function for a fairly long period of human development (long before the formation of an innovative economy), therefore, they are "typical", in fact, for any economic system, regardless of its model, management system, level of organization of production and other defining features of a particular social formation.

At the same time, the assertion that such elements are "typical" for any economic system does not mean that their activity in the conditions of an innovative economy, and even more so within the framework of the functioning of the NIS, is "the same" as in a non-innovative economy. In other words, the activity of such institutions as "generators of ideas" ("generators of new knowledge"), production systems and financial institutions, as participants in the innovation process within the framework of the functioning of the NIS, differs significantly from the functioning of similar institutions in a non-innovative economy, and primarily in terms of their level of organization and management.

The formulated statement is based on the following logically obvious dependencies and regularities.

1. The data of international statistical reference books [69] and ratings [70] show that the quantity and quality of innovations generated, produced, implemented and distributed in an innovative economy is much higher than in a non-innovative economy, which is undoubtedly obvious. At the same time, this means that the level of intensity (as well as the effectiveness) of the activity of typical institutions in different models of economic systems differs significantly from each other. That is, the dynamics and effectiveness of all processes – processes occurring both "inside" each such institution, and between the institutions themselves belonging to the same or different functional subsystems of the NIS – are much higher in an innovative economy than in a non-innovative economy, which characterizes significantly a higher level of quality of the functioning of these "typical" institutions, and hence the level of quality of their management.

2. One of the prerequisites for the effective operation of the National Innovation System is the achievement of "synchronism" in the work of all four of its functional subsystems, and hence the totality of the elements included in each of them (according to the theory of systems, only under this condition can a "system effect" arise [71] or synergy effect [72]). This means that the level of efficiency of the functioning of typical institutions (primarily the level of their organization and management) must correspond to the level of efficiency of the functioning of the newest institutions, and in this case, investment and innovation systems.

3. The modern sphere of innovation is characterized by a reduction in the duration of the life cycle of innovations [73] and the expansion of areas of innovation activity [74]. This occurs as a result of increasing the dynamics of processes in all NIS subsystems (additionally confirming the previously formulated regularities) and expanding the activity of the elements of these subsystems themselves. For example, the leading universities of the world, which are characteristic elements of the knowledge generation subsystem, today quite often take a direct part in the "production processes" of creating the final innovative product, actively engaged in its production and distribution (i.e., without involving the institutions of the production subsystem). Moreover, at the same time, they can also act as the main investors in the implementation of a specific innovative project (i.e., without the involvement of institutions and subsystems of financial support [75]).

It is obvious that a similar situation with a "temporary change in the status" of a "characteristic" institution of one or another functional subsystem of the NIS, in the process of implementing its innovation activities, can now be observed in almost all components of the National Innovation System. This means that "typical" institutions that are "characteristic" of their functional subsystem of the NIS acquire the features of "migratory" institutions that, at different stages of the innovation process, can perform the functions inherent in the institutions of other functional subsystems of the National Innovation System.

Thus, the presence in the national economy of effectively functioning "characteristic" institutions with signs of "migratory" significantly reduces the duration of the life cycle of innovations. This is primarily due to the shortening of the period between the stage of "generation of new knowledge" and the stage of "creation of innovative products". Such a reduction in the duration of the specified period becomes possible by reducing the so-called "non-technological time losses" in the process of implementing innovative activities (non-technological time losses are the time required to form a system of links (information, regulatory and financial) between the main participants in the innovation process ("generators of ideas", production systems and investors of the innovation project) in order to carry out innovation activities).

In this case, a modern enterprise, which, for example, "specializes" in the production of innovative products and has a unit in its structure that purposefully and systematically "generates ideas", and at the same time its financial management actively uses the latest tools to finance innovative activities (fundraising), crowdfunding [76]), the other two participants in the innovation process, which are usually necessary for a "traditional" enterprise to implement a specific innovation project, may become "unnecessary". At the same time, such a modern enterprise (and in the general

case, a "production system") acquires the features of a "migrating" institution, since it "takes over" the functions of "typical" institutions of the other two NIS subsystems. Obviously, a similar situation can arise among organizations that are typical institutions of the other two functional subsystems of the National Innovation System – knowledge generation and financial support. As a result, they can also "take over" the functions of institutions that are characteristic of other subsystems of the NIS, and therefore acquire the features of a "migrating" institution.

Thus, the above justifications of the previously formulated assertion that in the conditions of the functioning of an innovative economy (and, consequently, in the conditions of the functioning of the NIS), the innovative activity of typical institutions differs significantly from the activities of similar institutions in a non-innovative economy, allows to draw the following conclusions:

1. One of the prerequisites for the formation and effective functioning of the National Innovation System is an equally high level of development of all subsystems (and, consequently, the elements of these subsystems), which makes it possible to "synchronize" their activities within the NIS. This means that the level of organization and management of typical institutions as a whole should correspond to the level of organization and management of the "latest" institutions that are characteristic exclusively for the National Innovation System, that is, investment and innovation systems.

2. One of the features of the functioning of "typical" institutions in the innovation economy in general and in the NIS in particular is that they can "temporarily change" their status as a participant in the innovation process (idea generator – production system – investor of an innovation project) at different stages of the innovation process. This means that according to the criterion of the ability of one organization to independently (i.e. without the participation of other participants) perform various functions in the process of innovation, "typical" institutions partially acquire (or can acquire) some features of IIS, in particular, independently, self-sufficiently and with relatively equal efficiency to perform three main functions within the framework of a single innovation process – investment, production and innovation. (It should be noted that this ability is characteristic of investment and innovation systems and is determined by the specifics of their operating activities, which combines three sub-types of activity – investment and innovation (investing in the process of generating new ideas and new knowledge), production (production of innovations, production innovative products) and innovation-investment (turning the results of innovation into new investments necessary for further innovation)).

3. The presence of similar features between typical institutions and investment and innovation systems regarding their ability to independently and self-sufficiently perform various basic functions of innovation activity allows to state that the features of organizing the IIS activities and managing them are (or may be) relevant for the management and organization of activities "model" institutions operating within the framework of the National Innovation System.

Thus formulated conclusions indicate the need for an in-depth study of the features of the functioning of investment and innovation systems, as well as the processes of organizing and managing them.

A kind of confirmation of the need for such research can also be the fact that today in the scientific space there are quite a few publications (both domestic and foreign authors) directly

related to the problems of the functioning of investment and innovation systems, or problems related to their activities.

At the same time, only a relatively small number of research results published by scientists in the field of investment and innovation systems [77] (including studies of categories semantically similar to IIS, in particular, innovation and investment clusters [78], innovation and investment dominants [79], investment and innovation systems [80], investment and innovation models [81], innovation and investment complexes [82], innovation and investment mechanisms [83], innovation and investment instruments [84], innovation and investment levers [85], innovation and investment components [86], etc.) makes it impossible to conduct a comprehensive analysis of the processes of organizing IIS and the features of their management.

Moreover, this situation indicates the need for a priority study of the general problems of the functioning of the IIS, which will fully reveal the essence of such institutions, determine the mechanism of their activity and its main tools. And only after that it will be possible to conduct further research on the organization of investment and innovation systems and the features of their management.

However, the aforementioned problem is further complicated by the fact that, firstly, in the vast majority of scientific publications of this direction – exploring the various "innovation-investment" or "investment-innovation" objects mentioned above – their authors do not give their own formulation of such definitions, no generally accepted interpretation. Secondly, the names of the categories described above, which are semantically similar to "investment-innovation" systems, are often formulated by their authors "mirror", that is, either "innovation-investment mechanisms" [87] or "investment-innovation mechanisms" [88]. At the same time, there is no explanation in the publications themselves as to why exactly this wording, and not vice versa, should be used to define this category. Moreover, in such scientific articles there is no analysis of whether institutions differ from each other, which in the scientific literature mean "mirror" – "investment-innovation" and "innovation-investment" objects (and if they differ, then what is the essence of such a difference), whether these categories are identical.

Therefore, for further research, given the above problems, it is necessary to formulate two remarks:

1) the names of objects (categories) that contain "mirror" phrases "investment-innovative" or "innovative-investment" in this study should be considered identical, since their authors in their publications do not define such definitions, and do not emphasize because it is this sequence of categorical adjectives that should be in these phrases;

2) to define the category "investment-innovation system" it is necessary to use just such a sequence of categorical adjectives in the phrase "investment-innovation" (rather than "innovation-investment"), since it is this formulation that reflects the logic of the process of implementing innovation activity, where investments act as a "resource" necessary for the implementation of such activities, and innovations – its end result, the product of such activities.

As noted above, IIS are the key and defining elements of the National Innovation System (their totality forms one of its four functional subsystems) and characteristic institutions for both economically developed countries and NIS. At the same time, one of the features of the functioning

of the National Innovation System itself is the so-called "interactive activity of the NIS institutions" [66], which can be effectively carried out only if the national economy (and society as a whole) has an integral system of links between them – informational, regulatory and financial.

Thus, it is logical to assume that the most effective approach (from the point of view of the possibility of obtaining results of an applied nature) to reveal the essence of investment and innovation systems is an approach based on the definition of the "physics of processes" [89] of the mechanism of their functioning.

One of the features of this approach is that when conducting a study of the physics of the processes of the mechanism of functioning of IIS within the framework of the NIS, it is necessary to take into account their "subject-object" nature (which, of course, leads to the "complication" of such studies):

– at the level of a separate investment and innovation system, it is an independent subject, that is, a subject that generates "its own" processes and ensures their flow at "its own" level (at the level of functioning of the IIS itself);

– at the level of the National Innovation System (and in the general case at the level of the national economy of the country) – this is an object of the "general process", that is, a component (element) in the total set of processes and elements of the NIS, the coordinated and interconnected activity of which ensures the generation, production, implementation and dissemination of innovations, as well as the use of the results of each of these stages [66].

Therefore, taking into account such a feature, which is objective within the framework of this study, and also taking into account the significant diversity of IIS institutions (this is manifested in the presence of a large number of their fundamentally different organizational structures and forms, various organizational management systems, areas and directions of their activities, various branch affiliation, as well as other features characteristic of the newest organizations in the innovation economy), it is most optimal, from the point of view of revealing their essence, to consider the category "investment and innovation system" in dynamics, that is, by examining those changes in the general innovation process as well as post-innovation activities, which, in fact, are due to the presence of IIS and their functioning as characteristic institutions of the NIS. At the same time, it is important to note that such changes must be "formalized" (i.e., they must be expressed in the form of one or another "typical" scenario of the development of the situation), which, as a result, will allow them to be classified and thereby reveal the real essence of investment and innovation systems through their influence on the course of processes in the field of innovation.

Surely the last remark that needs to be made before starting this stage of the study is that, according to the definition of the definition of "investment and innovation system", one of the basic functions of its main activity is "turning investments into innovations" [66] (in fact, this is one from the stages of its production process). And as noted earlier, the process of innovation activity of any socio-economic system (including IIS) is based on the algorithm for the targeted conversion of investments into innovations, which indicates a significant similarity between the institutions of "IIS" and "non-IIS in the course of their innovation activities.

This means that at the beginning of this stage of the study, all institutions of the National Innovation System (i.e., both "IIS" and "non-IIS") should be considered as "ordinary" socio-economic systems that carry out innovative activities. At the same time, significant differences between them begin to appear precisely at the stage of their post-innovation activity, that is, after they create a specific innovative product, reaching the level of classification differentiation between these institutions.

As a result, on the basis of an assessment of the defining differences, it will be possible not only to identify the "investment-innovation system" among all socio-economic systems that carry out innovative activities (i.e., to clearly differentiate the categories "IIS" and "non-IIS"), but also to reveal their essence.

Thus, based on this approach to the subject of research (taking into account the definitions described above, the reservations and restrictions that it provides), the definition of "investment and innovation system" and the main goal of its functioning, as well as using the scenario analysis method, it is possible to conclude, the most likely are three development scenarios in the field of innovation, which are implemented by institutions (socio-economic systems) in an innovative economy.

The first possible development scenario is obviously the simplest. It assumes that the socio-economic system (SES), which has created an innovative product (as a result of its own successful innovative activity based on the "transformation" of investments into innovations) and selling it to consumers (in any of its forms: product, service, work, license, intellectual property, etc.), receives significant additional cash (financial) receipts, which leads to a significant increase in its own financial resources. At the same time, all additional income received from the sale of this innovative product, this institution completely (100 %) directs to its own consumption (to its own consumer needs).

It is obvious that such a scenario (it is schematically presented in **Fig. 1.2** as a series of successive stages of investment-innovation and post-innovation activities of the socio-economic system) identifies such an institution as "non-IIS" and is extremely unlikely for any functioning business entities (and even more so for such entities in the innovation economy in general or the National Innovation System in particular), which means that it can be considered only as a "theoretically possible" option.

The second possible development scenario (it is schematically presented in **Fig. 1.3**) can be interpreted as the "economic growth" of the socio-economic system. According to this scenario, the socio-economic system at the stage of post-innovation activity sells its own innovative product (which it created as a result of its own successful innovative activity), and all the money received from such a sale is directed not to consumption (i.e. not to its own "consumer needs" not only in the first scenario), but solely to expand its operating activities. At the same time, its operating activities are characteristic exclusively for a business entity that is not an investment and innovation system (for IIS, operating activities include three sub-types of activities – investment and innovation, production and innovation-investment, as noted above).

It is quite obvious that the last stage of the second scenario, the stage of post-innovation activities of the socio-economic system, is characterized only by the growth of the main financial

and economic indicators of its operational activities. Thus, this scenario reflects the process of possible economic growth of this institution as a result of the successful implementation of a certain innovative project by it as part of its innovative activity.

It should be noted that the economic categories "growth" and "development" are not identical. At the same time, in modern economic literature, the category "economic growth" is often identified with the category "quantitative economic development" [90]. Moreover, sometimes instead of the word "quantitative" (development) use the words "unidirectional" or "linear" (development) [91].

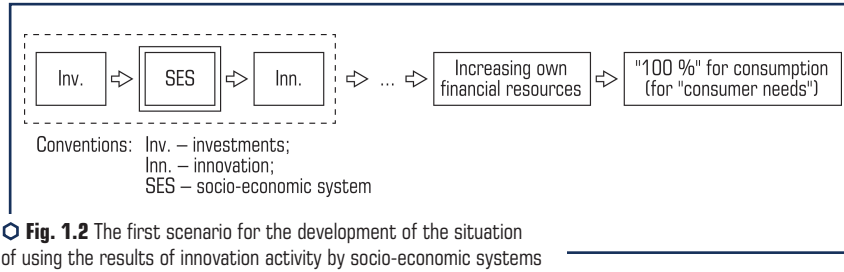

Fig. 1.2 The first scenario for the development of the situation of using the results of innovation activity by socio-economic systems
Source: Author's development

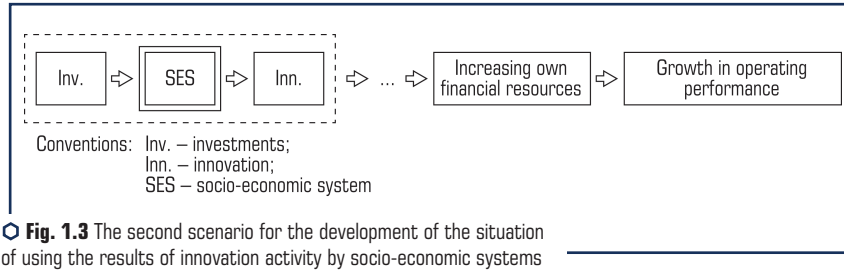

Fig. 1.3 The second scenario for the development of the situation of using the results of innovation activity by socio-economic systems
Source: Author's development

Obviously, the second scenario is quite realistic, given that such cases are not an exception or a rarity (even today) in the activities of a significant number of business entities in a non-innovative economy. At the same time, in the conditions of an innovative economy, the probability of this scenario for the development of the situation for a particular institution is extremely low, because, due to its non-orientation towards its further innovative activity, it cannot be characterized by high dynamics of the flow of all its processes and a high level of their quality (which certainly affects its information links and the quality of the information itself).

As a result, the pace of development of such a socio-economic system begins to slow down, which makes it impossible for its further "not too active" innovation activity (in the form of separate "one-time" innovation projects), and as a result, it will lead to a drop in its competitiveness in an innovative economy.

Carrying out a comparative analysis of the first and second scenarios allows to formulate some intermediate generalizations:

1. The second scenario of the development of the situation regarding the use of the results of innovative activities by business entities in the National Economy is more realistic than the first, since it provides (provides) the possibility of their economic growth (quantitative economic development), which may be a sufficient condition for the further functioning of institutions that are not investment and innovation systems, in a non-innovative economy. The first scenario does not imply such a possibility.

2. Both the first and second scenarios are a reflection of the situation in which the innovative activity of economic entities is non-systematic, that is, it is carried out, in most cases, in the form of separate "one-off" innovative projects. Moreover, the implementation of such projects is "separated" in time, that is, they are all carried out "sequentially" one after the other with a certain time lag. At the same time, the duration of such a time lag (post-innovation or inter-innovation period) is commensurate with the total duration of the life cycle of an innovative project, which indicates a low rate of dynamics of all processes in such socio-economic systems associated with their development and innovative activity.

3. Both the first and second scenarios are fully consistent with the so-called innovation model proposed by the Ukrainian scientist Vozniuk, M. in the work "Organizational and institutional conditions for investment and innovation activity in the region" [92], which confirms the correctness of the above conclusions.

Thus, the intermediate conclusions described above are quite informative for understanding the essence of such business entities whose innovative activity corresponds to the first or second development scenario. At the same time, such enterprises themselves are clearly identified as "non-IIS", which is important for the classification of institutions of the national economy and its NIS.

In addition, the second conclusion is of one more importance for further research, since it states that the sign of "non-systematic" innovation activity of socio-economic systems indicates not only the failure of their functioning in an innovative economy, but also the lack of consistency in their innovative activities (in other words, the characteristic features of the innovative activity of such business entities are both "non-systematic" and "non-systematicity"). And, in turn, the lack of consistency in innovation activity indicates that such institutions do not meet the criteria for investment and innovation systems, since they lack the defining feature of their operational activity – the ability to systematically produce innovations.

The course of the third possible scenario for the development of the situation is schematically shown in **Fig. 1.4**. It is obvious that it already meets the criteria of the model of innovative development of socio-economic systems to a greater extent, since it involves the use of the results of successful own innovation activities not for simply improving their financial and economic condition (second scenario) or eating them away (first scenario), but for the formation of "new investments" (in the diagram they are presented as "Investments ↑" or "Inv. ↑"), necessary for the further development of such institutions. Moreover, in this scenario, all three subtypes of

operating activities that are characteristic exclusively for IIS are clearly visible – investment and innovation, production, and innovation and investment.

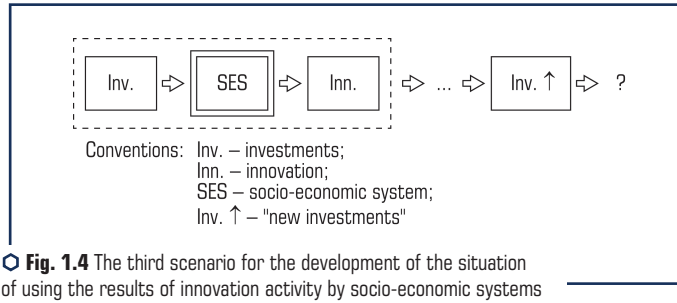

Fig. 1.4 The third scenario for the development of the situation of using the results of innovation activity by socio-economic systems
Source: Author's development

However, as can be seen from **Fig. 1.4**, this scenario is incomplete, since its last stage is still "unknown" due to the uncertainty of the "investment ↑" category. Therefore, further research requires, first of all, clarification of the category of investment ↑, which will make it possible to determine the last stage of this scenario, and hence the scenario of the development of the situation itself or its possible options.

In view of the fact that the category "investment ↑" is a kind of "derivative" of the category "investment", which is obvious according to the logic of the third scenario (as well as according to the specifics of the IIS operating activities), further research needs, first of all:

1) a clear identification of the very concept of "investment" – this is necessary for an unambiguous interpretation of this definition within the framework of this study;

2) the use of a modern extended classification of investments according to their main characteristic features – this is necessary to be able to conduct a comprehensive comparative analysis between the categories "investments" and "investments ↑" in order to identify the main differences between them, which, as a result, will allow to determine the category "investments ↑".

It is obvious that in order to define the category of "investment" in this work, given the direction of its research, it is advisable to use their most general interpretation: "Investment is an investment of capital with the aim of increasing it and making a profit" [93]. It should be noted that such a definition of this definition today is not only the most general, but also the most common in the scientific literature in the field of investment activity.

To conduct a comprehensive comparative analysis between the categories "investment" and "investment ↑", one should use their most complete general classification, presented in the works of the domestic scientist Bezpiat, I. "Basic approaches to the classification of investments", in which she, summarizing the results of scientific research of domestic and foreign authors, identifies 16 main classification features of investments [94], as well as Ukrainian scientists Belenky, P.,

Shevchenko-Marcel, V. and Drugov, A. "Investment-innovative ensuring the competitiveness of the region", in which they classify investments only in the form of their innovativeness [95].

The analysis of these signs according to the criterion of the direct and immediate impact of "investments" on "innovations" – that is, the impact of investments on the possibility of carrying out effective innovative activity – made it possible to identify only three signs that are decisive for the development of one or another variant of the final phase of the third scenario.

The first such defining feature is the feature "according to the object of investment in intangible assets", which includes two categories of investments – "innovative and intellectual investments" [94]. At the same time, the author uses the results of studies by two other Ukrainian scientists – Peresada, A. and Fedorenko, V., which mean these two categories of investments, in particular: "Innovative investments are investments in innovations, and intellectual investments are investments in intellectual property arising from copyright, inventive law, the right to industrial designs and utility models" [96].

The second defining feature is the feature "behind extensive and intensive influence on social production", which also includes two categories of investments – investments of "intensive and extensive type" [94]. At the same time, as the author of this approach himself notes, "investments, the results of which contribute to the intensification of social production, should be considered investments of an intensive type, and, accordingly, investments, the results of which contribute to the extensification of social production, are investments of an extensive type" [97].

The third defining feature is the feature "according to the criterion of the direction of actions", according to which, according to the Ukrainian researcher Leus, M., three categories of investments can be distinguished: "net investments – initial investments that are directed to the foundation of the project; extensive investments, directed direction is to increase the production potential, reinvestment – profits aimed at expanding production" [98].

Thus, the three classification features described above are decisive for revealing the essence of the "investment ↑" category in terms of the possibility of their direct impact on the innovative activity of the enterprise, which, in turn, allows to outline two possible options for completing the third scenario.

Obviously, the first such plausible option, which does not imply differences between the categories "investments" and "investments ↑" on the basis of "object of investment in intangible assets" (i.e., according to the criterion "innovative and intellectual investments", the value of "investments ↑" does not exceed the amount of "investments"), from the point of view of the possibility of their direct influence on the further innovative activity of a certain institution, cannot be considered a variant of its innovatively directed development. In this case, in the absence of prerequisites for the further innovative development of the socio-economic system, the categories "investments ↑" and "investments" may differ in terms of their values and on the basis of "extensive impact on social production", which identifies them as "extensive type investments", and on the basis of "direction of action", which classifies them as extensive investment or reinvestment. It should be noted that in this case, a fairly high level of correlation is observed between the second and third signs, which confirms the correctness of the conclusion made.

The results of the study are important because, firstly, they identify the main difference between the concepts of "investment" and "investment ↑" in terms of their values (or volumes) according to a certain criterion (in terms of the possibility of their direct impact on further innovative activity), which in practice can be expressed in positive dynamics between these categories either in terms of quantitative indicators, or in terms of qualitative non-innovative indicators (i.e., qualitative indicators that are not characterized by an innovative component), or in terms of quantitative and qualitative non-innovative indicators [63].

Secondly, such a probable version of the third scenario is, in fact, a reflection of the process in which the socio-economic system purposefully uses the results obtained by it from the implementation of a certain innovative project to form new investments that, in terms of their quantitative and/or qualitative non-innovative parameters exceed the previous investments that were used by it for the implementation of this innovative project. As a result, this scenario is a pronounced development scenario, the varieties of which can be:

1) development of the activities of the institution;

2) development of the institution itself;

3) development of the institute and its activities.

At the same time, none of the above variants of this scenario has an innovative orientation, since "investment ↑" does not exceed "investment" by the criterion of "innovation and/or intelligence", and therefore, they, having no "in themselves" innovative component, are investments of extensive type.

Thus, the first version of the third scenario, despite the three possible variants of its completion, can be schematically described by one "universal" model – "investments ↑" are directed by the enterprise not into the sphere of innovation, but exclusively for its expanded economic growth, which is characterized by positive dynamics the main indicators of its economic activity according to quantitative and/or qualitative non-innovation criteria. At the same time, such a "universal" model, by its features, cannot be considered some kind of "separate" or "independent" development scenario – in view of the variability of only the last "final" stage. Therefore, it should be interpreted as "one of the options for the third development scenario" (for example, "scenario 3a"), which is schematically presented in **Fig. 1.5**.

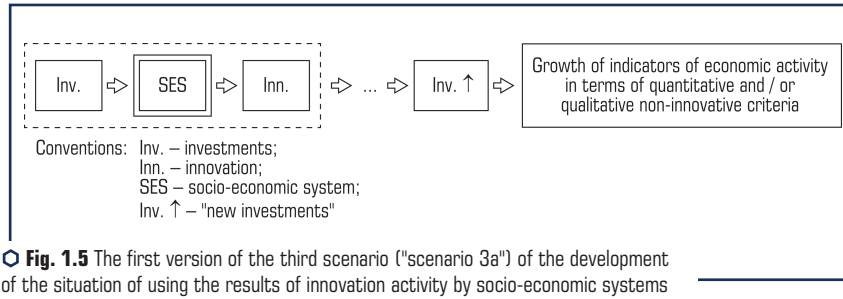

Fig. 1.5 The first version of the third scenario ("scenario 3a") of the development of the situation of using the results of innovation activity by socio-economic systems
Source: Author's development

The second probable variant of the third scenario, which provides that on the basis of "object of investment in intangible assets" the value of "investments ↑" is greater than the value of "investments" (i.e., according to the criterion "innovative and intellectual investments", the volumes of "investments "investments"), from the point of view of the possibility of their direct influence on the further innovative activity of the socio-economic system, is undoubtedly a variant of its innovatively directed development. It is obvious that in this case, since there are real prerequisites for the further innovative development of this institution, the categories of investment and investment differ from each other in magnitude and on the basis of an intensive influence on social production, which identifies them as investments of an intensive type, and in the "direction of actions", which classifies them as a net investment. It should be noted that in this case, a high level of correlation is observed between all three classification features of investments, which also indicates a high level of consistency in the investment activity of an enterprise, which is typical for investment and innovation systems.

In such a situation, it is quite logical to assume that an enterprise that, as a result of the successful implementation of a "preliminary" innovative project, has formed "new investments" that are characterized as "innovative and intellectual investments" and at the same time correspond to the level of "intensive investment", will send them as a "net investment" for further own innovation activity in order to create "new innovations". Such a development of the second variant of the third scenario seems absolutely natural and unambiguous, because the situation in which investments characterized by an innovative component will be used by a business entity not for his further innovative activities, and, for example, for the simple expansion of his usual economic activities, would be indicative of "irrational behavior of the manufacturer", which seems extremely unlikely.

Thus, the second version of the third scenario (**Fig. 1.6**, "scenario 3b"), which reflects the innovatively directed development of the socio-economic system, can be schematically described by such a model – "investments ↑" are directed by the enterprise exclusively into the sphere of its innovative activity, which, in as a result, it provides it with the opportunity to create "new innovations", that is, "innovations ↑", which is a direct evidence of the permanence of its innovative activity.

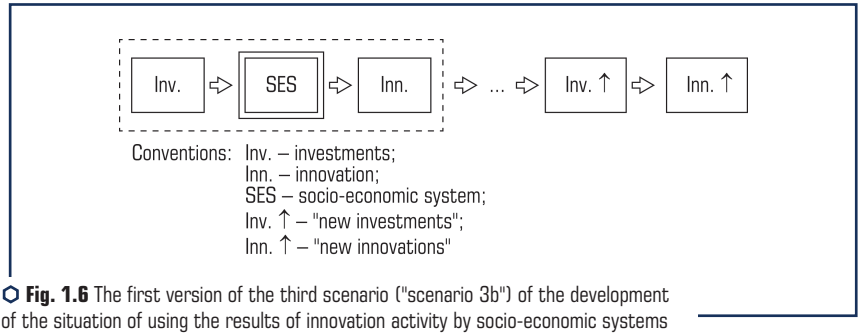

Fig. 1.6 The first version of the third scenario ("scenario 3b") of the development of the situation of using the results of innovation activity by socio-economic systems
Source: Author's development

Obviously, this version of the third scenario not only fully reflects all the features of the operating activities of investment and innovation systems, but also conditionally includes two incomplete cycles of such activities: investment and innovation, production, and innovation and investment activities of the first cycle (Inv. → Inn. → Inv. ↑), and investment and innovation activity of the next cycle (Inv. ↑ → Inn. ↑), which is a direct evidence of the permanence of innovation activity.

To complete this stage of the study, it is necessary to clarify the category of "innovation". To this end, it would be appropriate to use the approach that has already been used to define the category "investment ↑".

To define the category of "innovation" in this work, given that they become objects of intellectual property [99], the following interpretation should be used: "Innovation is such targeted changes in the system (the entire system) that determine the development (replacement) of its paradigm" [66], since it is this definition of this definition that is most complete corresponds to the direction of this study and the main approaches to revealing the essence of investment and innovation systems.

To conduct a comprehensive comparative analysis between the categories of "innovation" and "innovation ↑", one should use their most complete classification, presented in the work of the Ukrainian researcher Kariuk, V. "Improvement of the system of specific classification of innovations", in which she, summarizing the results of scientific research by domestic and foreign authors, identifies 14 main classification features of innovations [100].

An analysis of these features according to criteria that can characterize the further development of the socio-economic system as innovatively directed, revealed only one such feature – "in terms of the effectiveness of innovations", according to which they are divided into high-performance and low-performance [100].

Such a "limitation" in the number of features on the basis of which this comparative analysis can be carried out is explained by the fact that innovations are primarily a "commodity" (as opposed to "investments", which in this situation act, to a certain extent, as a "universal resource"), and therefore are characterized by "their" consumer properties, which are "absolute", and therefore "incomparable". Therefore, in this case, the other six qualification features (out of all fourteen) directly or indirectly characterize the innovative direction of the development of the institution – in terms of the scale of the influence of the innovation process, the depth of changes, the degree of influence on changes, the degree of novelty, the significance and direction of actions – actually "tied" to the consumer properties of "specific" innovations, which makes it impossible to use them for such a comparative analysis [100].

In other words, a comparative analysis of the categories "innovation" and "innovation ↑" can be carried out only according to such classification features that are "universal" in terms of their consumer characteristics as a "product" (corresponding to the category "innovation") and "product ↑" (corresponds to the category "innovation ↑").

Therefore, it can be stated that the classification feature "according to the effectiveness of innovations" is decisive for revealing the essence of the category "innovations ↑", which is

necessary to identify the type of development of the socio-economic system based on its innovative activity. In particular, if the value of the category "innovation ↑" on the basis of "the effectiveness of innovation" is greater than the value of the category "innovation", then "scenario 3b" (**Fig. 1.6**) is a pronounced scenario of the innovation-oriented development of this institution, and the "innovations ↑" themselves can be classified as "high performance" [100].

Obviously, otherwise, when the difference between the values of the categories "innovation ↑" and "innovation" on the basis of their effectiveness is "zero" or negative (i.e., on the basis of "productivity of innovations" Inn. $\downarrow \leq$ Inn.), "scenario 3b" (**Fig. 1.6**) does not correspond to the model of innovation-oriented development of the socio-economic system, and the "innovations" themselves should be classified as "low-performing".

Thus, according to the results of the study, based on the analysis of the expected scenarios for the development of the situation, the following conclusions can be drawn.

1. "Scenario 3b" schematically reflects the process of functioning of a "typical" investment and innovation system, which in the general case can be described in the form of an algorithm:

$$\text{Inv.} \rightarrow \text{Inn.} \rightarrow \text{Inv.} \uparrow \rightarrow \text{Inn.} \uparrow, \tag{1.3}$$

where Inv. – investments; Inn. – innovations; Inv. ↑ – "new investments" or "investments ↑" (see above); Inn. ↑ – "new innovations" or "innovations ↑" (see above).

Obviously, the proposed algorithm is a "universal" algorithm, since it reflects the process of purposeful implementation of innovative activities by any enterprise over a certain period of time. In other words, the presentation of the situation development scenario in this form does not allow identifying an institution that carries out innovative activities as an "investment-innovation system" or "non-investment-innovation system".

2. In order to be able to clearly classify the institutes "IIS" and "non-IIS", this algorithm must be supplemented with a system of conditions, compliance (or non-compliance) with which will make it possible to clearly determine which category a particular enterprise carrying out innovative activities belongs to. Such an algorithm with a system of conditions (in the form of inequalities) that meets the main criteria for the functioning of an "ideal" IIS is represented by formula (1.4):

$$\begin{cases} \text{Inv.} \rightarrow \text{Inn.} \rightarrow \text{Inv.} \uparrow \rightarrow \text{Inn.} \uparrow; \\ \text{Inv.} \uparrow - \text{Inv.} = \Delta\text{Inv.} > 0; \\ \text{Inn.} \uparrow - \text{Inn.} = \Delta\text{Inn.} > 0; \\ T_{IA} \Rightarrow T_{MA}, \end{cases} \tag{1.4}$$

where T_{IA} – the period of time during which the enterprise carries out innovative activities; T_{MA} – the period of time during which the enterprise carries out its main activities.

It is obvious that this algorithm describes the functioning of an "ideal" investment and innovation system, in which the duration of the period of its innovation activity approaches the period

of time of its main activity ($T_{IA} => T_{MA}$), and at the same time, the effectiveness of its investment and innovation activity is continuously increasing ($\Delta Inv. > 0$; $\Delta Inv. > 0$) with each implemented innovation project. As a result, such a process acquires all the signs of an innovation-oriented development of the socio-economic system, which, at the same time, has all the signs of an investment and innovation system.

3. In the event that one (any) of the three criteria does not meet the conditions defined by formula (1.4) (i.e., the total duration of time during which the enterprise was engaged in innovative activities is significantly less than its main activity ($T_{IA} \ll T_{MA}$), or the effectiveness of its investment or innovation activity is not positive ($\Delta Inv. \leq 0$; $\Delta Inn. \leq 0$)), then this institution, although it does not meet the criteria of an "ideal" IIS, however, retains the main features of "investment-innovation system". Such a statement can be explained as follows: the algorithm for the implementation of innovative activity by a certain enterprise corresponds to formula (1.3), however, its efficiency is not maximum either by the criterion of the duration of such activity, or by the criterion of quantitative and/or qualitative characteristics of "new" investments and/or new innovations. Obviously, if two (any) of the three criteria do not match, such an institution will have even fewer signs of IIS.

4. In the case when all three criteria do not meet the conditions defined by formula (1.4), it can be argued that such an institution does not have the characteristics of an IIS, and therefore is identified as a "non-investment and innovation system". Moreover, in this case, the very fact that the enterprise complies with this algorithm for its implementation of innovative activities (formula (1.3)) seems unlikely, since the permanent continuation of "unprofitable" innovative activity is evidence of the irrational behavior of the manufacturer, which confirms the correctness of this conclusion.

So, the main results of the study can be considered the definition of the algorithm for the process of functioning of investment and innovation systems, which actually reveals the essence of such institutions and the features of their activities. In addition, the application of this algorithm in combination with a system of certain criteria conditions (in the form of inequalities) that characterize the effectiveness of investment and innovation activities in absolute and temporal dimensions make it possible to identify and classify enterprises engaged in innovative activities into three categories.

Thus, the main result of the study should be considered the definition of the algorithm for the process of functioning of investment and innovation systems, which actually reveals and details the purpose, role, place and essence of such institutions and the features of their activities.

The application of the proposed algorithm in combination with a system of criteria conditions defined in the form of inequalities (1.4), characterizing the effectiveness of investment and innovation activities in absolute and temporal dimensions, makes it possible to identify enterprises engaged in innovative activities and differentiate them according to the following three criteria:

1) "ideal" IIS is an enterprise whose activities fully comply with the basic algorithm of the process of functioning of investment and innovation systems and all criteria conditions that characterize the effectiveness of investment and innovation activities in absolute and temporal terms. Obviously, such business entities, meeting all the signs of an "ideal" IIS, are characterized by a pronounced innovation-oriented development;

2) an enterprise with IIS features is an enterprise which activity as a whole corresponds to the basic algorithm of the process of functioning of investment and innovation systems and partially meets the criteria conditions that characterize the effectiveness of investment and innovation activities in absolute and temporal terms. At the same time, the range of the level of compliance of the enterprise with the features of the investment and innovation system can be quite wide, depending on what (what) signs (features) is the discrepancy, and what is its (their) value. In addition, such an assessment simultaneously characterizes the development model of this enterprise for its compliance with the conditions for the innovatively directed development of socio-economic systems;

3) an enterprise that is not an investment and innovation system is an enterprise whose innovative activity does not meet any of the criteria that characterize the effectiveness of investment and innovation activity in absolute and temporal terms. As a result, this makes it impossible for them to introduce a model of innovation activity based on the algorithm of the process of functioning of investment and innovation systems, which, in turn, does not contribute to the formation of prerequisites for its innovation-oriented development.

CONCLUSIONS

Thus, as a result of stating the facts of intellectualization, dynamic development and changes in the mentality of modern society, globalization and informatization of the world economy and its economy, the necessity of modernizing such undoubtedly important and necessary attributes as proper and high-quality management and management of all spheres of its vital activity.

At the same time, it is demonstrated that the leading scientists and experts of the world schools of management and management have already identified the main needs for changes and the conditions for managing new people of the 21st century, who should learn to lead in a new way, and also set the necessary directions for changes, which consist in the humanization and intellectualization of systems management national and world economies and all their subsystems on the basis of priority innovation of methods and technologies of management and administration.

After all, the further use of traditional approaches in modern administration requires not just their improvement, but radical, large-scale and simultaneous changes in all, without exception, spheres of the physical activity of mankind, which must always be preceded by the results of its intellectual activity. Since innovations and innovative development of society are, first of all, the products of the intellectual activity of people, the necessary changes in the management of the sphere of intellectual activity and the subsequent transformation of intellectual products into real results with positive consequences for society are its most important component.

Therefore, the transition from bureaucracy to humanocracy should also take place in the management of the structures and processes of any National Innovation System as a new foundation for the modern model of innovative development of the country's economy.

The structuring of the NIS according to the functional criterion into four subsystems (knowledge generation, production, financial support and innovation infrastructure), the allocation of information, regulatory and financial links between the latter and the determination of the conditions for their effective interaction, proposed in the study, provide a new organizational structure for the implementation of generation, production, implementation and dissemination of innovations processes in society.

Justification of the need to introduce investment and innovation systems into this structure as a functionally necessary subsystem determines the organizational and structural novelty of the NIS, which today is characteristic only of similar institutions in economically developed countries of the world.

A comprehensive theoretical analysis of the scenarios and options for the functioning of the NIS in combination with an added element – the functional subsystem of the IIS led to the conclusion that it is the absence until recently of this type of institutions in non-innovative economies that makes it impossible to form their own National Innovation System in such countries.

An in-depth study of the features of the functioning of investment and innovation systems as key subsystems of the NIS through the analysis of structures, scenarios, options and processes for organizing and managing them made it possible to reveal the purpose, role, place and essence of such institutions and the features of their functioning, as well as to determine the algorithm of their functioning, presenting it by means of a system of inequalities of criterion conditions. The application of this algorithm in practice makes it possible to evaluate the effectiveness of investment and innovation activities in absolute and temporal terms, and also allows to identify and differentiate the subjects of innovation activity according to three criteria:

1) subjects that meet the conditions of the "ideal" IIS and are characterized by a pronounced innovation-oriented development;

2) subjects with IIS features, which generally meet the conditions of innovation-oriented development;

3) subjects that are not investment and innovation systems and do not form the prerequisites for their innovation-oriented development.

Therefore, a completely justified direction for further research should be considered the approbation of the formulated structural-functional and algorithmically criteria-based recommendations in the practice of managing the functioning of real subjects of the national economy of different categories in order to verify their impact on the state and results of innovation-oriented development.

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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DOI: 10.15587/978-617-7319-64-0.CH2

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CHAPTER 2

RESEARCH OF IMPACT OF NANOECONOMICS ON THE NATIONAL ECONOMIC SYSTEM DEVELOPMENT

ABSTRACT

The diverse world is striking in the multitude of forms and types of various economic phenomena. Yes, the economy is characterized by the existence of different levels. The most decisive is the macro level, as the level of development of national economic systems. It is described by such categories as social reproduction, economic development and growth, economic balance and economic structure. All these phenomena depend to a certain extent on the economic behavior of individual economic agents that form the nanoeconomics. An analysis was made of the impact of nanoeconomics on the macroeconomics of an individual state based on the characteristics of the nature of nanoeconomics, its material and non-material forms, regularities and evolution. Separately, the system of households was characterized as a center of individual consumption. It was also noted that the structure of the national economy as part of the service sector, industry and the agro-industrial complex forms an entrepreneurial sector with active individuals. The latter are a spokesman for nanoeconomics as a kind of innovative economy, because nanoeconomics forms a high-quality system for the development and implementation of nanotechnological production solutions. The amount of research and development costs affects the volume of industrial and agricultural products sold and the number of services provided.

The distinctive features of the obtained results can be considered the approximation of the regression coefficient to unity, which indicates the presence of a close relationship between the indicators of the development of nanoeconomics on the macroeconomic situation in a particular country. Conclusions were drawn on the relevance of the individual systemic factor for the development of national economic systems.

KEYWORDS

Nanoeconomics, baby economics, human economics, nanotechnology economics, simple social reproduction, macroeconomics.

Actualization of macroeconomic processes occurs in the vast majority of countries of the world under the influence of a subjective personal factor. Nanoeconomics is the conductor of such

influence. Nanoeconomics has its own nature, patterns and evolution of development that affect the processes of macroeconomic reproduction.

The macroeconomic environment is measured by economic growth and the process of social reproduction. These are factors of economic development on which macroeconomic dynamics depends. The process of expanded reproduction can be supplemented by the stages of training and education of individuals who can become generators of ideas for various kinds of production processes.

The impact of nanoeconomics on the macroeconomic level of management and economic equilibrium occurs through the impact on consumption, savings and investment. Economic equilibrium is reflected through the ratio of supply and demand, production and consumption. Thus, by influencing supply, nanoeconomics becomes the determinant of the labor force, which is a factor of production. And influencing demand, nanoeconomics is an exponent of the consumer function, for which family cells, households, are responsible.

The structure of the gross domestic product implies the allocation of the service sector, industry and the agro-industrial complex. This distribution occurs at the production level and is formed as a whole due to the creation and functioning of FLP as a systemic economic phenomenon. The nanoeconomics also consistently affects these industries, as a person economically finds those industries where the income is higher and the return on investment is the highest. Nanoeconomics is an expression of the innovative economy and can be characterized through the analysis of data on the impact of costs on research and development in all areas of social production.

In this regard, this study may be relevant.

2.1 UPDATED STUDY OF THE IMPACT OF NANOECONOMICS ON THE DEVELOPMENT OF THE NATIONAL ECONOMIC SYSTEM

The question of the influence of nanoeconomics on macroeconomic development is almost not considered in modern scientific literature. The first to introduce the concept of "nanoeconomics" was Kenneth Arrow [1]. However, there is a significant number of works devoted to qualitative changes in the national economy. Thus, the authors of [2] analyze the development of the national economy in the context of the COVID-19 pandemic and testify that the crisis should become a new platform for the evolution of both developed and developing economies. Of particular importance in this context is the individual factor, which implies that it depends on individuals how countries will overcome the consequences of quarantine.

A number of authors [3] note that socioeconomic development depends on the formation of a special mechanism within households. These family cells influence the intensification and optimization of economic relations in different countries. The economy of households becomes the focus and source of growth of national economic systems, however, the aspect of using households as a lever of nanoeconomics is not considered. The question of the influence of the household as a unit of the population of individuals requires further study. The cultural factor of nanoeconomics

has a significant impact on the promotion of the national economy. Thus, the authors of [4] prove that the economy, as a cultural phenomenon, has a synergistic effect on the promotion of national economies to highly developed stages, to the development of the noosphere. In particular, it is noted that intellectual capital becomes the key to the intensification of cultural phenomena at different levels of the economic system. This study does not apply the actualization of the personal development factor of the cultural factor of macrodevelopment. The impact of cultural individual factors on macroeconomic progress requires further study.

Economic growth in developed and developed countries under the influence of concentration and diversification of exports is considered in the work of scientists [5]. It is confirmed that the weighted circumstances of export concentration and diversification affect the way countries out of the crisis. Developed countries should operate with these categories to improve their own economic situation. This issue needs to be disclosed in the context of the impact of nanoeconomics on international trade conditions for development.

In the development of economic systems, the educational factor of the information economy is of particular importance [6]. Digitalization [7] is becoming a source of economic development. As it was said [8], the economics of education is a factor in the activation of economic processes and their digital aspect. It is with educational institutions that the influence of the educational process on economic development as a whole begins. To explore how the informatization of education affects macroeconomic development becomes the key to the analysis and synthesis of the synergy of education in the economic environment.

In [9], devoted to the impact of innovations on the development of national and world economies, nanoeconomics is considered as a kind of innovative economy aimed at the formation and use of high technologies and nanotechnologies in the production activities of innovative entities. The question of the impact of nanotechnology economics on macroeconomic development also needs further research.

It is noted that there are several billion inhabitants in the world and underestimation of the impact of each of them on economic development is a big problem. Therefore, the individualization of economic life within the framework of nanoeconomics should be carefully studied and the principles and trends of its influence on the development of the national economic system should be formed.

These issues require further consideration, since the economic life of a particular country must take into account the personal components of development, the works cited only touch on this aspect, and a thorough study should be carried out.

The aim of the study is to identify the impact of nanoeconomics on the development of the macroeconomic situation in a particular country. This will make it possible to take into account the individual factor as much as possible in the dynamics of the development indicators of the national economic system.

To achieve this aim will allow the following tasks:

– to define conceptual approaches to the interpretation of nanoeconomics as an economic category;

– to determine the directions of the influence of nanoeconomics on the process of social reproduction and economic growth;

– to identify the impact of nanoeconomics on the macroeconomic level of management and economic equilibrium;

– to highlight the principles of the influence of nanoeconomics on the service sector, industry and the agricultural sector of a particular country.

The object of this study has a theoretical direction. However, there is an assessment of multifactorial regression as the quintessence of determining the impact of nanoeconomics on the development of the national economic environment. This estimate was made on the basis of statistical data from one of the countries with transition economy. These data made it possible to formulate a hypothesis about the dependence of the main indicators of the development of the national economic system on the indicators of the dynamics of the nanoeconomics based on the mathematical analysis of the correlation. The studied indicators included: GDP, GDP per capita, volumes of industrial and agricultural products. The research methods used in this article include: system analysis, structural approach, convergence and divergence, comparison, observation and generalization.

2.2 RESULTS OF RESEARCH ON THE IMPACT OF NANOECONOMICS ON THE MACROECONOMIC DYNAMICS OF ONE OF THE COUNTRIES WITH TRANSITION ECOMOMY

2.2.1 CONCEPTUAL APPROACHES TO THE EXPLANATION OF NANOECONOMICS AS AN ECONOMIC CATEGORY

It should be noted that most researchers recognize nanoeconomics as the initial level of economic relations.

Let's define the considered nanoeconomics [8] as an integral part of social production (the economy as a whole). The productive force of the latter is individuals who, in the process of learning and activity, acquire the skills of economic behavior. They make optimal management decisions and, through the use of nanotechnologies, ensure the achievement of high levels of competitiveness and the dissemination of experience in acquiring it in the economic environment.

Let's dwell on the nature of nanoeconomics. So, nature is a set of natural conditions for the existence of human society. The second nature is the material conditions of its existence created by man. The implementation of the exchange of substances between man and nature is the law that regulates social production, the condition of human life itself. The total activity of society has an increasingly noticeable impact on nature, requiring rationalization [10] and regulation of their interaction. Thus, nature creates the conditions for the existence of nanoeconomics, which can be divided into material and non-material ones [11]. The material conditions of nanoeconomics are the totality of the materialized circumstances of human life, which is reflected in the process of social production. This is manifested in the production infrastructure, production process and production technologies (technologies-products and technologies-processes), these are also the circumstances of the management of social production. The material conditions of the nanoeconomics are individual production property, when

individuals have assets, receive income and invest in development. Owners of embodied property are subjects of nanoeconomics. Property is the socio-economic basis for the functioning of the economic system of nanoeconomics. Property in the economic sense is historically and logically determined.

But the material conditions of the nanoeconomics are wider than property relations, because they include both the regulation and management of this property. Thus, hired workers (managers) are also participants in nanorelationships, since they manage all processes within the framework of social production and it is their actions that lead to profit as the main goal of entrepreneurial activity.

The non-material conditions for the existence of nanoeconomics are the whole set of informational, ideological, cultural, mythical, philosophical, scientific and other conditions and factors of an individual's development. This is a set of traditions that form a person as an owner, producer and consumer of goods. If some national cultures have certain rules for doing business, they must be taken into account during international cooperation. The material and non-material conditions of the nanoeconomics form the patterns of its development.

The first regularity in the development of nanoeconomics assumes a combination of the following successive phenomena: baby economics, economics, and the economics of nanotechnologies. The system of nanoeconomics begins with the family, its formation and development, with the birth of children, their upbringing at home, in a preschool educational institution, school, college, college, university. So, the initial stage of nanoeconomics is baby economics. As a new category, it is a controversial phenomenon, approaches to the definition of which are few researchers.

Baby economics [8] is associated with the level of sociologization of the child, when a small person is already economical from birth, because an entire industry is working around the birth of a child:

– artificial methods of fertilization;

– accompanying a pregnant woman in specialized clinics (which costs significant financial costs for the family of a pregnant woman);

– the act of birth itself, paid in advance by the family;

– nursing a newborn child in a hospital;

– huge industry of children's products: from clothes to strollers;

– hiring a babysitter if needed;

– not free visits to preschool institutions;

– children's fashion industry (when leading couturiers create collections of children's clothing);

– the school and school life of the child, where, in particular, the financial behavior of the student is formed (how to manage the funds that the parents gave out on the day).

And such a separate aspect as the use of children in difficult labor positions in the criminal world. And this can be considered the second regularity. It lies in the fact that nanoeconomics begins with a baby economics, which has its own specific conditions for functioning and development.

The authors formulated the definition of baby economics [8] as an integral part of nanoeconomics. Due to the complex use of physical-natural, social, intellectual, material, financial and other resources in childhood, it leads to the formation of a personality that in adulthood produces benefits based on educated knowledge and skills.

The third pattern, according to the authors, is that the human economy is the central link in the chain of nanoeconomic processes. There is a combination of cultural, social and economic approaches. As it is known, culture is the transfer of skills, abilities and experience to future generations. These are the traditions of doing business, the traditions of using the means of labor and the production of certain goods and services. These are the conditions for cooperation within certain teams and society as a whole. The collective in which a person lives (his/her immediate environment) is the family. The economic sign of the family is the household.

Another regularity is the development of the economy of nanotechnologies within the framework of the nanoeconomics system.

The regularities of the formation of nanoeconomics affect its evolution, which is manifested in changes in the economic behavior of individuals. This evolution is the evolution of Homo sapiens in the broadest sense. Accordingly, the stages of the formation of nanoeconomics and its evolution by Rohnen, S. [12]:

– primitive era (from the appearance of commodity-money relations to the end of the 15th century) is characterized by the emergence of economic individuals;

– commercial era (begins with the time of the great geographical discoveries and ends with the middle of the 19th century). The driving force behind the behavior of entrepreneurial individuals during this period was the search for huge personal gains associated with the trade in colonial goods in Europe;

– expansion era of (1850–1914) is characterized by a massive reorientation of individual entrepreneurs to export exotic overseas goods to more profitable and economically promising business areas;

– concession era (1914–1945) is characterized by the formation of colonies at concession enterprises of a significant stratum of native mid-level managers specially trained at enterprises and educational institutions of metropolitan countries;

– nation-states era (1945–1970), having provided a powerful impetus to the development of nanoeconomics, made it the sphere of the whole world, in which systems such as "metropolis-colony" suspended their existence;

– globalization era (since the 1970s). This period of development of nanoeconomics is marked by revolutionary technological changes.

In the context of globalization, nanoeconomics is determined by certain characteristic features by Servan-Shraiber, Zh.-P. [13]:

1. Accessibility and universality. Each person goes through the conditions of self-improvement, each individual is a subject of nanoeconomics and his/her representative within certain groups (households, enterprises and state economies). Any person is a potential element of the nanoeconomics, this is its accessibility. And universality is determined by the fact that all levels of economic systems are based on the nanolevel.

2. Stepwise development of nanoeconomics. When an individual, after graduation, gets a position in a certain company, gains experience and decides to create his/her own business, first as an individual, which then transforms into a family business, and then into a corporate one. It usually

starts with trading activity, continues with related productions, and then the production process based on attracting investments.

3. Technological globalization of nanoeconomics. The possibilities of computerization, informatization and telecommunications fundamentally changed the nature of the nanoeconomics, which in modern conditions has received three fundamentally new features:

– it can be effectively carried out without leaving the office;

– it can be done in real time;

– it can, with the help of telecommunications, cover all business markets for products, capital, labor, information, etc.

4. "Financialization" of nanoeconomics. Reflects the financial content of all economic transactions. Even if we are talking about barter, it is still based on the conditions for financing the supply of goods through the counter delivery of the counterparty's products. In addition, the whole process of using nanoeconomics in the development of globalization involves a financial component. The latter includes: investment in training, receiving wages at the workplace, own business, development of nanotechnologies and their implementation in their own production.

5. Complex interaction of nanoeconomic and international. When it comes to the influence of an individualized factor on global processes in the world. Nanoeconomics is represented in the global environment by individual individuals entering into a dispute for resources to improve the efficiency of their activities. Global business takes into account the cultural differences of collaborating agents from different countries of the world.

Schematically, all the distinctive features of nanoeconomics in the context of globalization are shown in **Fig. 2.1**.

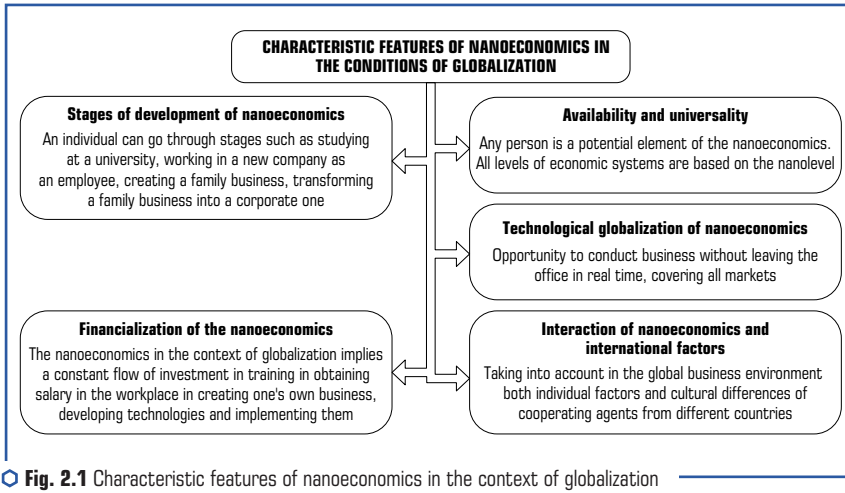

Fig. 2.1 Characteristic features of nanoeconomics in the context of globalization

Thus, the nature of nanoeconomics implies material and non-material components that define an individual as an owner, producer and consumer. Patterns define the nanoeconomics with its three components – the baby economics, the human economy and the economy of nanotechnology. The evolution of nanoeconomics conditionally begins from the era of great geographical discoveries to the modern development of mankind. The era of globalization, determined by certain special characteristics of the development of the nanoeconomics, stands out in particular.

All these characteristics of the nanoeconomics in the context of the development of international economic relations (IER) suggest that it actively influences the development of economic systems in different countries of the world [14]. The state is the leading subject of the IER, forming their various levels, and this subject develops under the influence of an individual factor, which will be discussed in the further parts of this study.

2.2.2 ANALYSIS OF THE IMPACT OF NANOECONOMICS ON THE PROCESS OF PUBLIC EDUCATION AND ECONOMIC GROWTH

Social production as production at the macro level is production to meet human needs and is in constant motion, passing through the following stages: own production, distribution, exchange and consumption of products and services [15]. Macroproduction is designed to satisfy the needs of individuals in certain goods and services. The nature of nanoeconomics provides, in addition to the production function, a consumer function, that is, social production aims to satisfy the needs of individuals. This is the connection of supply and demand through an emphasis on nanoeconomic aspects. Production as a set of separate individuals who are owners, managers and workers who produce a certain product becomes the focus of supply. On the demand side, an individual also stands out, because it depends on his/her preferences whether the demand on the supply side is satisfied.

Let's note that the process of social production, taken not as a one-time act, but in constant repetition and restoration, is social reproduction. The economic cycle also concerns nanoeconomics. When it comes to products and services, the individual changes their use throughout life: the generation born after the First World War radically changed the conditions of their existence around objects. Yes, they began to go to the cinema to watch films and news, they had a radio station to understand the processes displayed on public radio waves. Then television sets appeared, providing for the possibility of watching movies and programs at home, in the late 80s the first personal computers appeared (POISK, for example), to which this generation joined with great attempts. These items are a sign of the entry into the life of information and telecommunication technologies that continue to change and change the laying around.

Let's note that for simple reproduction, it is necessary to constantly restore all factors of production: labor, means of production, natural resources and habitat.

The factor connecting nanoeconomics with social reproduction is the labor force, because the main subject of nanoeconomics is an individual. The reproduction of the labor force is associated

with the restoration of the working capacity of workers in the broadest sense: that is, with the preparation of the next proper shift instead of workers leaving production. This can be achieved by constant restoration of items and means of personal consumption, the development of social protection systems, and the training of workers with appropriate qualifications. The labor force is a carrier of economic skills and competencies that its representatives exchange for wages spent on a decent existence. The labor force is the proposed side of the nanoeconomics. In the nanoeconomics, this aspect of supply is complemented by property, which can become property for starting one's own business and turning oneself into an entrepreneur, developing a business and hiring other labor. The consumer side of the nanoeconomics provides for the allocation of oneself and persons related in living within the household, for the implementation of active consumer actions.

Nanoeconomics can be defined as a social form of existence of reproduction. Hence, an obligatory component of the reproduction process is its common side as a form of existence of the productive forces.

Let's note that the starting point of the social product is production, the ultimate goal and driving motive is consumption.

Nanoeconomics defines a part of a separate economic individual in the process of production. If there are certain specialists who were competent and had the appropriate skills, distinguished from others, then they can invest their labor in the manufacture of this product. As the classic of scientific thought Smith, A. said, if there are natural conditions and the quality of workers, these countries can specialize in the manufacture of just such a product. So, if in Portugal there are natural conditions for the production of wine and there is a gift of winemakers, then this country will specialize in the manufacture of just such a product. If in England there are conditions for raising sheep and traditions for the production of woolen fabric, then the country should produce this particular product. Specialization is the basis for the implementation of distribution. Natural conditions dictate the direction in which production will develop, and these conditions entail the emergence of habits to produce a product in a certain way. This second component dictates the conditions for the development of nanoeconomics. Nanoeconomics is formed in such a way as to ensure the production process in a particular area. This is how technologies of a state nature are formed, and if they successfully solve problems in a certain area, they can be distributed throughout the world.

At modern enterprises, the result is achieved by joint, complementary efforts of managers, mechanics, programmers, etc., between which there is an exchange of activities [16]. Within the framework of nanoeconomics, there is an exchange of results of activities, when some specialists complement the actions of others. At modern enterprises, it is impossible to exist separately, separately performing only their own forms of labor. Engineers should link their work with economists and psychologists in order to get synergies from such joint activities. This is first. Secondly, the exchange is a stage of movement of the produced product, when goods and services are exchanged on the basis of the division of labor. Specialization requires nano-efforts, because what is given by nature requires the formation of traditions in the production of a particular product, and such isolation leads to the exchange of insufficient goods and services. And, accordingly, such a trade regime

leads to the exchange of such products. Understanding the terms of use of this product leads to the desire to create something similar and your own. Economic theorists argue that if there is a demand, then it does not matter who produces this product, the main thing is that there is a certain manufacturer that satisfies these needs. So, what a country receives as imports, it can eventually begin to produce as import substitution. Thus, there is an exchange not only of goods and services, but also the experience of individual individuals of technological processes and managerial practices within the framework of the nanoeconomics system. Thirdly, through exchange, the participant in production receives the share of the social product due to him/her in distribution. As a result of the exchange, an individual is involved in the formation of the gross domestic product. The division of GDP per inhabitant is an indicator of the importance of nanoeconomics for the development of the national economic system, as well as a general indicator of the level of socio-economic development of the country. Exchange promotes production or slows it down, speeding up or slowing down the movement of goods and services. The exchange as a whole is trade relations, which at the expense of the consumer depend on the conditions for the nanoeconomics development.

Consequently, the final stage in the movement of the social product is consumption, that is, the realization of use value. Two types of consumption should be distinguished: industrial and personal.

The labor force that consumes the means of production within the enterprise in which it works is the carrier. And this is the first side of nanoconsumption.

Personal consumption is not just a physiological or educational-cultural act. Its important social nanofunction, along with the reproduction of the labor force and the person as a whole, is the creation of certain incentives, motivations for the growth and development of the nanosubject. This is the other side of the drift.

Thus, nanoconsumption includes two forms:

1) as part of production consumption, when the labor force (nanosubject) consumes other factors of production to manufacture a product that satisfies certain needs;

2) as part of personal consumption, when a person restores and develops his/her strength and ability for highly productive work through the use of various kinds of materialized products and the receipt of various services (educational, informational, medical and recreational, entertainment, etc.).

As it is known, there are two types of playback: simple and extended.

Nanoeconomics, which characterizes simple reproduction, is determined by the physical and certain professional properties of a person, when there is a limit to professional efforts and development does not occur. Such reproduction is typical for traditional societies with a non-market economy, where the rate of expansion of production is very low, and hence the slowdown in economic and social progress.

Nanoeconomics expands the stages of conventional reproduction to extended. While simple reproduction begins with the production process, extended reproduction begins with an idea of a future manufactured product. Such an idea should appear on the basis of appropriate training of specialists – technologists or engineers. A certain person who generates ideas appears as a result of high-quality training and education in baby economics. Everything should contribute to the growth

of a specialist, from birth, a preschool institution in which emotional intelligence is formed. Then training and acquisition of competencies and skills takes place in high school and on the university bench. Thus, human capital is formed, which is used as an investment in the future.

The innovative component [17] of the process of expanded reproduction also begins with the baby economics. Quantitative and qualitative changes in the factors of production are achieved through the rationalization of their use, the development of scientific and technological progress. This type of reproduction is typical for a developed society, when considerable attention is devoted to the innovation component, from the educational process to the acquisition of practical skills in the development and implementation of the latest products and services. For the emergence of ideas for improving or updating products, it is necessary to have the appropriate conditions and basis. And the baby economics forms the basis.

Expanded reproduction of the social product is embodied in economic growth. This category is related to economic development. Economic development is a process of evolution of economic systems, and their quantitative component changes as economic growth. The increase in the scale of expanded reproduction occurs within the framework of economic growth. This growth at the macro level is helped by the development of the nanoeconomics. Strengthen the economic system can qualitative labor of individuals. An indicator of economic growth, such as annual GDP growth, reflects how creative the economy as a whole is. After all, it depends on the idea (the result of the creativity of an individual specialist) whether there will be an increase in sales indicators, whether consumption reacts positively to these innovations.

Economic growth can be exogenous and endogenous [18]. Thus, for the positive development of the country's economy, there must be endogenous growth, as caused by internal factors and impulses. The internal impetus for the development of the economic system at the macrolevel occurs as a consequence of the development of nanoeconomics. Yes, only residents who have the appropriate education and the ability to develop those options in which they are involved reproduce and grow the economy. A country with a powerful family business system [19] – Italy – is developing the household as an impetus to the formation of sectoral-territorial clusters within the national economy. Countries such as the USA or Great Britain have an individualistic approach to business, when the formation of wealth and the gross product and its increment depends on the individual worker rather than on his/her closest group.

Economic growth is manifested in the specific dynamics of the quantitative increase and qualitative improvement of the social product and its factors of production. There are two main types of economic growth – extensive and intensive – depending on how expanded reproduction is achieved.

Indicators of economic reproduction and growth are reflected in nominal gross domestic product (GDP). This indicator occupies a central place in the system of public accounts. GDP is defined as the gross value of all goods and services produced in the territory of a given country during a certain period, excluding the value of their intermediate consumption. In other words, we are talking about the elimination of double counting in the quantitative calculation of GDP, the requirement to take into account only final products and not to take into account intermediate products in the calculation.

How nanoeconomics affects economic growth and reproduction can be considered using the example of correlation analysis. Yes, GDP is correlated with the number of university students. The latter reflects the state of the baby economics in the country. The initial component of nanoeconomics – the baby economics – is manifested in how many universities and their students there are in a particular country. For one of the countries with transition economy, let's calculate the correlation between nominal GDP and the number of university students. The initial data for the analysis are presented in **Table 2.1**. Let's note that all calculations of correlation coefficients are made using the Python programming language, the pearsonr function of the scipy library of the stats package.

Table 2.1 Initial data for the correlation analysis of the dependence of nominal GDP and the number of students in higher educational institutions (universities) [20]

Index	**Years**					
to study the correlation coefficient	2016	2017	2018	2019	2020	2021
Nominal GDP (million USD)	96096	116520	131318	157721	151960	205247
to study the correlation coefficient	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22
Number of university students (persons)	1369432	1329964	1322324	1266121	1141889	1046669

Table 2.1 contains the initial data for calculating the closeness of the relationship between nominal GDP and the number of university students.

In **Fig. 2.2**, it is possible to see a graph of the correlation between the data from the **Table 2.1**. It is a downward straight line reflecting the inverse relationship between these phenomena.

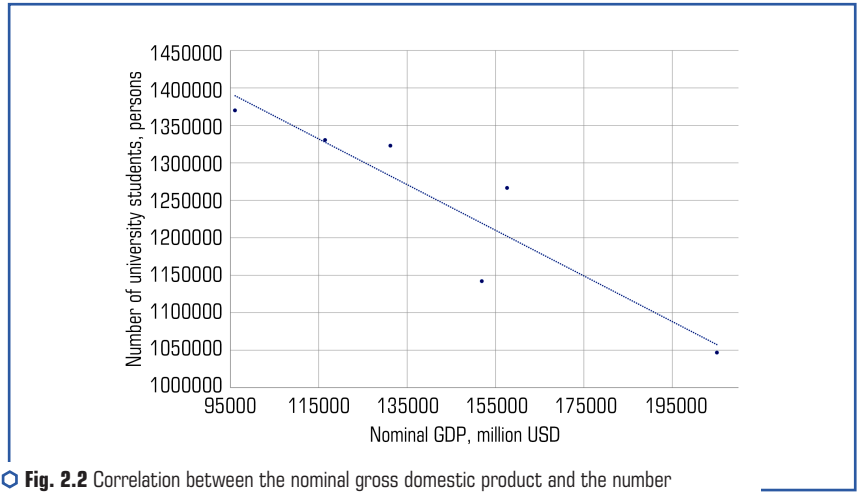

Fig. 2.2 Correlation between the nominal gross domestic product and the number of students in higher educational institutions of one of the countries with transition economy

The correlation coefficient is 0.919, which means an inverse relationship, that is, when the number of university students decreases with GDP growth. However, this dependence is quite dense, because it approaches 1. Such analysis data can be explained by the fact that the number of universities is decreasing compared to the 1990s and early 2000s. Accordingly, the number of students is reduced due to lower quality educational services, since universities that cannot withstand competition in the education market cease to exist. In addition, the output of professionals, including professional technologists, needed to ensure the functioning of production, is growing.

2.2.3 IMPACT OF NANOECONOMICS ON THE MACROECONOMIC LEVEL OF THE ECONOMY AND ECONOMIC EQUILIBRIUM

Modern Western economic thought considers the continuity of production across society due to the model of economic turnover of products and income.

The starting point in the economic turnover of goods is households offering land, labor, capital, and entrepreneurial abilities on the market. They pay direct taxes to the state, but receive from it educational and other services, transfer payments and wages (if they work in the public sector).

The economy of households as the primary link of nanoeconomics is the defining link of the country's economy. On the one hand, the country's economy includes individual consumption, which is formed within households and is the primary source of its existence. On the other hand, the future generation of economic individuals is growing in households, and how households cope with raising and educating children, such will be the next generation of consumers and producers of goods and services. As households live, so does the country.

In one of the transition economies, according to statistics, the standard of living is not high enough, but in reality, households have a fairly significant level of wealth. This can be explained by the fact that households have additional income. Thus, the rural population has food from household plots and from domestic animals, which is a significant amount of funds. In general, statistics show that the rural population has a small fortune, since additional income is not recorded by the state. In addition, there is income from agricultural shares for the lease of land by farmers. It should also be noted that the rural population is an active consumer of a variety of end products: from plumbing for home bathrooms to lawn mowers and power generators. In addition, in rural areas, residents organize sole proprietorships selling such equipment and other products, which provides them with additional income and the opportunity to have modern goods for a decent life.

Urban households also have additional wealth, say from renting out apartments for long or short periods of time. It can also be additional sources of work, when, say, teachers have income from tutoring, and doctors – from additional medical practice. It should be noted that urban residents are also trying to create sole proprietorships and have an additional share of income for their main job.

In general, in the country with the transition economy under study, private business in the form of sole proprietorship is a generator of economic impulses to heat up the entire macroeconomic

management system. Consequently, nanoeconomics and macroeconomics are quite closely intertwined. This interweaving occurs through an intermediary – the entrepreneurial system.

Enterprises pay direct and indirect taxes to the state, and receive grants, subsidies, subventions from it, if they fall under the system of benefits. Enterprises and sole proprietorships in particular are the conductors of individuals in the economic environment. They provide jobs and pay appropriate wages. Often such a wage is issued in envelopes or in half, and then taxes are paid in part. This indicates that an economical person has the ability to find additional sources of livelihood and improve his/her own quality of life.

The market economy implies coordination, balance between expenses and incomes, supply and demand both within individual industries and sectors of the economy, and across the whole society [21]. Macroeconomic equilibrium analysis requires a more careful consideration of such an economic phenomenon as aggregate demand, which takes the form of consumer (consumption spending) and investment (expenditure on capital goods).

So, consumption is the total amount of goods bought and consumed during a given period. The level of consumption depends on subjective and objective factors. The subjective factor includes the psychological inclination of people to consume; objective – the level of income, its distribution, the price level, the rate of interest, etc. It should be noted that consumption is formed at the level of nanoeconomics, when psychological and objective factors are formed within the household. The indicators of such consumption are the country's GDP and GDP per capita, since the latter is an indicator of the formation of the country's GDP depending on the population.

In the economic life of society, the phenomenon of saving is closely connected with the phenomenon of investment. Saving is the basis of investment. According to the natural-material structure, income takes the form of consumer and capital goods. The former go into non-productive consumption, and the latter into industrial consumption. In this country with transition economy, people have the means to invest as the difference between income and consumption expenditure. Since there are additional incomes that improve the quality of life, there are appropriate funds for saving and investing. The subjects of the nanoeconomics invest in capital and durable goods (cars, farm equipment, etc.), as well as in real estate. There are also funds to start your own business, which starts as an individual entrepreneur and continues in the form of Limited Liability Companies (LLCs) or Private Joint Stock Companies (PJSCs). Keynes, J. proved that if investment increases, then income increases to such an extent as to bring savings to the level of investment. Conversely, if capital investment is less than saving, then income will decrease so much that saving equals investment. This means that the economy is in equilibrium at the point where saving and investment balance. Thus, the concept of "economic equilibrium" means such a state of the economy, in which a constant balancing and mutual balancing of opposing structures (production and consumption, supply and demand) is achieved. In market systems, balancing is achieved through the market mechanism through the establishment of appropriate proportions. Equilibrium reflects the internal state of the market system, which is self-ordering. Thus, the nanoeconomics affects production and consumption through the human resources used in production processes and the

amount of funds that are spent on household needs. Equilibrium regulates the demand for human resources and their consumption of consumer and capital goods.

Let's calculate the correlation coefficient between GDP per capita and the number of individual entrepreneurs as a relationship between the macroeconomic state of the economy and its individual development indicator. The initial data for calculating the correlation coefficient are given in the **Table 2.2**.

Table 2.2 GDP per capita and number of individual entrepreneurs [20]

Index	**Years**					
to study the correlation coefficient	2016	2017	2018	2019	2020	2021
GDP per inhabitant (million USD)	2251	2743	3107	3754	3639	4959
to study the correlation coefficient	2016	2017	2018	2019	2020	2021
Number of individual entrepreneurs	1559161	1466803	1483716	1561028	1599755	1983269

The data given in **Table 2.2** show the growing dynamics of GDP per capita and the number of individual entrepreneurs.

The dependence graph of certain indicators is shown in **Fig. 2.3**.

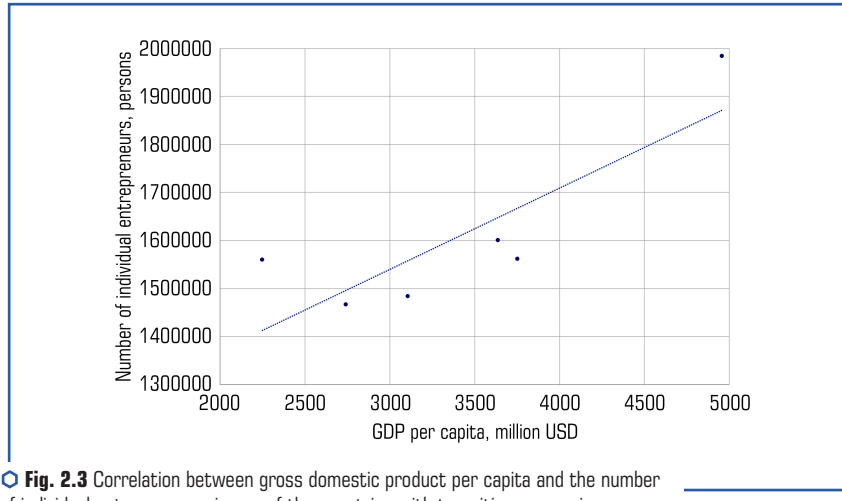

Fig. 2.3 Correlation between gross domestic product per capita and the number of individual entrepreneurs in one of the countries with transition economies

The correlation coefficient between GDP per capita and the number of individual entrepreneurs is 0.833. This means that the relationship between the analyzed data is quite dense and direct, when the larger the individual entrepreneurs number, the more intensively the GDP per

capita grows. These data indicate that entrepreneurs are actively developing their activities and replenishing the amount of gross domestic product produced.

Thus, it can be noted that nanoeconomics actively influences the development of the macroeconomic economy.

2.2.4 IMPACT OF NANOECONOMICS ON SERVICES, INDUSTRY AND AGRICULTURAL SECTOR

It should be noted that in general terms, the country's GDP has the following structure: services, industry and agriculture. The GDP of foreign countries shows that the majority in the structure of GDP falls on the service sector. The International Monetary Fund defines services as a change in the position of one institutional unit influenced by another institutional unit. This institution defines 11 types of services: from transport to government. A person living in the developed world consumes services to a greater extent than embodied products. A significant per capita income suggests that the funds are largely spent on the development of the individual, meeting the higher needs in Maslow's pyramid.

In addition, services are a type of activity that provides for a greater number of enterprises in this particular area. From 60 to 75 % of GDP falls on this area. Thus, Britain during the period of Margaret Thatcher carried out a restructuring of the national economy, encouraging laid-off miners to move into the service sector, opening their own small enterprises. In another example, the island nation of Nauru had a competitive advantage in the 1970s in the mining of phosphate rock. When these minerals dried up, the country switched to the provision of financial services on the basis of an offshore zone. This indicates that services can be the flagship of the economic development of individual countries of the world.

In some countries with economies in transition, the information technology (IT) sphere is intensively developing. IT engineers are gradually replacing process engineers working in industry. The IT sphere focuses on the use of the labor of individuals, both hired engineers and individual entrepreneurs. This segment of the economy is also focused on nanoknowledge in nanoelectronics, because the IT sector can develop only on the basis of high-quality production of electronic gadgets.

More and more traditional segments of the service sector, in which the production unit is an individual or household, are influenced by the innovation system in the country. After all, this is the most actively changing system under the influence of the quality of the process.

An illustration of the impact of the innovation system on the volume of services provided is given in **Table 2.3** and **Fig. 2.3**.

Table 2.3 shows the volume of services provided and the cost of research and development (R&D). And these data indicate that a growing trend is being displayed.

Fig. 2.4 indicates that there is a tight relationship between the indicated data.

The correlation coefficient between the volume of services sold and the costs of research and development is 0.828. This is a significant dependence, indicating that as the cost of science increases, the volume of services provided increases.

Table 2.3 Initial data for correlation analysis of the impact of the innovative component of service production [20]

Index	Years					
to study the correlation coefficient	2016	2017	2018	2019	2020	2021
The cost of the volume of services provided (thousand USD)	No data	7100128	7989912	9498686	9572315	12799667
to study the correlation coefficient	2016	2017	2018	2019	2020	2021
Expenditures on R&D (million USD)	465	523	619	685	617	No data

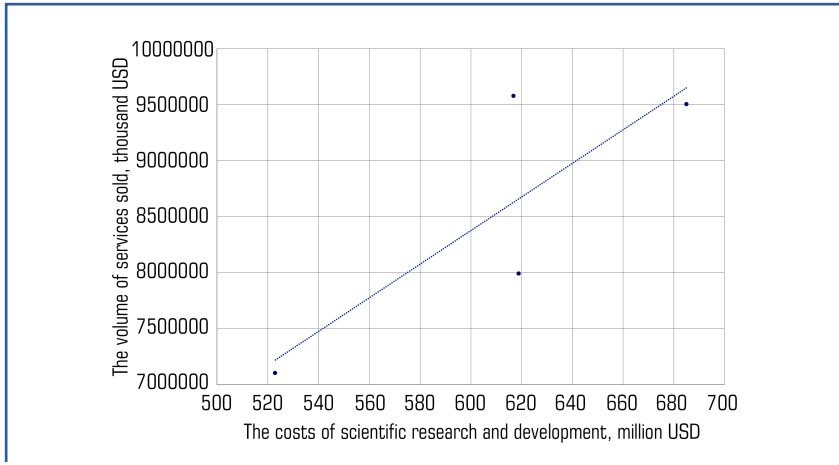

Fig. 2.4 Correlation between the volume of services sold and the costs of scientific research and development

Nanoeconomics as an innovative economy is determined by a significant share of research activities and its implementation in the service sector. The active use of innovation determines the research potential of this market segment.

Nanoeconomics as a human economy also affects the volume of services provided, because the individual factor should be used in the most optimal way.

Along with the service sector, industry is actively developing. In the structure of the GDP of developed countries, this segment of the national economy accounts for 20 to 30 %. And this area is under the influence of nanoeconomics. It should be noted that the level of development of such an industry as mechanical engineering, as a rule, determines the progress of the entire economy of the country. There are three countries in the world that characterize machine-building production, the USA, Germany and Japan. Twelve industrialized countries account for more than 50 % of engineering products. This is the most innovative segment of the market, in which the majority

of scientists and development engineers are involved. Most often, nanotechnologies are actively used in these industries.

It is known that the level of development of the national economy is determined by the level of clustering of economic systems. A cluster is an industry-territorial bundle in which many compatible and related manufacturers work. And it is the industry that is determined by such clustering. Countries with economies in transition had so-called production districts in Soviet times, which combined metallurgical complexes and machine-building enterprises. In these states, a chain between these basic industries should be debugged.

Other industries are also backbone. These include mining, chemical industry, mechanical engineering, industries for the production of consumer goods (furniture, textile, clothing, footwear, etc.) and others. In the conditions of the global economy, the competitiveness of enterprises in the vast majority of industries depends on the professionalism of specialists, their creativity, the ability to constantly innovate, apply nanoknowledge to create new technologies. Without the economy of nanotechnologies (as a component of nanoeconomics), in the near future, ensuring the process of expanded production reproduction will be problematic. Under the conditions of the new technological order, the formed individual (from birth to the production of nanoideas) should influence economic growth. Of particular importance in this context are society's spending on education at all levels of the educational process and R&D.

Let's calculate the correlation coefficient between the volume of industrial production and the costs of research and development in one of the countries with economies in transition, the initial data for which are shown in **Table 2.4**.

Table 2.4 The volume of industrial production and the volume of expenditures on research and development [20]

Index	**Years**					
to study the correlation coefficient	2016	2017	2018	2019	2020	2021
The volume of sold industrial products (million USD)	71254	84103	92568	98445	89897	134939
to study the correlation coefficient	2016	2017	2018	2019	2020	2021
Expenditures on R&D (million USD)	465	523	619	685	617	No data

Data in **Table 2.4** show that the volume of industrial production and the cost of research and development are increasing from year to year. And the correlation coefficient is 0.972, which is reflected in **Fig. 2.5**.

Such a high correlation coefficient indicates that the impact of nanoeconomics on macroeconomics is significant and direct, when with the growth of funding for science, the indicator of industrial production also grows.

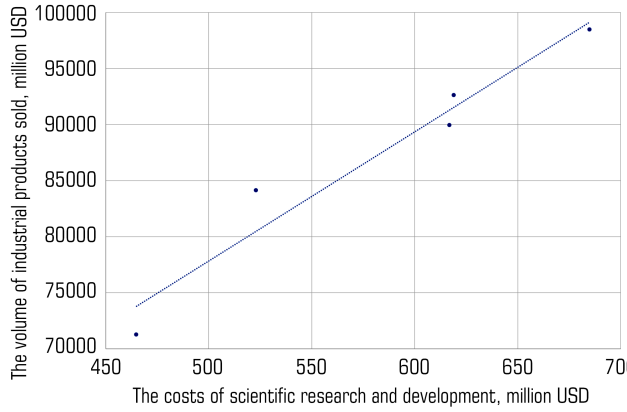

Fig. 2.5 Correlation between the volume of industrial products sold and the costs of research and development

Nanoeconomics also has an impact on the agricultural sector of the national economy. Note that in agricultural production, the economic process of reproduction, regardless of its social nature, is always intertwined with the natural. Therefore, rational management in this area requires knowledge and skillful use of not only economic laws, but also the laws of nature. The close relationship of economic processes with natural causes a significant impact of the latter on the results of economic activity, which affects the rate of reproduction.

Hence the possibility of sharper fluctuations in the rate of accumulation in comparison with other industries. If in industry a person as a subject of nanoeconomics can fully influence the production processes, then in agriculture this possibility is limited. Here the object of human activity is living organisms: plants and animals; biological processes proceed according to certain laws of nature. They objectively require the adaptation of the entire rhythm of production to the rhythm of nature: to the natural course of the production process. In agriculture, it is impossible to speed up the production process, as in industry.

A characteristic feature of the nanoeconomics of developed countries is the functioning of the agro-industrial complex (AIC) or agribusiness. This determines the essential features of social reproduction in this most important area of the economy.

In modern conditions, the clustering of the agrarian sector should take place. Thus, the production of food (grain, meat, milk, etc.) and industrial crops (cotton, flax, etc.) is based on an intersectoral production system. The latter covers agriculture and related sectors of the economy that supply it with the means of production, process and store agricultural raw materials and produce food. Their relationship can be expressed according to the scheme: production of means

of production – logistics and service – farm product – its industrial processing – sale in wholesale and retail trade. At all stages of production, supply and marketing of agricultural products, an active role belongs to economic individuals. Farms are usually sole proprietorships and their activities depend on subjective factors. This was clearly manifested during the hostilities, when farmers sowed areas and cultivated land at their own risk.

The formation and development of agribusiness is due to the transition of agriculture to the machine stage of production in the conditions of the fifth and sixth technological modes. Agribusiness is becoming more and more knowledge-intensive, and nanotechnologies are also used here, capable of growing plants with specified parameters. Agribusiness also depends on the innovation component, as discussed in the correlation study.

Table 2.5 shows the initial data for such an analysis.

● **Table 2.5** Initial data on the correlation analysis between the volume of agricultural production and the volume of expenditures on research and development [20]

Index	**Years**					
to study the correlation coefficient	2016	2017	2018	2019	2020	2021
The volume of sold products of agriculture, forestry and fishery (thousand USD)	16725803	18267037	19944995	22728106	22611237	26839708
to study the correlation coefficient	2016	2017	2018	2019	2020	2021
Expenditures on R&D (million USD)	465	523	619	685	617	No data

The characteristics in the **Table 2.5** indicate a growing dynamics, the correlation coefficient relative to which indicates a tight connection. The graph of the correlation dependence is shown in **Fig. 2.6**.

Table 2.5 and **Fig. 2.6** reflect that there is a high correlation between the sales of agricultural products and the costs of science. The correlation coefficient is 0.928. Yes, the production and sale of agricultural goods grows with the growth of expenditures on science. Nanoeconomics as an innovative economy also influences the formation of the agricultural sector in different countries of the world. The scientific world in the agricultural sector, in particular, is more subjective in objective conditions, when an individual researcher can change the vector of development of an entire industry. The country with an economy in transition has a whole network of agricultural educational institutions, from agricultural technical schools (colleges) to agricultural academies and universities. This network is an intermediary between the AIC and individual individuals.

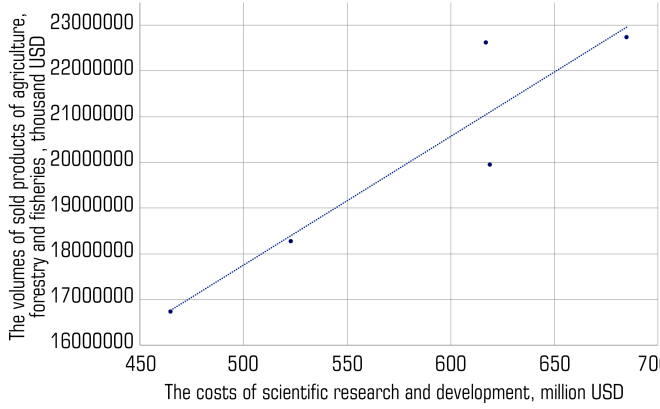

Fig. 2.6 Correlation dependence between indicators of volumes of sold products of agriculture, forestry and fisheries and the volume of expenditures on research and development

The obtained results of the influence of nanoeconomics on the macroeconomic environment can be explained by the fact that:

– nanoeconomics is defined as the level of an individual within a national economic system. The nature of nanoeconomics determines how it affects the system. Yes, the nature of nanoeconomics presupposes the existence of material and non-material conditions. Material conditions actively influence the provision of macroeconomic development. Non-material conditions are factors in improving the quality of life of individuals and the quality of production processes at the macro level. Four regularities in the development of nanoeconomics were identified. All of them affect the components of the nanoeconomic system: the baby economics, the human economy and the economy of nanotechnology. It is because of these subsystems that nanoeconomics has an impact on the macroeconomic conditions for the development of certain countries. Nanoeconomics is defined by an evolutionary approach. This evolution coincides with the evolution of international business and the countries where this business developed;

– the influence of nanoeconomics on the process of social reproduction and economic growth is determined by the gradual influence on the process of social expanded reproduction. The same: production – distribution – exchange – consumption – complemented by an innovative component: idea – research – implementation and an integral part of teaching technological solutions, in particular nanotechnological ones. Yes, to the idea, there should be training and education in the family and all sorts of educational bookmarks. The correlation coefficient between GDP and the number of students is 0.919, which can be explained by the decrease in the number of privately owned universities. If in the 1990s and early 2000s universities and their students were in sufficient

numbers, today it has decreased significantly. In addition, external independent evaluation (EIE) is also a limiter for university applicants in countries;

– the influence of nanoeconomics on the macroeconomic level of management and economic equilibrium occurs through the influence on the market mechanism of the ratio of supply and demand, production and consumption. Savings, investment and consumption are expressions of the processes of individualization of market mechanisms. It is through a person that entrepreneurs influence the market equilibrium. The correlation coefficient between GDP per capita and the number of individual entrepreneurs is 0.833 and indicates that there is a direct and close relationship between these phenomena. So, private entrepreneurs are at the forefront of the business sector of the economic system of one of the countries in transition. It is individual entrepreneur that form private incomes, which become the basis for consumption and their savings provide an opportunity for investment;

– the impact of nanoeconomics on the service sector, industry and the agricultural sector is determined by the fact that recently there has been an individualization of production and management processes within the economic system. Production is increasingly moving into the service sector, offering to form a competitive advantage in its intangible part. The industry remains the flagship of economic development and technology is crucial for building a successful business here. The agrarian sphere combines natural and economic relations. For a country with a transitional economy, all these three components are decisive for building an effective national economic complex. The impact of the nanoeconomics on the production of services, industrial products and agricultural goods was reflected through the correlation coefficient: 0.828; 0.972; 0.928 respectively. These are significant indicators, indicating a close direct relationship between the development of the defining segments of the economy and nanoeconomic advancement. The latter is a kind of innovative component of macroeconomics and characterizes innovative opportunities for the macroeconomic system as a whole.

The research method used has such features as a combination of macroanalysis and nanoeconomics analysis. It is noted how the human economy affects the process of expanded reproduction, economic balance and the structure of the economy. The limitations inherent in these studies are characterized by the inability to track the impact of each individual on macrodevelopment. Aggregates such as GDP per capita can be used to generalize nanoeconomic dynamics.

The disadvantages of the study include: the lack of analysis of the activities of an individual in the macroeconomic environment, the difficulty in applying the assessment of the economic practice of an individual within an enterprise and a public institution. Such shortcomings can be addressed by using the demographics and biographies of prominent world and country-specific managers.

This study proves that there is an individualization of economic processes in the world and its individual national economies. The advantages of this study compared to similar well-known ones are that individualization should have a systematic approach, which is ensured by considering it within the framework of the nanoeconomics, which begins with the baby economics and continues with the human economy and the economy of nanotechnology.

Correlation analysis makes it possible to determine mathematically how nanoeconomics affects the development of the national economic system. All calculated characteristics of the correlation coefficients tend to unity, which means that nanoeconomics actively influences the macroeconomic system of certain states.

CONCLUSIONS

1. The total activity of society has an increasingly noticeable impact on nature, requiring rationalization and regulation of their interaction. Of particular importance in this context is nanoeconomics as a systemic phenomenon of a nature associated with macroeconomic systems. As a component of the country's economy, it begins its countdown from the period of extensive geographical discoveries and acquires structured features in the period of nation-states. In the context of globalization, nanoeconomics is determined by certain characteristic features: accessibility and universality, gradual development, technological globalization, "financialization", and the complex interaction of nanoeconomic and international. All these characteristics of nanoeconomics in the context of the development of international economic relations ensure its active influence on the development of economic systems in different countries of the world.

2. Simple and expanded reproduction is the initial sign of macroeconomics. Both of these forms of reproduction are based on human labor. The labor of individuals is a public form of existence of the nanoeconomics. Extended reproduction can take place even more intensively through the education and training of individuals in certain educational institutions. There they are taught how to make decisions and nurture ideas about technology and innovation in the manufacturing process. Economic growth is based on the activation of expanded reproduction at the micro- and nano-levels and receives impulses for development from specific individuals. Thus, certain countries with economies in transition base their own development on the entrepreneurial activity of specific individuals, which is confirmed by correlation analysis.

3. The economy of households, as the primary link of the nanoeconomics, is the defining element of the country's economy, since individual consumption formed within households is the primary source of its existence. In modern conditions, households largely form the macroeconomic indicators of housekeeping. Specifically, in this nanoeconomic component, dependence on indicators of the development of the state economy is formed. In one of the countries with economies in transition, the wealth of households is provided through additional items of income from ancillary activities. At the macro level, this is the total income, reflecting all the income of family cells. The difference between income and consumption is saving, which is the basis for investment. In this country, funds in business are largely invested by sole proprietorships, which are a manifestation of entrepreneurial ability. As evidenced by the correlation analysis, the relationship between GDP per capita and the number of individual entrepreneurs is quite dense, which confirms the opinion regarding the active influence of nanoeconomics on macroeconomic management.

4. The national economy includes such structural elements as industry, services and the agricultural sector. In each of these parts, the activity of economic man is actively used. The latter is a manifestation of innovative activity, when a person economically comes up with ideas for improving production processes and this is helped by state policy regarding the costs of research and development. The most significant relationship between these indicators is observed in the agricultural sector and science ($R=0.979$), which indicates the possibility of an innovator's influence on the development of various sectors of the national economy.

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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DOI: 10.15587/978-617-7319-64-0.CH3

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CHAPTER 3

LEVELING BREAKS IN THE INNOVATIVE DEVELOPMENT OF SOCIO-ECONOMIC SYSTEMS

ABSTRACT

The chapter accounts for the problem of identification and leveling breaks in the innovative development of socio-economic systems in example of Ukraine in the face of new challenges for the state in the process of developing relations with the EU.

The aim of the chapter is to assess the level of innovation competitiveness of the Ukrainian economy and determine the most important factors for leveling breaks in its innovative development in the conditions of association with the EU.

The analysis of world rankings has shown that the innovative development of Ukraine determines comparative factor advantages in coverage of higher education, availability of scientific staff, and quality of research institutions, but low state support, lack of stability, and problems in institutional development hamper the country's innovative potential. Cluster analysis showed that Ukraine is in the same cluster as Poland. Bulgaria and Romania, which have not yet fully consistent with the level of technological competitiveness of EU leaders. Among the strengths of Ukraine is the development of human resources and labor effect. The correlation analysis between the components of the Global Innovation Index and the factors of increasing Ukraine's competitiveness indicates a moderate link between the development of clusters, the ratio of expenditures on R&D to GDP, and the export of ICT services. In order to level breaks in the innovative development of Ukraine it's necessary: to increase both foreign investments and state financing; improvement of regulatory acts, reduction of corruption, institutional improvement; support of technologies through of regional cluster programs or "smart specialization"; integration into the European Research Area.

KEYWORDS

Breaks in the innovative development, Global Innovation Index, high-tech products, socio-economic systems, EU-27 and Ukraine.

Presently, in a highly globalized and competitive world, technological change and innovation are the basis of the long-term economic growth of any successful country. As a consequence, the

development of economic policy-based countries, based on the development of the scientific, technological, and innovation environment, will contribute to their sustainable economic growth and global competitiveness. At the same time, in the conditions of competition's intensification in foreign and domestic markets for the leading countries of the world, the problem of advanced production technologies' introduction of the XXI century new industrial revolution is substantially aggravated.

In a highly globalized and competitive world, the basis for a country's long-term economic growth is technological change and innovation. At the same time, the core of technological change and innovation is scientific development. In this context, countries should formulate economic policies to develop a science, technology, and innovation environment in society and the economy that will promote sustained economic growth and global competitiveness [1].

Technological readiness is a key element in the growth of each national economy. It is impossible to imagine any aspect of human activity without technological tools. In addition, technology plays a significant role in shaping lifestyles, work, and communication in modern societies. Given this important role in social life and business, the results achieved in technological readiness largely determine the quality of life of citizens and the attractiveness of the economy of a given country. Consequently, the level of competitiveness in terms of technological readiness largely determines the overall competitiveness of a national economy in the global world. These are the main reasons why technological readiness requires special treatment in the formulation of a country's strategic development and why it should be monitored and improved in every national economy that advocates an open development model [2].

Thus, competitiveness now is the ability to manage change and adapt to it through innovation. Achieving and maintaining competitiveness requires a constant increase in productivity and constant adaptation to changes in the economic environment [3].

When change is the only constant, an economy that can attract new ideas, methods, or products faster than others will have an advantage. That is why the use of technological opportunities and innovations can accelerate the growth and development of any economy [4].

According to the European Commission definition, technological competitiveness is the ability of a national economy to generate long-term economic growth, productivity, and well-being, through technological and innovative development. Such development requires an environment for innovation and has the following elements: a high level of education; investment in research and development; and a developed innovative infrastructure, including high-quality research institutions capable of generating knowledge and supporting new technologies; extensive cooperation in scientific and technological development between universities and industry; protection of intellectual property rights, high levels of competition and access to venture capital and finance [5].

The importance of traditional competitive advantages has diminished considerably in the twenty-first century, and it is only through participation in technological competition in the world market that the competitiveness of national economies is now substantially enhanced. According to Holroyd, K., supporting scientific and technological innovation in the long term constitutes the main source of competitive advantage [6]. In most cases, the technological competitiveness of

an economy is described by researchers in the context of the impact of a technological factor on the dynamics of foreign trade, innovative competitiveness or innovative support for industrial modernization [7].

Research is gradually reflecting technological competitiveness in the measurement of the domestic development potential of a country's economy. According to Momaya, K., technological competitiveness is the ability to develop, transfer, absorb, produce, or commercialize technologies to maintain competitiveness [8]. Fagerberg, J. linked technological competitiveness with innovation potential [9]. This is also the position of Cassidy, M., O'Brien, D., who, by technological competitiveness, understand the innovative and adaptive potential of the economy [10]. Howells, J. defines a country's scientific and technological competitiveness as a country's ability to create and retain competitive advantages in the generation, diffusion and application of new knowledge through efficient use, building and modernizing its scientific and technological capacity in the context of globalization [11].

In our view, an approach to analyzing the competitiveness of the economy in terms of technological capabilities suggests that competitive differences among countries arise because of differences in their technological capabilities, that is, their ability to absorb, adapt, and efficiently use technology for development, efficiency and productivity.

By 2030, world-renowned institutions and international industry associations are predicted to be able to launch a revolution in industrial production only by introducing, first and foremost, high-tech industries. The wave of the new industrial revolution will drive the rise of new digital industrial technologies known as Industry 4.0, based on industries such as nanomaterials, 3D printing, genetic engineering, molecular biotechnology, cloud computing, multidimensional modeling, the Internet of Things, and artificial intelligence [12, 13].

Exports of high-tech products are the main indicator measuring technological competitiveness, i.e., the commercialization of research and development and innovation in international markets. It is the development, exploitation, and commercialization of new technologies that are vital to a country's competitiveness in the modern economy. High-tech products are a key driver of economic growth, productivity, and welfare, and tend to be a source of high value-added and well-paid employment [14].

The aim of the study is to assess the level of innovation competitiveness of the Ukrainian economy and determine the most important factors for leveling breaks in its innovative development in the conditions of association with the EU.

3.1 LITERATURE REVIEW

The impact of technological changes and industrial revolutions on the country's international competitiveness is the subject of study by a wide range of foreign economists and analysts. In addition, many well-known scientists offer their own methods for assessing the country's technological

competitiveness depending on the influence of various factors of the macro-environment, as well as the direct impact of export volumes and structure on competitiveness.

In their works, Jonson et al. [15] show that Western European nations, along with the USA and Japan, have been recognized as the most competitive economies in the world. Eastern European countries are generally considered to be lagging. They are examining the accuracy of these descriptions and the prospects for change in the coming decade. Georgia Tech 'High Tech Indicators' (HTI) contributes to the National Science Foundation (NSF) Science & Engineering Indicators. They cover 33 highly developed and rapidly industrializing countries. Our model of technological competitiveness contains four components: National Orientation, Socioeconomic Infrastructure, Technological Infrastructure, and Productive Capacity that promote 'Technological Standing'. They present indicator values, derived from survey and statistical panel data, for 13 European nations (plus the USA as a benchmark), for 1993–2005, and draw inferences about future high tech competitiveness. We are witnessing limited technological progress in the Eastern European States. The outlook for Europe is somewhat uncertain, given the sharp increase in competition from Asia.

Porter et al. [16] showed that the Georgia Institute of Technology, with the support of the National Science Foundation, had completed a decade of developing national high-tech competitiveness indicators. This chapter reports on the standing, emphasis, and rate of change of high-tech competitiveness for 28 nations. Results show strong standing for the '4 Asian tigers', comparable to many Western European countries. Their five '6 Asian Cubs' are experiencing rapid growth in high-tech production and export opportunities; the four tigers are no longer growing fast. Patterns are presented and discussed as well for 'the Big 3' (Japan, USA, Germany), three non-European developed economies, two former Eastern Bloc countries, and three Latin American nations. Their group of 180 experts predicts a surge in global high-technology export competition over the next 15 years.

At the same time, today all countries must take into account the influence of the main factors of the new industrial revolution. The most widespread concept today, Industry 4.0, was named in 2011 by German businessmen, politicians, and scientists, who identified it as a way of increasing the competitiveness of the German manufacturing industry through the enhanced integration of "cyber-physics systems" (or CPS) into production processes. In the report, Kagermann et al. [17] the main points of this concept were formulated, and its further development was described in the works of Ross [18], Schwab [19], which emphasize that today advanced production technologies are mainly 3D-printing, cloud technology, Internet things, new materials, robotics, and artificial intelligence.

Thus, we can conclude that Industry 4.0 technologies, combining the factors Smart TEMP (T (technology) – smart technologies, E (environmental) – smart environment, M (manufacturing) – smart production, P (products) – smart products), create new markets and industries, contribute to the growth of labor productivity, the competitiveness of sectors and national economies [20–22].

The Fagerberg paper [23] provides an overview of the literature on technology and competitiveness. First, the concept of a country's international competitiveness and various theoretical approaches to the relationship between trade and growth are discussed. A few empirical studies on the impact of technology (as evidenced by R&D, patents, etc.) on exports are then examined.

As a result, the author summarizes the findings and discusses lessons for policy. Moreover, América and Zamora Torres [24], based on foreign experience, argue that the share of high-tech products delivered to world markets is directly dependent on the development of national innovation infrastructure.

The question of improving the economic performance in the EU countries and finding an effective response to the current global challenges is directly linked to the widespread introduction of these advanced industrial technologies by the new industrial revolution in European countries [25–28].

Many economists have examined specific aspects of the impact of a country's export capacity on its competitiveness in world markets. Thus, Hausmann and Clinger [29] used one approach to assess the export potential for competitiveness. Looking at the "commodity space" of world exports, they note that a country's level of competitiveness depends on the food basket it exports. The greater the share of a country's high-tech products in world exports, the more competitive it will be. This position has been confirmed by the analysis of statistics from more than 100 countries. Building on this view, Hidalgo & Hausmann [30] argues that a country's export potential is influenced by a country's income level (namely, GDP): high-tech goods can be exported by high-income countries. It is clear that this point cannot be unconditionally and unequivocally accepted with regard to individual countries.

Melnyk [31] argues that the components of export potential include: the potential of internal resources (a function of the technical and technological base, staff qualifications, management methods, finance); the potential of the target foreign market; market access conditions, which include national (trade policy of the country, the system of support for export production) and external conditions (trade regime of the exporting country). Indeed, these factors influence the formation of export potential. However, Melnyk only points to the existence of functional dependence of export potential on these indicators, without its further formalization. Therefore, it is not possible to practically use the approach.

To forecast exports, Kireiev [32] proposes to use regression equations of supply and demand. Accordingly, the demand for national products of the country is determined on the basis of the sum of weighted by the correction factors of real-world GDP and the export price index. This equation is based on the assumption of the existence of global development cycles. In fact, countries are developing locally: around the "center countries" of production and export of goods are "satellite countries", which have similar economic indicators because of the close trade links between them.

Bogomazova [33] also provides a regression model for estimating export potential, describing the country's exports on the basis of three variables: the nominal exchange rate of the hryvnias against the US dollar, foreign direct investment inflows into Ukraine, and industrial and agricultural growth rates. In our opinion, such a model does not fully characterize the possibilities of forecasting Ukraine's exports, because regression models are quite difficult because the economic situation is changing very quickly.

In assessing the impact of regulatory authorities on the foreign trade of high-tech products in Ukraine, scientists note the possibility of using cause-effect relationships between indicators characterizing the market's business processes and government regulatory instruments that can be quantified [34, 35].

Thus, each of these methodological approaches to assessing the competitiveness of the country, taking into account the export potential of the economy has its own unique features, advantages, and analytical components.

In our opinion, the strength of the methodological approach is Jonson [15], Porter [16] is the use of four components in the technology competitiveness model – national orientation, socio-economic infrastructure, technological infrastructure, and productive potential, as well as the use of high-tech technology indicators to assess their competitiveness. In addition, the authors influence the export of technology (based on research and development, patents, etc.). At the same time, such research requires the processing of a large amount of statistical information, which is often difficult for ordinary researchers to access. In our view, a qualitative analysis based on comprehensive indicators is useful for a comprehensive and sufficiently simple assessment of a country's technological competitiveness.

Scientists and business analysts such as Kagermann [17], Ross [18], Schwab [19], investigated the influence of the factors of the new industrial revolution on the technological competitiveness of the country. At the same time, they came to the conclusion that today, in the context of insufficient statistics on the impact of specific breakthrough technologies on the country's economic development, the best quality indicators of the country's technological competitiveness remain integral indicators, primarily such as Global Competitiveness Index of World Economic Forum, the Global Innovation Index, IMD World Competitiveness Ranking and others.

Another group of scientists (América & Zamora-Torres [24]; Balcerzak [25]; Becker et al. [27]; Fagerberg [23]; Hausmann & Klinger [29]; Hidalgo & Hausmann [30]; Bogomazova [33]; Kireiev [32]; Koval et al. [35]; Melnik [31]; Sushchenko et al. [34]) investigated the impact of trade in technological goods on economic growth and conducted various assessments of the impact of a country's export potential on its technological competitiveness. An analysis of the results of these studies showed that indicators such as the ratio of high-tech exports to GDP of a country, the ratio of the number of employees involved in research and development to the employed population of the country, the ratio of research and development expenditure (R&D expenditure) to the country's GDP, relative (comparative) country advantages by product group and other categories are useful for a comprehensive assessment of a country's export potential. These indicators are often used to assess a country's export potential in a comprehensive manner and to identify the comparative advantages of its exports.

Thus, there is the problem of some combination of these methodological approaches in order to establish a comprehensive and relatively simple methodological approach to assessing a country's technological competitiveness (as in the case of Ukraine), taking into account the impact of the new industrial revolution.

3.2 IDENTIFICATION OF BREAKS IN THE INNOVATIVE DEVELOPMENT OF SOCIO-ECONOMIC SYSTEMS

Presently, in a highly globalized and competitive world, technological change and innovation are the basis of the long-term economic growth of any successful country. As a consequence, the development of economic policy-based countries, based on the development of the scientific, technological, and innovation environment, will contribute to their sustainable economic growth and leveling breaks in the innovative development. At the same time, in the conditions of competition's intensification in foreign and domestic markets for the leading countries of the world, the problem of advanced production technologies' introduction of the XXI century new industrial revolution is substantially aggravated [36].

Taking into account the signing of an association agreement between Ukraine and the EU countries in 2014, which provides cooperation in the innovation and scientific and technical sphere, the development and implementation of Ukraine's innovative potential through the intensification of innovative cooperation with the EU is an urgent direction of the foreign policy strategy.

At this stage of innovative development of socio-economic systems, the European Union is seen as the most successful example of regional economic integration. Today, despite a number of internal crisis phenomena, this integration group is one of the main geo-economic centers of influence in the system of international economic relations. Therefore, in our study the innovative development of the EU-27 countries and Ukraine as the innovative development of socio-economic systems was considered.

By 2030, world-renowned institutions and international industry associations are predicted to be able to launch a revolution in industrial production only by introducing, first and foremost, high-tech industries. The wave of the new industrial revolution will drive the rise of new digital industrial technologies known as Industry 4.0, based on industries such as nanomaterials, 3D printing, genetic engineering, molecular biotechnology, cloud computing, multidimensional modeling, the Internet of Things, and artificial intelligence [37, 38].

This revolution is also connected with the problem of leveling and improving the EU's economic performance. The dynamics of Europe's future development will depend on the quality of its scientific and technological innovations. In this context, EU Member States should develop economic policies to create a science, technology, and innovation environment that will promote sustained economic growth and leveling breaks in the innovative development. Considering the rather ambiguous state of development of Ukraine's high-tech sphere, the problem of assessing factors of formation of technological competitiveness of Ukraine in the face of new challenges for the state in the process of development of relations with the EU.

The root causes of internal fragmentation within the framework of the European integration project are quite multifaceted, and the economic heterogeneity of the EU member states and the unevenness of their development are the fundamental foundations for the formation of various blocs and general internal divergence.

However, the formation of internal alliances or various groups of states, distinguished by disproportions and unequal economic development, different rates of economic growth, a divergent vision of the existing geo-economic and geopolitical problems, to some extent an objective phenomenon in the course of the progressive development of the union, which included the formation, repeated expansion of borders and processes of deepening integration.

Determination of the level and state of development of innovations in Ukraine in the international context, in particular within the framework of integration processes, will be carried out in accordance with international ratings assessing the innovative potential, technological and innovative competitiveness. In this regards, it was studied and analyzed authoritative ratings in the field of determining the innovative potential of the economy of states, namely: the Global Competitiveness Index of World Economic Forum (GCI WEF); the IMD World Competitiveness Ranking (IMD WCR); the IMD World Digital Competitiveness Ranking (IMD WDCR) to assess the country's ability to develop and implement digital technologies; the Global Innovation Index (GII) to study the detailed indicators of innovation activities in the world.

The Global Innovation Index is produced jointly by Cornell University, INSEAD Business School and the World Intellectual Property Organization. In 2019, the Global Innovation Index covered 129 world economies based on 82 indicators, which are distributed in seven areas: institutions, human capital and research, infrastructure, market development, business development, knowledge and technology creation, creativity [39]. Therefore, the dynamics of this index for the EU countries and Ukraine since the signing of the association agreement (2014) was considered (**Table 3.1**).

According to the Global Innovation Index from 28 studied countries, Ukraine ranks 28th in 2014–2017, and 27th in 2018–2019. Also for the period of 2014–2019 there are significant breaks in innovation development among EU countries. The lowest rates were in countries such as Bulgaria, Greece, Croatia, Poland and Romania. The highest rates are in the UK, Sweden, Finland, the Netherlands, Denmark and Germany.

In general, the Global Innovation Index is formed of 7 sub-indices, that explains the reasons for the breaks in innovation development of countries. **Fig. 3.1** presents these sub-indices, and **Table 3.2** presents the data of the given sub-indices for the EU and Ukraine in 2019.

So, in terms of the quality of institutions, Ukraine is in the last 28th place, next to such countries as Bulgaria and Romania. But the leaders in this sub-index are Denmark, the Netherlands, Finland and Sweden. In terms of human capital and research, Ukraine ranks 24th ahead of Bulgaria, Croatia, Romania and Slovakia, and the leaders are Denmark, Germany, Austria, Finland and Sweden. Ukraine's infrastructure is in last place with a huge break over the EU countries, while in Denmark, Ireland, Sweden and the UK, the state of infrastructure is one of the strengths of the state of innovative development. According to the sub-index of market sophistication, Ukraine is on the penultimate place together with Romania and Slovenia, and the best indicator is in Britain and Denmark. In terms of business sophistication, Ukraine is in 25th place ahead of Greece, Romania, Croatia and Slovakia, and Sweden, Finland and the Netherlands took the first positions. Knowledge

and technology outputs is the most powerful sub-index for Ukraine, in which it ranks 18th, ahead of Bulgaria, Croatia, Latvia, Lithuania, Malta, Poland, Portugal, Slovakia and Slovenia. The first positions are also have Sweden, the Netherlands, Ireland and Britain. In terms of creativity, Ukraine is ranked 24th ahead of Greece, Croatia, Romania and Poland, and the leaders are Luxembourg, Malta, the Netherlands and the UK.

Table 3.1 Dynamics of the Global Innovation Index of the EU countries and Ukraine in 2014–2019

Country	2014	2015	2016	2017	2018	2019
Belgium	51.7	50.9	52	49.9	50.5	50.2
Bulgaria	40.7	42.2	41.4	42.8	42.6	40.3
Czechia	50.2	51.3	49.4	51	48.7	49.4
Denmark	57.50	57.7	58.5	58.7	58.4	58.4
Germany	56.00	57.1	57.9	58.4	58	58.2
Estonia	51.5	52.8	51.7	50.9	50.5	50
Ireland	56.70	59.1	59	58.1	57.2	56.1
Greece	38.9	40.3	39.8	38.8	38.9	38.9
Spain	49.3	49.1	49.2	48.8	48.7	47.9
France	52.2	53.6	54	54.2	54.4	54.2
Croatia	40.7	41.7	38.3	39.8	40.7	37.8
Italy	45.7	46.4	47.2	47	46.3	46.3
Cyprus	45.8	43.5	46.3	46.8	47.8	48.3
Latvia	44.8	45.5	44.3	44.6	43.2	43.2
Lithuania	41	42.3	41.8	41.2	41.2	41.5
Luxembourg	56.90	59	57.1	56.4	54.5	53.5
Hungary	44.6	43	44.7	41.7	44.9	44.5
Malta	50.4	50.5	50.4	50.6	50.3	49
Netherlands	60.60	61.6	58.3	63.4	63.3	61.4
Austria	53.4	54.1	52.6	53.1	51.3	50.9
Poland	40.6	40.2	40.2	42	41.7	41.3
Portugal	45.6	46.6	46.4	46.1	45.7	44.6
Romania	38.1	38.2	37.9	39.2	37.6	36.8
Slovenia	47.2	48.5	46	45.8	46.9	45.3
Slovakia	41.9	43	41.7	43.4	42.9	42
Finland	60.70	60	59.9	58.5	59.6	59.8
Sweden	62.3	62.4	63.6	63.8	63.1	63.7
UK	62.4	62.4	61.9	60.9	60.1	61.3
Ukraine	36.3	36.5	35.7	37.6	38.5	37.4

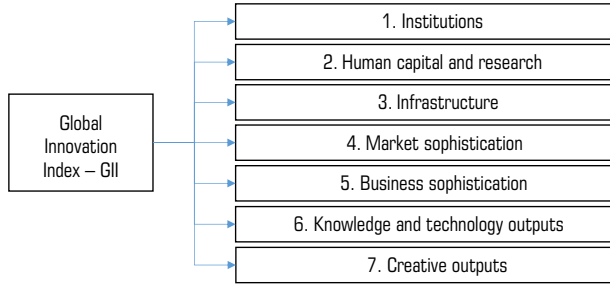

Fig. 3.1 Subindexes of the Global Innovation Index

Table 3.2 Data from the sub-indices of the Global Innovation Index of the EU and Ukraine in 2019

Country	Institutions	Human capital and research	Infrastructure	Market sophistication	Business sophistication	Knowledge and technology outputs	Creative outputs
Belgium	82.0	55.0	57.2	55.3	54.1	40.8	38.5
Bulgaria	68.3	30.6	53.7	47.5	40.3	31.4	33.8
Czechia	78.6	43.4	56.4	52.4	46.3	43.8	43.1
Denmark	91.7	63.1	65.8	66.9	59.1	46.4	48.6
Germany	86.4	63.2	62.0	58.6	56.1	52.7	49.6
Estonia	81.7	42.1	61.5	52.6	42.6	36.0	51.7
Ireland	85.5	48.4	66.3	54.6	55.8	56.9	43.3
Greece	67.2	49.5	51.7	50.3	32.4	25.1	30.1
Spain	78.1	47.0	63.1	59.5	38.7	37.2	39.7
France	83.2	55.8	62.3	62.9	53.3	45.0	45.0
Croatia	69.3	35.6	51.6	46.0	34.3	25.6	31.0
Italy	75.3	45.4	59.4	51.4	42.2	38.9	36.8
Cyprus	80.3	35.8	55.9	58.2	47.6	41.2	41.1
Latvia	77.2	36.9	50.5	54.4	37.4	27.5	42.8
Lithuania	76.0	36.3	51.7	50.9	38.0	24.4	40.3
Luxembourg	80.7	41.7	58.7	46.9	60.7	42.2	56.2
Hungary	71.6	41.0	52.7	45.7	40.8	42.8	34.6
Malta	75.2	36.6	61.1	45.2	54.9	31.9	55.0
Netherlands	90.9	52.4	61.8	58.2	63.7	61.8	53.2
Austria	86.0	60.2	61.4	52.8	53.8	36.7	41.4
Poland	73.6	41.2	53.8	47.9	38.4	30.9	32.4
Portugal	81.8	47.7	56.8	49.8	37.3	29.8	39.4
Romania	67.1	29.1	54.5	43.2	33.6	30.3	25.8
Slovenia	82.3	46.6	53.9	43.6	44.1	30.7	42.1
Slovakia	73.1	32.4	54.2	47.4	35.6	34.0	37.1
Finland	93.6	63.4	62.1	57.3	63.9	55.1	48.1
Sweden	90.1	62.1	69.1	62.1	68.8	61.8	51.9
UK	87.1	59.3	64.4	76.0	54.3	56.6	52.2
Ukraine	53.9	35.6	36.0	43.3	34.8	34.6	33.5

Thus, the quality of institutions is not Ukraine's strength as an innovator and is significantly behind all EU countries. Human capital is the driving force in development of innovation in Ukraine, but it requires increased attention from the public and private sectors, as the country may lose one of its strongest competitive advantages. It can be said that the state of infrastructure development remains at a frankly low level. Speaking about the level of market sophistication in Ukraine, it is advisable to note that Ukraine remained at the level of 2014 and ranks 27th among all the studied economies of the EU countries. Ukraine has improved the indicator of business sophistication. It can also be seen that Ukraine has the highest position among all other sub-indices in terms of knowledge and technology outputs, which shows that the country's scientific and educational potential, knowledge of the population are the biggest advantages of Ukraine, which currently ensure the country's competitiveness in innovation. In terms of creativity, Ukraine has also significantly improved its position in recent years.

While comparing the state of innovative development with other countries of the world according to the Global Innovation Index, it can be admitted that the breaks in the innovative development of Ukraine are the following: in 2014 it ranked 63rd among 143 countries of the world with an indicator of 36.26; 2015 – 64th place (36.45) among 141 countries; 2016 – fifty-sixth place (35.52) among 128 countries; 2017 – 50th place (37.62) among 127 countries; 2018 – 43rd place (38.52) among 126 countries; 2019 – 47th place (37.40) among 129 countries; 2020 – 45th place (36.32) among 131 countries of the world [5].

So, the world has entered an era of cardinal socio-economic changes caused by a new technological revolution, associated with a number of significant technological innovations. Currently, the real practice of the implementation of the Agreement during 2015–2020 found a very insignificant impact of European integration measures on the acceleration of technological progress in the Ukrainian economy, significantly lags behind in scientific and technological development from the leading countries of the world – as evidenced by international rankings and significant breaks in innovative development both among the EU countries and for Ukraine.

3.3 METHODS FOR LEVELING BREAKS IN THE INNOVATIVE DEVELOPMENT OF SOCIO-ECONOMIC SYSTEMS

For leveling breaks in the innovative development of socio-economic systems on the example of Ukraine and to accelerate European integration processes, it is necessary to develop an approach to determine the impact of selected factors on individual indicators of innovation development.

The study proposes a method for leveling breaks in the innovative development of the country, which includes three stages:

I. Qualitative analysis of four international integral indicators, namely:

– the Global Competitiveness Index of World Economic Forum (GCI WEF), including indicator of technological readiness (9th pillar: Technological readiness) and indicator of innovation (12th pillar: Innovation);

– the IMD World Competitiveness Ranking (IMD WCR), in particular indicator of infrastructure;

– the IMD World Digital Competitiveness Ranking (IMD WDCR) to assess the country's ability to develop and implement digital technologies;

– the Global Innovation Index (GII) to study the detailed indicators of innovation activities in the world.

II. Positioning the country in a European competitive environment through *cluster analysis*.

III. Modeling the relationship between indices and factors of innovative development based on *correlation and regression analysis*.

The correlation analysis is used to determine and study the relationship between the indicators studied and to establish the relative degree of dependence of the performance indicator on each factor.

The main purpose of multiple regression analysis is to consider the relationships between a dependent variable and several independent variables. It is necessary to analyze the relationship between the resulting variable and the many factors, and then to identify the factors that most influence the outcome. This analysis can predict the value of a finite variable depending on the values of certain factors.

The forecast linear equation that estimates the multiple regression model that will be used (3.1):

$$Y = a + b_1 \times X_1 + b_2 \times X_2 + b_3 \times X_3 + \ldots + b_n \times X_n, \quad (3.1)$$

Y is the dependent variable, what is being predicted or explained; X_1, X_2, X_3, X_n are the independent variables, that are explaining the variance in Y; 'a' is the constant or value of function with zero value of all factors; b_1, b_2, b_3, b_n are the regression coefficients.

R_2 will be used to describe the precision of the process model. If the value exceeds 0.7, the model is considered reliable.

Aiming to find out how Ukraine's innovative development has changed since the signing of the association agreement with the EU, Ukraine and the 27 EU countries were chosen as a model for the study.

The research period is 2011–2019, because 2011 (according to the world's leading experts) was the beginning of a period of economic recovery in the leading economies after the global financial crisis of 2008–2009. It was also in 2011 that they first began to speak of a new industrial revolution, the main factors of which were having a growing impact on breaks in the innovative development of the world's leading economies, particularly those of the European Union, and associated countries.

3.4 RESEARCH RESULT

The research result is the identification of the main ways to leveling breaks in the innovative development of Ukraine.

Positioning the country in a European competitive environment through cluster analysis on all 10 indicators of the European Innovation Scoreboard (EIS) for the EU-27 and Ukraine (**Table 3.3**).

The result of clustering is shown in **Fig. 3.2**, where 7 clusters with a threshold value of 310 were identified and presented in **Table 3.4** [40, 41].

Table 3.3 Source data for the cluster analysis on the main indicators of the European Union Innovation Scoreboard for EU and Ukraine

Country	Human resources	Attractive research systems	Innovation-friendly environment	Finance and support	Firm investments	Innovators	Linkages	Intellectual assets	Employment impacts	Sales impacts
Ukraine	53.40	17.27	169.63	11.30	45.13	20.18	37.55	20.90	86.86	35.15
Slovakia	94.30	56.38	87.32	28.29	82.73	37.25	63.03	39.85	140.54	114.23
Slovenia	127.30	100.95	143.03	36.57	134.66	61.36	116.25	81.94	105.27	67.73
Sweden	216.98	210.95	310.18	141.05	175.53	103.43	154.93	122.64	167.78	89.22
Romania	13.64	32.77	112.94	48.11	10.57	0.00	40.48	23.78	45.19	62.07
Portugal	105.07	135.20	227.24	96.22	124.46	156.33	64.92	70.80	96.15	55.42
Poland	75.36	36.65	211.02	46.81	95.84	14.31	40.68	65.84	106.15	55.67
Netherlands	175.53	220.98	280.54	139.01	98.20	112.24	159.42	105.23	138.59	93.71
Malta	88.73	87.58	233.14	106.98	105.75	53.20	17.10	128.61	187.23	59.02
Latvia	75.99	52.51	138.30	126.72	73.84	35.70	56.34	59.09	100.25	50.82
Luxembourg	177.95	236.20	236.20	122.67	81.91	126.84	90.16	141.04	189.20	84.75
Lithuania	119.47	54.29	187.53	97.67	101.13	98.82	108.96	52.43	64.72	53.17
Italy	61.45	111.14	121.18	65.21	94.88	116.85	69.05	96.18	87.01	80.36
Ireland	175.23	171.08	149.53	83.10	113.90	118.67	84.10	53.36	200.86	128.70
Hungary	51.48	66.76	144.47	53.39	106.56	30.39	60.65	44.50	150.19	84.68
Croatia	65.70	50.24	71.37	44.83	117.94	85.99	67.50	32.81	80.89	38.29
France	159.41	140.94	143.14	159.11	108.90	113.97	103.08	78.89	93.00	88.67
Finland	198.53	173.53	321.58	158.75	168.70	153.29	167.92	118.73	93.54	90.08
Spain	177.85	105.21	197.25	90.40	83.58	40.92	67.93	70.12	114.85	83.96
Greece	92.69	77.99	76.73	61.50	85.37	130.97	129.70	39.13	57.37	67.58
Estonia	140.54	121.60	137.96	104.89	123.33	95.05	133.79	112.74	79.11	66.43
Denmark	206.89	224.56	329.62	167.89	139.59	86.59	154.14	137.40	118.34	73.85
Germany	108.73	105.35	169.76	138.36	190.03	122.38	139.59	119.78	113.88	119.12
Czechia	84.42	83.72	121.55	66.78	121.71	86.72	92.67	51.69	148.78	94.68
Cyprus	118.76	145.25	140.13	86.90	101.07	73.55	61.41	98.03	75.62	98.49
Bulgaria	60.08	29.42	74.59	13.45	52.91	23.97	35.59	77.89	120.10	40.26
Belgium	133.53	190.72	158.14	131.08	158.96	133.63	168.53	81.73	95.46	103.90
Austria	143.26	167.85	130.65	109.55	127.20	135.09	187.75	126.30	75.42	83.94

Source: the study based on [5]

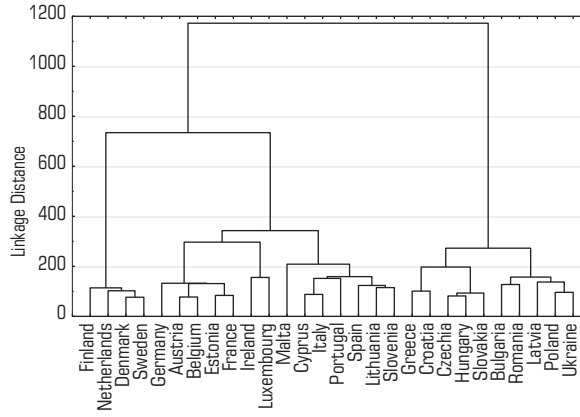

Fig. 3.2 Dendrogram of the EU countries and Ukraine according to EIS 2019 indicators
Source: own calculations based on [40]

Table 3.4 The composition of the selected clusters of the EU countries and Ukraine according to the indicators of the European innovation scoreboard (EIS) 2019

Cluster	Countries
Cluster 1	Finland, Netherlands, Denmark, Sweden
Cluster 2	Belgium, Germany, Austria, France, Estonia
Cluster 3	Ireland, Luxembourg
Cluster 4	Malta
Cluster 5	Cyprus, Italy, Portugal, Slovenia, Lithuania, Spain
Cluster 6	Croatia, Greece, Czech Republic, Hungary, Slovakia
Cluster 7	Ukraine, Romania, Poland, Bulgaria, Latvia

Source: own calculations based on [40]

Ukraine is a part of cluster 7 (**Fig. 3.3**) that is far behind the others. The most problematic indicators are "Attractive research system" and "Innovators". If the average EU is 136.6 and 95.9, then for the cluster 7, these indicators will be 33.7 and 18.8 respectively. Some advantages countries of cluster 7 have only in indicators of "Innovation-friendly environment" (141.3) and "Employment impacts" (91.7), reflecting general trends in Ukraine. Thus, the cluster analysis showed that Ukraine is now in a single cluster with countries, such as Bulgaria, Romania, Poland, and Latvia, which have not yet fully been able to adapt their economies to the level of technological and innovative competitiveness of the leading countries.

Among countries in cluster 7, Poland and Latvia have the most innovative development. Their strengths include "Innovation-friendly environment", "Employment impacts", "Firm investments", and "Human resources" indicators (**Table 3.3**). In Bulgaria, "Intellectual assets" (at the level of Belgium

and France) and "Employment impacts" (the highest level among the cluster, which is equal to the same indicator for countries such as Germany and Denmark) are among the greatest advantages of innovative development. Ukraine is the second-to-last cluster country. Romania has the lowest indicators among the EU-27 countries for the components of the "European Union Innovation Scoreboard" like "Human resources", "Attractive research systems", "Firm investments", "Innovators", "Intellectual assets", "Employment impacts". But the available results show that Ukraine has some strengths in the European competitive environment, such as innovation-friendly environment and labor.

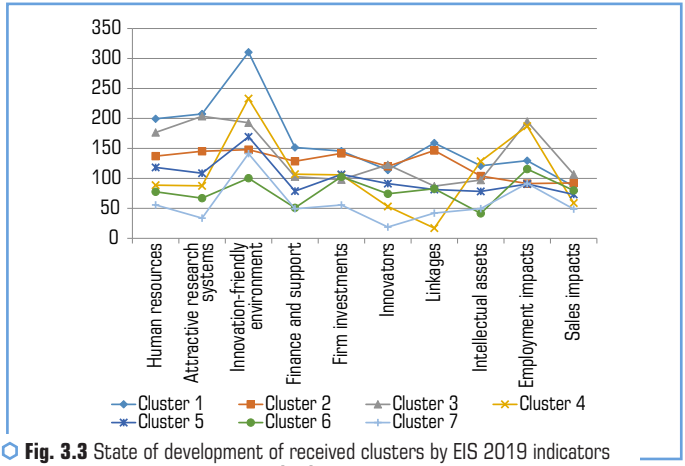

Fig. 3.3 State of development of received clusters by EIS 2019 indicators
Source: own calculations based on [40]

For deeper conclusions, further analysis was made of the state of infrastructure development (**Fig. 3.4**). Compared to other countries in the cluster, Ukraine has the lowest level of infrastructure development in the cluster. Poland and Bulgaria are leading on this indicator.

To assess the degree of influence of chosen factors on the indices that determine the breaks in the innovative development of Ukraine, it was used the method of correlation and regression analysis based on the main indicators of the GCI WEF (including Technological readiness and Innovation), the IMD WDCR, the GII and our own calculations.

The chosen factors (independent variables X1–X12) can be divided into the following categories, **Table 3.5**:

1. Conditions for creating educational and institutional capacity: expenditure on education (X1), the number of graduates in science and technology (X2), quality of research institutions (X3), the ratio of the number of employees involved in research and development to the employed population (X4).

2. Innovation financing: the ratio of R&D expenditure to the country's GDP (X5), FDI inflows (X6).

3. Innovative infrastructure: access to ICT (X7), state of cluster development (X8).

4. The economic effect of innovation: the ratio of exports of high-tech products to industrial exports (X9), the ICT services exports (X10), the number of PCT patents (X11), income from intellectual property use (X12).

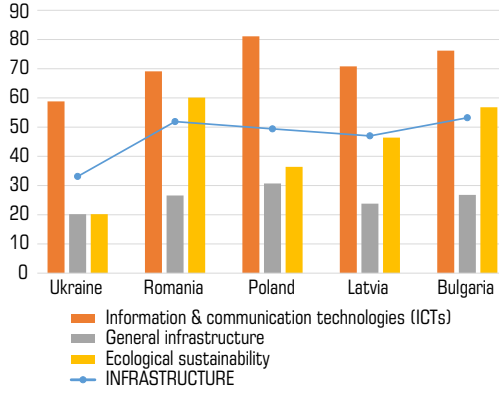

Fig. 3.4 State of development of Infrastructure in the countries of the seventh cluster by GII 2020 indicators
Source: the study based on [42]

Table 3.5 Source data for correlation between chosen factors and indices that determine the breaks in the innovative development of Ukraine

Year	Expenditure on education, % of GDP	Graduates in science and technology, %	Quality of scientific research institutions	Ratio of employees involved in R&D to the employed population, %	Ratio of R&D expenditures to GDP, %	FDI inflows (% of GDP)	ICT access	State of cluster development	Ratio of high-tech products export to industrial exports, %	ICT services exports, % of total exports of services	PCT patents applications, million pop.	Income from the intellectual property use, million $
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
2011	5.9	26.3	3.6	0.947	0.738	4.417	47.9	28.6	3.277	17.923	0.3	107
2012	5.9	26.3	3.7	0.877	0.754	4.651	48.6	35.4	4.737	19.34	2.1	124
2013	6.2	25.6	3.6	0.822	0.759	2.46	52.7	31.17	4.134	22.204	2.9	167
2014	6.7	25.6	3.8	0.792	0.649	0.634	61.6	33.3	4.129	30.482	3.2	118
2015	6.7	25.5	4.2	0.778	0.617	3.351	62.7	32.5	3.994	31.442	3.6	85
2016	6	25.5	4.2	0.627	0.700	3.689	64.8	32.5	3.295	31.756	3.9	73
2017	5.9	26.7	3.9	0.608	0.600	2.165	66	35.5	2.795	33.513	3.6	72
2018	5.9	26.7	3.9	0.600	0.600	2.6	66	35.5	2.900	31.3	3.7	74
2019	5	24.2	3.5	1.100	0.4	3.2	66.5	37.3	2	31.7	3.9	74

As dependent variables (Y1–Y5), the indices that reflect the competitiveness of Ukraine were selected, namely the GCI WEF (Y1) and its main indicators, such as "Technological readiness" (Y2) and "Innovation" (Y3); GII (Y4) and the IMD WDCR (Y5) (**Table 3.6**).

Table 3.6 Results of calculation of variables (Y1–Y5)

Year	Global Competitiveness Index	Technological readiness (GCI)	Innovation (GCI)	Global Innovation Index	World Digital Competitiveness Ranking
	Y1	Y2	Y3	Y4	Y5
2011	4.000	3.74	3.1	35.00	–
2012	4.140	3.6	3.2	36.10	–
2013	4.050	3.28	3.0	35.80	54
2014	4.140	3.5	3.2	36.30	50
2015	4.030	3.45	3.4	36.45	59
2016	4.000	3.58	3.4	35.72	59
2017	4.110	3.8	3.4	37.62	60
2018	4.010	3.84	3.4	43.00	58
2019	4.120	3.9	3.5	47.00	60

Source: own calculations based on [8–10]

Based on the Table of initial data for the indicated indicators in the period 2011–2019 years, a correlation analysis was carried out, the results of which are presented in **Table 3.7**.

The data given in **Table 3.7** show that the GCI WEF of Ukraine has basically a very weak link with such factors as the number of graduates in science and technology, expenditure on education, the quality of research institutions, the ratio of R&D expenditures to GDP, and FDI inflows. The GCI WEF is closely related to only one indicator of state of cluster development (0.594), and has little in common indicators such as ICT access, ICT services exports and education expenditure.

The link between technological development and the chosen factors is weak or moderate. There is a strong correlation between this index and expenditure on education (–0.729) and income from intellectual property use (–0.730), state of cluster development (0.516), the ratio of R&D expenditure to GDP (–0.624) and access to ICT (–0.371).

The link of innovation potential to the factors selected is mostly either strong, very weak or almost non-existent. Thus, indicators such as access to ICT (0.844), income from intellectual property use (–0.909), export of ICT services (0.802), number of PCT patents (0.703) and ratio of R&D expenditure to GDP have a significant link with Ukraine's innovation potential (–0,755).

The correlation between the GII and the factors shows that the link between them is mostly moderate or strong. The three main factors are the ratio of R&D expenditure to GDP (–0.879 –

a very close link), state of cluster development (–0.727) and the ratio of high-technology exports to industrial exports (–0.743).

Table 3.7 Correlation between chosen factors and indices that determine the breaks in the innovative development of Ukraine

Factors	Global Competitiveness Index	Technological readiness (GCI)	Innovation (GCI)	Global Innovation Index	World Digital Competitiveness Ranking
Expenditure on education, % of GDP	–0.12381	–0.729	–0.37023	–0.70557	–0.57762
Graduates in science and technology, %	–0.19581	0.0893	–0.30045	–0.41941	–0.01487
Quality of scientific research institutions	–0.40208	–0.203	0.477786	–0.30827	0.268272
Ratio of employees involved in R&D to the employed population, %	0.324322	0.096	–0.19326	0.288689	–0.05928
Ratio of R&D expenditures to GDP, %	–0.2739	–0.623	–0.75517	–0.87914	–0.47486
FDI inflows, % of GDP	–0.33551	0.165	0.033029	–0.10409	0.802082
ICT access	0.015384	0.371	0.843931	0.565446	0.604922
State of cluster development	0.593752	0.516	0.594049	0.726723	0.475249
Ratio of high-tech products export to industrial exports, %	0.146648	–0.789	–0.6702	–0.74305	–0.6957
ICT services exports, % of total exports of services	0.063871	0.270	0.80242	0.447864	0.514709
PCT patents applications, million pop.	0.146025	0.040	0.702985	0.470915	0.787447
Income from the intellectual property use, million $	0.172407	–0.730	–0.90995	–0.47957	–0.73414

Source: own calculations based on [43–45]

The IMD WDCR has the greatest connection with indicators such as FDI inflows (0.802), the number of PCT patents (0.787), and income from intellectual property use (–0.734).

To complete the study, a multiple regression analysis was conducted based on the factors the correlation with which the correlation was strongest.

On the basis of the multiple regression analysis of the modeling and prediction of changes in the values of the main indices that determine the global and technological competitiveness of Ukraine, it has been possible to establish the following.

The coefficient of determination is insignificant (R^2=0.5592), so the reliability of the model is very low and the results of regression analysis on this factor indicate that there is no link between the Global Competitiveness Index and the selected factors (**Table 3.8**).

Table 3.8 Source data for multiple regression analysis between the Global Competitiveness Index (GCI WEF) and selected factors

Year	Global Competitiveness Index	State of cluster development	FDI inflows (% of GDP)	Ratio of high-tech products export to industrial exports, %
	Y1	X1	X2	X3
2011	4.000	28.6	4.417	3.277
2012	4.140	35.4	4.651	4.737
2013	4.050	31.17	2.46	4.134
2014	4.140	33.3	0.634	4.129
2015	4.030	32.5	3.351	3.994
2016	4.000	32.5	3.689	3.295
2017	4.110	35.5	2.165	2.795
2018	4.010	35.5	2.6	2.900
2019	4.120	37.3	3.2	2.000
Results of multiple regression analysis between the Global Competitiveness Index (GCI WEF) and selected factors				
Multiple R			0.747846	
R^2			0.559273	
F			2.114964	
Significance F			0.216959	
Y			3.461275	
X1			0.015957	
X2			–0.01125	
X3			0.030031	

Source: own calculations based on [43]

$$Y = 2.5351 + 0.0707 \times X_2.$$

The increase in the number of graduates in science and technology by 1 % will increase the index of technological development (in the GCI WEF) at 0.0707; $R^2 = 0.752202$ (**Table 3.9**).

$$Y = 3.1108 + 0.0006 \times X_1 - 0.033 \times X_3.$$

Improving the quality of research institutions by 1 point will increase the index of innovation potential (in the GCI WEF) to 0.0006. Increasing the revenues from the use of intellectual property for $1 million will reduce the index of innovation potential by 0.033; $R^2 = 0.893797$ (**Table 3.10**).

Table 3.9 Source data for multiple regression analysis between Technological Readiness (composed of GCI WEF) and selected factors

Year	Technological readiness (GCI)	Ratio of high-tech products export to industrial exports, %	Graduates in science and technology, %	Income from the intellectual property use, million $
	Y2	X1	X2	X3
2011	3.74	3.277	26.3	107
2012	3.6	4.737	26.3	124
2013	3.28	4.134	25.6	167
2014	3.5	4.129	25.6	118
2015	3.45	3.994	25.5	85
2016	3.58	3.295	25.5	73
2017	3.8	2.795	26.7	72
2018	3.84	2.900	26.7	74
2019	3.9	2.000	24.2	74

Results of multiple regression analysis between Technological Readiness (composed of GCI WEF) and selected factors	
Multiple R	0.867296
R^2	0.752202
F	5.059245
Significance F	0.056462
Y	2.535193
X1	–0.1627
X2	0.070742
X3	–0.00166

Source: own calculations based on [43]

Table 3.10 Source data for multiple regression analysis between Innovation (GCI WEF) and selected factors

Year	Innovation (GCI)	Quality of scientific research institutions	ICT access	Income from the intellectual property use, million $
	Y3	X1	X2	X3
2011	3.1	3.6	47.9	107
2012	3.2	3.7	48.6	124
2013	3.0	3.6	52.7	167
2014	3.2	3.8	61.6	118
2015	3.4	4.2	62.7	85
2016	3.4	4.2	64.8	73
2017	3.4	3.9	66	72
2018	3.4	3.9	66	74
2019	3.5	3.5	66.5	74
Results of multiple regression analysis between Innovation (GCI WEF) and selected factors				
Multiple R			0.945408	
R^2			0.893797	
F			14.02652	
Significance F			0.007198	
Y			3.110847	
X1			0.000642	
X2			0.008395	
X3			–0.0033	

Source: own calculations based on [43, 44]

$$Y = 50.8041 + 0.4271 \times X_2.$$

Increasing the level of cluster development by 1 point will increase the GII by 0.4271; $R^2 = 0.924411$ (**Table 3.11**).

$$Y = 51.52405 + 2.106391 \times X_1 - 1.71027 \times X_2 + 1.651747 \times X_3.$$

An increase of 1 % in FDI inflows would result in an increase of 2,106391 points in the IMD WDCR. An increase of 1 % in exports of high-tech products to industrial exports would result in an increase of 1.71027 points in the IMD WDCR, and an increase in the number of PCT patents would result in an increase of 1.651747 points in the IMD WDCR; $R^2 = 0.840884$ (**Table 3.12**).

Table 3.11 Source data for multiple regression analysis between Global Innovation Index (GII) and selected factors

Year	Global Innovation Index	Ratio of R&D expenditures to GDP, %	State of cluster development	ICT services exports, % of total exports of services
	Y4	X1	X2	X3
2011	35.00	0.738	28.6	17.923
2012	36.10	0.754	35.4	19.34
2013	35.80	0.759	31.17	22.204
2014	36.30	0.649	33.3	30.482
2015	36.45	0.617	32.5	31.442
2016	35.72	0.700	32.5	31.756
2017	37.62	0.600	35.5	33.513
2018	43.00	0.600	35.5	31.3
2019	47.00	0.4	37.3	31.7
Results of multiple regression analysis between Global Innovation Index (GII) and selected factors				
Multiple R			0.924411	
R^2			0.854537	
F			9.790969	
Significance F			0.015561	
Y			50.80415	
X1			–32.7322	
X2			0.4271	
X3			–0.21111	

Source: own calculations based on [9]

Table 3.12 Source data for multiple regression analysis between the Digital Competitiveness Index (IMD WDCR) and selected factors

Year	World Digital Competitiveness Ranking	FDI inflows (% of GDP)	Ratio of high-tech products export to industrial exports, %	PCT patents applications/million pop.
	Y5	X1	X2	X3
2013	54	2.46	4.134	2.9
2014	50	0.634	4.129	3.2
2015	59	3.351	3.994	3.6
2016	59	3.689	3.295	3.9
2017	60	2.165	2.795	3.6
2018	58	2.6	2.900	3.7
2019	60	3.2	2	3.9
Results of multiple regression analysis between the Digital Competitiveness Index (IMD WDCR) and selected factors				
Multiple R			0.916997	
R^2			0.840884	
F			5.284739	
Significance F			0.102451	
Y			51.52405	
X1			2.106491	
X2			–1.71027	
X3			1.651747	

Source: own calculations based on [10]

Correlation analysis has showed the importance of taking into account the impact of chosen factors on the level of innovative development of Ukraine. The presented method can be applied in leveling breaks in the innovative development of Ukraine at the stage of activation of EU integration processes.

3.5 MANAGEMENT OF BREAKS IN THE INNOVATIVE DEVELOPMENT OF SOCIO-ECONOMIC SYSTEMS

Further process of Ukraine's integration into the EU economic space is a priority path of development. In order to achieve its most effective scenario, it is necessary to develop

a clear management of breaks in the innovative development of socio-economic systems on the example of Ukraine.

Weaknesses of Ukraine's innovative development are: the country's economy, which plays the role of a resource donor and takes a negligible part as a subcontractor in the scientific and technical sphere; lack of a unified and clear system of state support for entrepreneurship; low level of investment in research and development, especially in enterprises; rising unemployment; the innovative potential of regions to attract foreign capital is used too poorly; the development of science takes place separately from economic needs; low level of cooperation between the science sector and business, which is not yet strategic; the problem of fragmentation of entrepreneurship, which results in the complexity of major innovation projects; most businesses are focused on survival rather than the development and implementation of innovation strategies; the results of research activities are poorly confirmed by foreign publications and patents; low level of innovation culture of societies; educational programs in higher educational institutions are not sufficiently adapted to the needs of the labour market; a small share of business entities in international competitions and programs [46, 47].

Thus, the main goals of break management in the innovative development of Ukraine are to increase innovation activity and improve the results of innovation.

To achieve these goals, the management system should: be based on the ability to predict the consequences of the implementation of decisions and on this basis to adjust management actions taking into account the situation; be multivariate, nonlinear and situational, so that it is possible to compare management actions with trends in the socio-economic environment.

Given the priority role of industry in ensuring and regulating innovation development, the main directions of state policy of innovation development at the present stage should be: determining the main directions of innovation breakthrough based on a comprehensive analysis of global trends, technological forecasting and careful analysis of existing innovation potential; providing favourable conditions for technological modernization of the production base of enterprises, increasing innovation efficiency and investment attractiveness of production; adoption of the concept of partnership of the state, scientific community in achievement of parameters of the state branch programs and projects of formation of the internal market of consumption of food and expert potential of science-intensive production; creation of an effective infrastructure for the generation of scientific knowledge and the implementation of innovative processes aimed at forming a market for science-intensive products in accordance with consumer demand; increasing the role of regions in the development of innovation processes, methods of promoting innovation. Therefore, at the state level it is necessary to ensure the formation of regulatory framework and information and analytical support of the market, monitoring and forecasting of market conditions, strict control over product safety and implementation of European product quality standards. In modern conditions, the innovative development of production enterprises is possible only on the basis of an appropriate model, which should take into account the regional characteristics of production and opportunities for innovative development.

The formation of an innovative model of production development is a systemic problem and requires a comprehensive solution to a number of problems: gradual increase in funding for regional production science from all sources to promote the transformation of priority industries in the region in high-tech developments and effective investment policy; increasing the effectiveness of regional-branch science and creating a powerful package of competitive innovations (modern technical complexes adapted to the conditions of a particular region); formation of economic mechanisms to stimulate demand for innovative products, preferential lending of resources and credit support, preferential taxation of innovative projects; increasing the level of capitalization of intellectual property through the introduction of its objects into economic circulation and further use of the obtained results to finance research and development; creation of a flexible modern regional innovation infrastructure capable, together with the relevant national infrastructure, of providing a rapid transition from basic and applied research to the practical application of their results.

In addition, in the process of managing breaks in innovation development in Ukraine, it is necessary to create a clearly defined concept of further innovation development and economic security and focus on creating a favourable business environment, harmonizing the government system, reducing the class break, eradicating corruption and attracting new investment [48].

Due to this, the urgent task is a scientifically sound study of break management systems, its organizational structures, mechanisms that ensure the balance of the management system and meet modern market needs. Understanding the conceptual essence of management as a complex system will make it possible to solve problems of optimization of management processes, increase their efficiency.

Too large a list of objects related to the management of breaks in the innovative development of Ukraine, makes us think about the question, what unites all these objects, on what influences depends on their innovative development, what are the differences in their properties. Such parameters in terms of a systems approach are: structure, interaction with the environment, goals and objectives of management. Based on this, it is possible to select the following control objects:

1. Since the socio-economic system is based on human activities, the decomposition of the socio-economic system to lower levels of the system we get as one of the components – man, i.e. in management it is necessary to influence people, therefore, use appropriate approaches, principles and methods. Therefore, to build an innovative model of economic development requires special attention to the development of human capital as the foundation of society.

2. Since we are talking about management, the methods and approaches of general management theory can be used to manage breaks in the innovative development of the socio-economic system.

3. Improving the results of innovative development includes elements of the economy, so when managing breaks in the innovative development of socio-economic systems using methods used in economic fields of science. This management system should encourage the subjects of the national economy to innovate and invest in innovation in order to increase the supply of innovative products, technologies and knowledge.

4. The concept of innovative development and economic security, creating a favourable business environment, eradicating corruption and attracting new investment is a complex large system,

characterized by a large number and variety of its constituent elements. A large system is usually characterized by numerical management arrays, which should help diversify the organizational forms of the national economy, ensure cooperation of small, medium and large enterprises, support leading large enterprises and associations that can implement national innovation priorities, development of research and production cooperation, industrial and financial integration.

5. A complex system is characterized by the fact that the control object usually behaves anti-intuitively, there is no mathematical description of the operator of the control object, because it is non-stationary and can be difficult to identify. Usually, the patterns of behaviour of the system are determined by its structure and characteristics of the elements, as well as the conditions of operation.

Thus, attempts to determine the patterns of development of socio-economic systems, which can be described by mathematical models, have scientifically sound prerequisites. Currently, a fairly large number of economic laws of development and behaviour of socio-economic systems of different levels. Based on the system and process scientific approaches in [49] proposed a methodical approach to modelling the process of supporting transformational management decisions, based on a kind of management tools – a bank of methods and models that allows to prepare, make and maintain management decisions based on model building transformation in accordance with the situation at the facility.

Management of breaks in the innovative development of socio-economic systems is an organized management [50], which focuses on the rapid disclosure of obstacles to innovation and the formation of prerequisites for continuous monitoring and their timely overcoming to restore the viability of businesses on an innovative basis.

The process of managing breaks in innovation development involves: analysis of the state of the macro- and micro-environment and the choice of the best strategy for the socio-economic system; disclosure of economic measures, management actions to identify obstacles to innovative development, the formation of a system for monitoring the environment of economic entities to identify breaks; strategic controlling of innovation activity of social and economic systems; prompt assessment and analysis of the financial condition of economic entities in order to identify the possibility of curtailing the innovation process; policy development in the conditions of curtailment of the innovation process and removal of business entities from this state; constant accounting of innovation risk and development of measures to reduce it.

The classification of strategies of innovative development of economy, which includes diffusion of innovations, the state support of innovative forms, the local innovative environment, intersectoral scientific and technical clusters, commodity cloning, license copying, self-development, strategy of advanced development, strategy of sustainable development, strategy of local development is resulted in work [51] and their characteristics will allow using methods of break management in the innovative development of socio-economic systems to establish cooperation between all participants in the innovation process, which promote innovation at all stages of creating and bringing an innovative product to market and solve the problem of building an innovative economy with developed entrepreneurship, innovation and high productivity in the areas [52].

This will make it possible to address the issue of creating innovations in these areas, namely: to increase funding for research on a competitive basis, focusing on the transition of results obtained in basic research in the field of applied research and scientific and technical development, to finance which business is involved; to review the priority directions of development of science and technology in order to bring them closer to the directions identified in the developed countries of the world, on the basis of modern world technological trends; to create within the settlements places intended primarily for the development of intellectual, creative activity, innovation movement, development of creative industries (including the allocation of territories, the creation of appropriate infrastructure, providing information-analytical and methodological support for innovation culture); to create, with the involvement of world experts, trainers, mentors, the European Entrepreneurship Network (EEN), schools of exchange of experience and national resources for entrepreneurship and innovation training, including in-service training networks for both teachers and heads of higher education and research institutions; improve the quality of education by bringing it closer to the needs of the global market and the needs of professionals capable of creating, adapting and using technological innovations, supporting the implementation of disciplines in entrepreneurship, financial literacy and intellectual property protection.

Taking into account the data obtained at each stage of the study, the results of calculations and correlation-regression analysis, the following recommendations can be made for managing breaks in the country's innovative development in the framework of EU association and transformation: development of an effective and clear strategy increase financial support for innovation and modernization of Ukrainian industries in order to increase the competitiveness of Ukrainian goods in the markets of the countries under consideration and diversify mutual trade, increase R&D expenditures and research funding to increase Ukraine's innovative development and attractiveness for cooperation in this field, development and implementation of joint educational programs, research and technical projects, etc.

CONCLUSIONS

The analysis of world rankings has shown that innovative competitiveness of Ukraine is determined by comparative factor advantages in coverage of higher education, availability of scientific staff and quality of research institutions, but breaks in the innovative development are caused by low state support, lack of stability and problems in institutional development hamper the country's innovative potential.

Ukraine remains predominantly an importer in the global market of high-tech products, because its foreign trade in high-tech products is characterized by low share of these products in total exports of the country and a significant trade deficit. It has only small comparative advantages in the markets of foreign countries in such high-tech products, as aircrafts, space crafts and their parts.

The conducted cluster analysis indicates that Ukraine is now in the same cluster with the countries Bulgaria, Romania, Poland, and Latvia that have not yet fully adapted their economies to the level of innovative development of the leaders of the countries. The strengths of Ukraine in the European competitive environment include innovation-friendly environment and labor.

Thus, the modeling and forecasting of the development of the main indices, which determine breaks in the innovative development of Ukraine, showed and made possible the following authors' recommendations for leveling these breaks:

1. It is required to ensure an increase in the number of such graduates by creating and improving research centers at the universities.

2. It is required to diagnose operation quality of research institutions, develop strategies for their improvement and achieving adequate state funding for science. The country needs the development of intellectual property legislation and support for small and medium-sized enterprises, which are the driving force behind the country's innovation activity.

3. It is required to develop a program of innovative industrial clusters, which provide for a system of incentives for participants and related fringe benefits and improve the mechanisms of state financial support of cluster development.

4. Ukraine should improve its investment climate. The state support is required for the development of high-tech industries and increase in the volume of those types of production, which revealed comparative advantage. It is necessary to increase the funding of science and development (grants, patents, etc.).

In addition, for leveling breaks in the innovative development of Ukraine, it is also necessary to:

a) increase both foreign investment and state financing by improving the country's investment climate, increasing the availability of credit resources for high-tech enterprises and creating special lending programs;

b) a broad reform of governance and basic institutions, reduction of corruption, restoration of trust in the government, a reform of the judicial system, improvement of regulatory acts and other institutional improvements;

c) reforming the state and supporting small and medium enterprises, supporting technologies based on the formation and expansion of regional cluster programs or through "smart specialization";

d) implementation of technology exchange programs, production experience, integration of Ukraine into the world scientific and technological information space, first of all within the framework of the EU.

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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DOI: 10.15587/978-617-7319-64-0.CH4

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CHAPTER 4

STRATEGIC DIRECTIONS OF ECONOMIC AND ENVIRONMENTAL MANAGEMENT OF REGIONAL RESOURCES IN THE CONDITIONS OF CONTINUOUS DEVELOPMENT

ABSTRACT

In this chapter, the object of study is an innovative model of regional management of freshwater resources in the context of achieving environmental goals.

When solving the problems posed in the work, the methods of analysis and synthesis, comparative comparison and logical generalization were used. On their basis, an analysis of the main principles of adaptation of the world experience of regional management of freshwater resources in the context of the implementation of the European Union Water Framework Directive was carried out, environmental priorities for regional management of freshwater resources, their innovation and investment dominants, targets and a model of environmentally balanced management were determined.

According to the results of the study, it is noted that:

– effective management of freshwater resources is implemented through the appropriate management functions, which together contribute to the implementation of certain goals for the development of the water complex, ensuring a balance of interests of all subjects of water use;

– at the present stage of development of the national economy in the context of global trends, environmental forecasts and social challenges, the obvious and uncontested goal of managing freshwater resources is to ensure a balance between the three vectors of sustainable development (economic, environmental and social), which is the triune imperative of state and regional development policy and protection, distribution and use of public resources. The implementation of this goal requires the development of a unified strategy that defines the main imperatives of water policy, which are guidelines for decision-making at all levels, create framework conditions and criteria for using the available water potential, uniform rules for all participants in the water resources market;

– the main directions for improving the system of investment support for the innovative development of the region's water management systems include: improvement of regulatory and legal support and development of public-private partnerships, including in the form of ESCO contracts;

– the proposed model of sustainable socio-humanitarian and environmentally balanced management of freshwater resources at the regional level, taking into account innovative forms of

interaction in the field of water use, requires the transformation of the targets for the functioning of the water management complex in the direction of meeting the needs of present and future generations in freshwater resources.

Thanks to the results of the conducted studies, it is possible to more objectively and balanced assess the possible schemes and tools for managing the territory's freshwater resources. The conceptual approach presented in the chapter is a rather flexible tool with a free choice of elements of analysis depending on the goals and objects of management.

KEYWORDS

Freshwater resources, regional management, innovative model, balanced management, sustainable development, environmental protection.

Among the main goals of Sustainable Development is the provision of access to high-quality water, which is of great importance for people, nature and all economic activity. The importance of quality water for the health of the nation has been proven to all scientists and scholars. In addition, it should be noted that a large amount of water is required for energy production, crop production and the production of everyday goods. Today it is necessary to state the shortage of water resources. That is why the restoration of water resources to their natural state, the conservation and purification of freshwater resources is important.

In this context, innovation is the driving force behind the process of cleaning, conserving and restoring freshwater resources. That is why, in the context of the implementation of the Sustainable Development Goals, there is a need to study the level of financial support for innovative processes in environmental protection, which makes it possible to implement the tasks set. It is important to adapt the world experience in freshwater resources management for the regions of Ukraine in the context of the implementation of the Water Framework Directive. Certain issues require in-depth study.

The study reveals scientific approaches to the formation of an innovative model of freshwater management, characterizes the strategic vectors and key imperatives of an innovative model of freshwater management; the investment dominants for the implementation of an innovative model for the sustainable use of freshwater resources in the region are determined, the improvement of models for managing freshwater resources on an innovative basis in the context of sustainable development is outlined.

The practical significance of the results obtained lies in the possibility of introducing scientific and practical approaches to substantiate an innovative model for managing freshwater resources of territories in the context of sustainable development.

Based on the results of the study, an innovative model for managing freshwater resources and monitoring the implementation of strategic priorities at the national and regional levels has been developed.

4.1 STRATEGIC VECTORS AND KEY IMPERATIVES OF AN INNOVATIVE FRESHWATER MANAGEMENT MODEL

Freshwater resources on a global scale are becoming increasingly scarce, which is the result of an escalation in demand due to population growth and the need for increased food production, increased industrialization due to rising living standards, pollution due to various human activities and the impact of climate change [1]. Scientists predict that due to the scarcity and poor quality of fresh water, by 2050 at least one in four people is likely to live in a country with a shortage of fresh water. In this regard, ensuring the availability and sustainable management of water resources has been adopted as one of the Sustainable Development Goals by the United Nations until 2030.

According to the Ministry of Environmental Protection and Natural Resources of Ukraine, "In 2020, 9.6 cubic meters of fresh water were withdrawn from natural water bodies (90 % from surface and 10 % from underground sources). Over the past decade in Ukraine there has been a reduction (by 1.5 times) in the use of water resources (from 14.8 km^3 in 2010 to 9.6 km^3 in 2019) and the discharge of return water (from 7.8 km^3 in 2010 up to 5.2 km^3 in 2020), which is due to a decline in commercial production, a decrease in water use due to an increase in water supply tariffs and a slight reduction in its losses. In 2020, 60 % of fresh water was used for production needs, 21.4 % for irrigation needs, and 17.3 % for drinking and sanitary needs. Water losses during transportation reached 1.2 km^3, which accounted for 12 % of the total volume of withdrawn water. Starting from 2013, there has been a decrease in the total capacity of urban treatment facilities (only in 2019, its slight increase was recorded), and the share of polluted and insufficiently treated wastewater in relation to the total volume of return water disposal in 2020 amounted to 10 %" [2].

Despite certain positive trends, the main problems of an economic, environmental and social nature in the context of providing access to water resources, their use for domestic and industrial needs and the quality of surface waters remain. Against the backdrop of an inefficient water management policy for the use of water resources in industry and agriculture, improper state control over the level of danger of untreated water discharges, irrational land reclamation and drainage processes, the natural balance has been disrupted, which has led to gradual desertification in some regions, increased risks of droughts and floods.

It should be noted that the importance of effective management of freshwater resources both in the global and in the national context is confirmed by their role in the approved Sustainable Development Goals of Ukraine until 2030 as one of the priorities of state and regional management. As noted in [3]: "The national water strategy should ensure the achievement of a good state of water resources and lay the foundation for overcoming the significant disproportion in the access of the population to quality water supply and sanitation, formed between urban and rural areas".

To determine progress towards sustainable development in the context of the implementation of Goal 6 "Clean water and adequate sanitation", a number of indicators have been established, the achievement of which is analyzed both at the national and regional levels. **Table 4.1** shows the state of implementation of the goals of sustainable development of water resources in Ukraine.

Table 4.1 Dynamics of achievement of indicators of implementation of the Sustainable Development Goal 6 "Clean water and adequate sanitation" in Ukraine [4]

Indicators of achieving sustainable development goals	2015	2016	2017	2018	2019	2020	2025*	2030*
1. Safety and quality of drinking water in terms of microbiological indicators (by % of non-standard samples)								
1.1. By type of area								
urban area	3.1	4.3	4.6	5.1	5.7	–	**	**
countryside	7.6	10.4	11.2	11.8	11.4	–	**	**
1.2. By type of water supply								
centralized	4.6	6.4	6.7	7.7	8.2	–	**	**
decentralized	18	23.1	20.4	23.4	24.6	–	**	**
2. Share of rural population with access to centralized sewerage systems, %	3	2.5	2.5	2.5	–	2.4	10	46
3. Share of urban population with access to centralized sewerage systems, %	92	94	95	96.1	–	97	100	100
4. The volume of discharges of polluted (polluted without treatment and insufficiently treated) wastewater into water bodies, mln. m	875.1	698.3	997.3	952	737.2	725	557	279
5. The share of discharges of polluted (polluted without treatment and insufficiently treated) wastewater into water bodies in the total volume of discharges, %	16.38	12.93	21.15	18.27	13.72	13	10	5
6. Water intensity of GDP, m^3 of water for 1000 UAH GDP (at actual prices)	23.85	19.61	15.27	11.73	10.3	3.2	2.9	2.5
7. Current water intensity of GDP, % to the level of 2015	100	82.23	64.02	49.16	43.19	90	80	70

** – reference point;*
*** – indicator is specified*

As the data in the table show, over the past 5 years, positive changes in the management system of freshwater resources in the context of the main indicators of the sustainable development goals have been achieved for most indicators. In particular, in terms of the level of water intensity of GDP, both in general and in relation to the base year 2015, there is significant progress. Thus, in 2020, the level of GDP water intensity was 3.2 %, which is almost 20 % lower than in 2015.

The volume of discharges of polluted (polluted without treatment and insufficiently treated) wastewater into water bodies, as well as their share in the total volume of discharges, is decreasing. In particular, according to the monitoring report, the total volume of polluted wastewater discharges into surface water bodies in 2020 amounted to 725 million m^3, which is 12 % less than in 2015, and their share decreased by 6.8 %. At the same time, the current rate of reduction is not enough to achieve the final goals in 2030. It is necessary to continue the process of reforming the system with the involvement of international experience, to improve the technology of water intake, distribution and purification, to introduce resource-saving technologies in all systems of the national economy.

So, today freshwater resources are becoming one of the determining factors of the region's competitive advantages, a key factor in ensuring food security, economic development and demographic growth. That is why the management of such valuable natural resources requires the formation of a new concept based on an integral strategic approach, the main goal of which should be protection, balanced use and preservation for future generations.

In this context, the issues of defining and systematizing the features and main directions of the strategic management of water resources are being updated as a determining factor in the revival of the industry at a qualitatively new level.

In our opinion, in addition to those given in **Table 4.1** indicators, the main goal of freshwater resources management is to ensure a balance between the three vectors of sustainable development (economic, environmental and economic), which are the triune imperative of state and regional policy in the field of development and protection, distribution and use of national resources.

Specifically, with a focus on achieving a balance between the vectors of sustainable development, the development goals of regional systems should be developed. In this context, it should be noted that the focus on only one or two vectors leads to a significant reduction in the performance of the vector that was left without attention. For example, taking into account exclusively environmental factors in the management of freshwater resources will lead to a number of decisions that will limit the access of the population and business to the amount of resources necessary for the effective functioning, which will lead to a social crisis and a contraction of the economy. Focusing on social factors, without taking into account the other two, can lead to the deterioration of the ecological state of water bodies and related ecosystems, as well as financial opportunities for investing in the protection and reproduction of water resources. The priority provision of economic interests will lead to environmental degradation and social collapse.

The main vectors and tasks on the agenda for water resources management both at the national and regional levels in the context of ensuring the imperative of sustainable development are shown in **Fig. 4.1**. The development vectors of the freshwater management system determine the priority tasks that should be implemented within the management system at all levels (national, regional, territorial) and ensure a balance between the key imperatives of sustainable development.

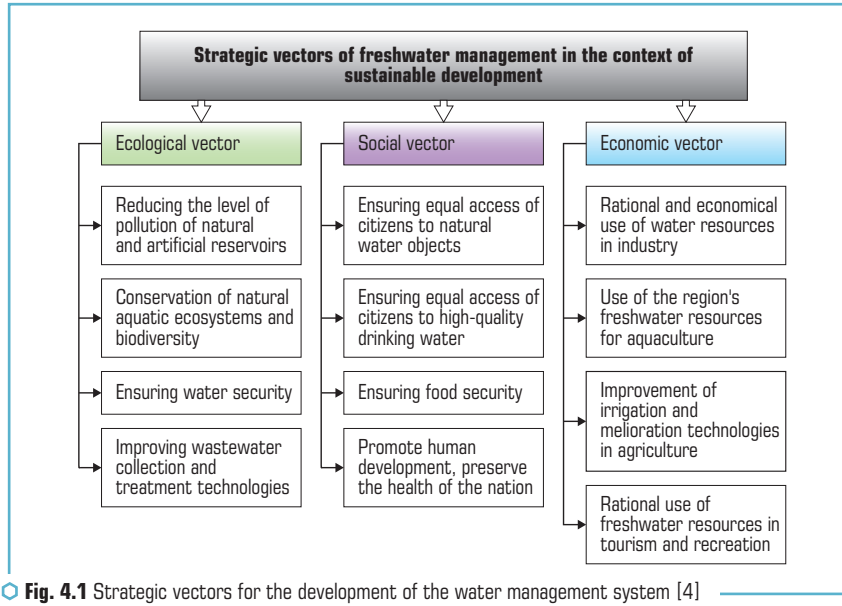

Fig. 4.1 Strategic vectors for the development of the water management system [4]

Let's agree with the opinion of Shyrokov, M. that "water management should be based on the theoretical foundations of management, taking into account the specific features of the management object and the balance of interests of all stakeholders. In this aspect, the national water management model can be considered as an open system, at the input of which the system receives information about needs, financing, human and energy resources, etc., and at the output-water management services, the state of natural and artificial reservoirs, energy, information, goods and services" [5].

Thus, the effective management of freshwater resources is implemented through the appropriate management functions, which together contribute to the achievement of certain goals for the development of the water complex, ensuring a balance of interests of all subjects of water use, as well as the sustainable use of the existing potential, both in the context of meeting the current needs of the population and the economy, and in long term.

The main functions of water management according to the classical approach include planning, organization, motivation, regulation and control. Coordination of functions is based on an effective system of communication and decision-making, the quality of which and the level of execution depend on an effective management structure.

Planning for the protection and efficient use of water resources involves the creation of science-based plans for the development of water basins, taking into account their potential to provide the population and the economy with quality water in the required quantity in accordance with the ability and predicted needs, identifying the discrepancy between the needs and potential

of water resources and making decisions to eliminate these problems; planning measures for the protection and purification of water bodies, ensuring water security, developing cost estimates necessary to fulfill these tasks. Work planning in the water resources management system is based on outdated approaches and covers mainly such areas as: flood protection of settlements, repair and modernization of individual water supply and sanitation infrastructure facilities, planning activities to monitor the state of individual water bodies. The current plans do not contain a clear definition of tasks, indicators of their implementation and sources of funding (as a rule, funding is carried out on a residual basis), and are also poorly oriented towards the introduction of innovative technologies. The disadvantage is also the lack of high-quality information and analytical support for the planning system, a clear systematization of indicators for different levels of management and areas of work.

The function of the organization is realized, first of all, through the creation of effective organizational structures for water resources management, a clear distribution of responsibilities, rights and powers of management and supervision bodies. Now the process of reforming the water resources management system is underway, the purpose of which is to create effective basin administrations. "The Law of Ukraine "On Amendments to Certain Legislative Acts of Ukraine on the Implementation of Integrated Approaches to Water Resources Management Based on the Basin Principle" initiated structural changes in the field of water resources management. Namely, river basin districts have been established, the creation of basin councils has been introduced, as well as a number of management tools: a river basin management plan, schemes for the use and protection of water and restoration of water resources, water management balances, water monitoring, typology of water bodies, etc. A new procedure for the implementation of state monitoring of waters has been determined, on the basis of which the preparation of monitoring programs for the areas of river basins specified by law has begun" [2]. Despite a certain beginning of reforms in the organization of water resources management, the old organizational model is still in effect, since the regulatory and legal field has not been formed, which will clearly determine the procedure for creating relevant institutions and granting them powers in the relevant areas of management; the responsibility of state bodies in the sphere of assistance to the processes of creation of basin administrations and their coordination is not defined; there are no mechanisms for covering the costs of providing water services, as well as covering the costs of the functioning of bodies at all levels.

Motivation as a function of managing the water management complex in general consists in the formation of a set of incentives and restrictions that will influence the behavior of economic entities, the population and water management personnel in the direction necessary to achieve sustainable development goals. So far, the system of motivation in the context of water resources management is not given significant importance. The implementation of this function in the context of ensuring the economical use of water resources is carried out by setting appropriate tariffs for water supply services for the population and businesses and the use of drainage systems. Also, sanctions mechanisms, quotas, etc. are used as a motivation for reducing pollutant emissions.

However, these mechanisms are not properly regulated. In our opinion, the motivational mechanism in the water management system needs to be improved by:

– implementation of economic incentives in the form of a reduced tax rate or preferential depreciation for enterprises and organizations that introduce new technologies aimed at water purification and its reuse in production processes; reduction of harmful emissions into surface water bodies; innovative irrigation systems;

– implementation of economic incentives in the form of state subsidies, preferential taxation or participation of the state in partial coverage of costs for utilities that provide water supply and sanitation services to the population and introduce innovative technologies;

– improvement of the personnel remuneration system in the system of management, distribution and control over the implementation of state policy in the field of water management.

The function of regulation and coordination consists in the distribution of powers for management and control at all levels, the establishment of effective communications between levels, links and subjects of the external environment. In accordance with the legislation of Ukraine, the central bodies that are entrusted with the functions of general management and supervision of compliance with the law, the implementation of state programs in the field of protection and reproduction of water resources, the planning and formation of legislative initiatives, include the Ministry of Environmental Protection and Natural Resources and the State Water Agency, UGS, SEI and others bodies defined by law.

In order to introduce integrated water resources management on the principle of the basin, 12 basin water resources administrations, as well as 13 basin councils, have been established. However, the issues of distribution of powers between the representation of the State Water Agency in the regions are represented by other government bodies, offices, etc., which causes duplication of powers.

Thus, the implementation of the functions of regulation and control is limited due to the lack of a unified water cadastre and water accounting system, "gaps" in the legal framework for the distribution of powers between different levels of management; duplication of supervision and control functions at the state and regional levels, lack of transparent mechanisms and rules of the game in the water market. The effective implementation of this function requires, first of all, the improvement of the organizational structure and the creation of legal support that defines the functions and also regulates the rights, powers and responsibilities of state institutions and officials in the management of water resources, the creation of a unified information system for accounting for surface, underground and other water bodies and standards for their evaluation; digitalization of management of the aqua sphere with the involvement of GIS technologies.

Thus, ensuring effective water resources management requires the improvement of organizational and economic mechanisms, namely:

1) distribution of legislative, executive and controlling functions in the field of water use, taking into account decentralization according to the basin criterion;

2) clear regulation of the powers, responsibilities and reporting procedures of the relevant water management bodies;

3) development of uniform standards for determining fair tariffs for water use for different categories of consumers and in the context of types of economic activity;

4) create a unified interactive database of water resources of Ukraine and regions;

5) formation of supervisory committees that control the implementation of programs in the field of water management with the participation of all stakeholders;

6) unification of procedures for registration, rehabilitation, provision of consulting services and strengthening of public-private partnership institutions in the field of water management.

Regional management of natural resources should be carried out in accordance with the basics of environmental management and be focused on the introduction of innovative technologies in the system of accounting, control, distribution and use of resources. According to Martienko, A. and Bondarenko, S. the main provisions of such management should be reflected in the form of a directed policy, a strategy for the development of territorial economic systems, regions, the state and will be implemented in the following areas:

– compliance with the level of environmental safety and the requirements of environmental legislation;

– continued harmonization of the legislative and regulatory framework and its use in all sectors of the economy, ecology, social sphere, licensing, environmental management, audit, standardization, certification, insurance;

– rationalization of the use of natural resources, taking into account their functions, significance, value as the natural capital of the state;

– creation of funds to support innovation activities (fundamental research, innovation programs, business support);

– allocating part of the funds from privatization to innovative investment in ensuring the R&D quality;

– ensuring the implementation of innovative programs, projects for the prevention and crisis situations in the production sector and in solving issues of regional management and environmental protection;

– systematization and harmonization of all monitoring systems for the collection, processing and exchange of information of an environmental and economic nature;

– addition and modernization of the existing systems of training and retraining of specialists;

– introduction of the institute of guarantees of the regional authorities for the R&D quality;

– systematization and creation of a unified database of investment projects;

– development of introduction into the practice of making managerial decisions in the investment sphere of "threshold" values of indicators of environmental and investment security, etc. [5].

Undoubtedly, the conceptual basis for the formation of an effective water resources management system is an appropriate strategy that defines the main imperatives of water policy, which are guidelines for decision-making at all levels, creates framework conditions and criteria for using the available water potential, uniform rules for all participants in the water resources market. The water strategy is also the basis for adapting the relevant legal framework, creating appropriate institutional and economic mechanisms for water management at all levels.

The strategic aspects of water management in Ukraine are defined in the draft water strategy of Ukraine, heard at a meeting of the Cabinet of Ministers on June 16, 2021. This strategy defines the main tasks in the field of management and protection of water resources for the period up to 2030 and provides for:

– preparation of the necessary changes in the legislative framework, in particular, in terms of the implementation of the basic norms that meet the terms of the Agreement on the "Association of Ukraine with the EU" and international standards in this area;

– formation of a system of modern monitoring of surface water quality using innovative technologies;

– reforming the organizational structure of water resources management on the basis of the basin principle and regulation of relations in this area;

– creation of river basin management plans.

The strategic goal and main goals of the Strategy are presented in **Fig. 4.2**.

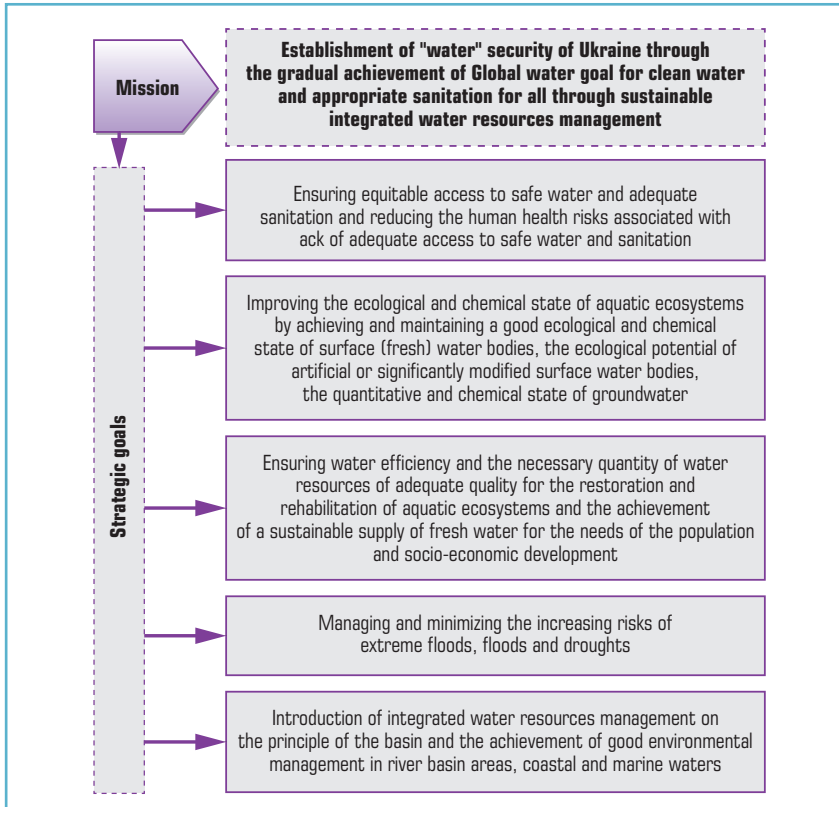

Fig. 4.2 Mission and goals of water resources management in Ukraine [2, 4]

The implementation of these goals requires the formation of appropriate resource and industry strategies. According to the classical definition, a strategy is a way to achieve goals, which is selected from alternative options, taking into account the available opportunities and limitations, and reflects the essence of the policy of an economic entity in this area as much as possible.

The National Water Strategy is developed on the basis of an analysis of the existing water potential, its territorial differentiation, development forecasts in accordance with climate change and other impact factors, as well as forecast needs in the context of the main types of water users; assessment of the ecological situation of water basins and trends in this direction; assessment of the technical condition of water intake structures, transportation, purification and drainage systems; impact on ensuring food, economic and environmental security of territories.

Separately, one can single out regional strategies characterized by a certain combination of resource and sectoral strategies at the level of individual administrative-territorial units. Regional strategies take into account, first of all, the level of provision of the region with freshwater resources, the structure of the economy in terms of types of economic activity, the size and structure of the population by type of settlements, as well as forecasts for the development of these indicators.

Due to the specific features of the water management complex, sectoral strategies are proposed to be developed according to the criterion of the subject of consumption of water resources and the ultimate goal of their use. So, a separate strategy is needed:

– primary water users, that is, state and municipal water supply and sewerage services that carry out centralized water intake, water distribution and drainage;

– secondary users – households, government agencies, enterprises of various industries.

The above subjects are differentiated depending on the volume of consumption, the goals and characteristics of use and the level of impact on the ecological situation of water bodies. Strategies in this context should contribute to the most equitable distribution of water resources between individual entities by differentiating the relevant tariffs, defining a list of restrictions on additional taxes for an insufficient level of purification of water discharged into the environment and promoting general re-equipment, modernization of technologies in the industry on an innovative basis.

Analyzing the intake and consumption of fresh water in the context of sectors of the national economy (**Table 4.2**), it should be noted that the largest share of consumption in 2020 (47.5 %) falls on water supply; sewerage, waste management, that is, housing and communal services. A significant share in the structure of water consumption is also occupied by the supply of electricity, gas, steam and conditioned air (30.2 %), as well as agriculture (24.1 %).

In the last ten years, there have been significant structural changes in the volume and structure of water consumption by type of economic activity, which must be taken into account when developing sectoral strategies for the rational use of water resources. In particular, over the period 2010–2020, the share of primary water users in the structure of fresh water consumption increased significantly, which increased by 27.6 %. Such an increase, taking into account the reduction in water consumption per person during the same period, indicates the irrational use of water and its significant costs during abstraction and transportation. This is primarily due

to the technical condition of water intake facilities, equipment and water supply systems, the average wear rate of which is 73 %.

Table 4.2 Structure and dynamics of fresh water consumption by industry

Industry	2010		2015		2020		Changes 2020/2010		Changes 2020/2015	
	million m^3	%	million m^3	%	million m^3	%	million m^3	%	million m^3	%
Total	9817	100	6608	100	9459	100	–358	0	2851	0
Agriculture, forestry and fisheries	2565	26.1	1595,0	24.1	1320,0	14.0	–1245	–12	–275	–10
Mining and quarrying	256	2.6	215,0	3.3	272,0	2.9	16	0.3	57	–0.4
Processing industry	1848	18.8	685,0	10.4	434,0	4.6	–1414	–14	–251	–5.8
Supply of electricity, gas, steam and air conditioning	3118	31.8	2848,0	43.1	2854,0	30.2	–264	–1.6	6	–13
Water supply; sewerage, waste management	1952	19.9	1255,0	19.0	4490,0	47.5	2538	27.6	3235	28.5
Other industries	78	0.8	10,0	0.2	89,0	0.9	11	0.1	79	0.79

A positive is reduction in the use of fresh water in agriculture against the background of an increase in the volume of cultivation of agricultural crops. Over the past 10 years, the volume of water consumption in agriculture has decreased by 270 million m^3, and the share of the industry in the structure of total water consumption has decreased by 12 %. This testifies, first of all, to the improvement of irrigation and reclamation technologies, the transition of a significant part of agricultural producers to drip irrigation and other water-saving technologies. The reduction in the total volume of fresh water consumption in industry, unfortunately, is primarily due to the reduction in the volume of industrial activity in physical terms.

According to the authors, the general structure of the industry strategy in the context of individual consumers should contain the terms shown in **Fig. 4.3**.

For each type of user, it is advisable to develop a differentiated combination of strategy components that together ensure balanced water consumption, fair distribution of resources, minimize

environmental impact, stimulate the modernization of technical systems on an innovative basis and, in general, will contribute to the achievement of sustainable development goals socially.

Resource strategies determine the choice of alternatives for providing the process of implementing the strategy with the necessary types of resources, namely: material, financial, personnel, energy and information.

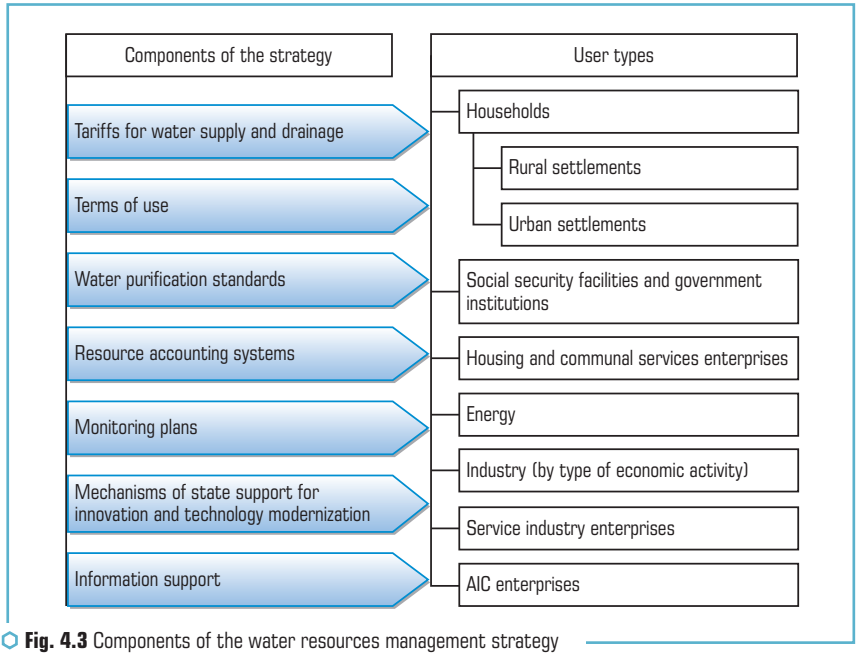

Fig. 4.3 Components of the water resources management strategy in accordance with the types of consumers [6]

Accordingly, in the context of each type of resource, a strategy is formed that determines the volume of necessary resources, the choice of the most optimal sources of their attraction and ways to optimize their use.

The logistics strategy determines the list of material resources necessary for the effective functioning and development of water resources, the provision of services to the population, the state and business, as well as the implementation of water protection and monitoring measures of material resources. The strategy involves the analysis of strategic resource zones in terms of materials, machinery, equipment, selection of suppliers and conclusion of relevant agreements. Since water resources are predominantly in the sphere of public administration, and the purchase of resources is carried out at the expense of the state budget and budgets of other levels, the selection of suppliers should be carried out through public tender purchases using the Prozorro system.

The financial strategy for the sustainable development and use of water resources is aimed at identifying the main and additional sources of financing for the implementation of the water strategy, creating effective and transparent mechanisms for selecting budget-funded projects, organizing control over the distribution and use of funds. In the structure of financing costs for the implementation of work in the field of water management, more than 96 % are budgetary funds. As additional sources of raising funds, one can consider international assistance in the framework of the implementation of sustainable development projects, investments from business in the framework of the implementation of public-private partnership projects and foreign investments in the development of joint projects.

The authors of the Water Strategy of Ukraine [7] note that improvement in the financial support of the water sector and attraction of investments in the industry would be facilitated by a more active introduction of market relations, in particular:

"– establishing partnership relations between the state and business structures on the basis of public-private partnership agreements;

– corporatization of the management of water facilities, natural and artificial water bodies and integral property water management complexes (water supply and sewerage and water management and reclamation);

– formation of an institutional environment for increasing the level of capitalization of water management activities and diversifying the sources of investment support for the implementation of water management and water protection projects".

In the context of global trends and state policy on the formation of an information society, an important condition for building an effective information system is the development of a plan for the digitalization of water resources, the introduction of modern technologies for searching, systematizing and managing data, creating an information map of water resources, and increasing the level of information literacy of employees. An important task of water policy is to promote the rational use of water resources among the population. It is citizens who are a conscious force capable of contributing to the implementation of a strategy for the sustainable use of water and other natural resources at all levels and in all areas of the economic complex.

4.2 INVESTMENT DOMINANTS FOR THE IMPLEMENTATION OF AN INNOVATIVE MODEL FOR THE SUSTAINABLE USE OF FRESHWATER RESOURCES IN THE REGION

Of course, in addition to an effective system of control and administration of water resources, an important factor in the implementation of an innovative model for the sustainable use of freshwater resources in the regions is the introduction of new technologies aimed at cleaning freshwater bodies and promoting the rational use of water resources. The activation of such work requires sufficient funding and attraction of additional investments in the industry.

In order to work out all the possibilities in the field of attracting investments and other sources of financing projects to provide the population and the economy of the regions with sufficient

quality water, the Government created the Interdepartmental Coordination Council for Water Resources of Ukraine. The Council will make it possible to coordinate the activities of all parties in the formation and implementation of state policy in the areas of drinking water, water supply and sanitation [8].

Statistical data show that the main source of financing the costs of work in the field of water management are the funds of the state and regional budgets. In 2015–2019, the gross volume of financing of the industry almost doubled (**Table 4.3**), which indicates the priority of this area for the development of the economy and territories. In the context of the main areas of financing during the period under review, the greatest growth is observed in the field of financing the costs of management and management of the water sector, which is associated with the reform of the industry, the introduction of information technologies in management.

Table 4.3 Financing of works in the field of water management from the state budget [9]

Directions of financing	2015	2016	2017	2018	2019	growth, %
Total	1143121,2	1158162,9	1559437,4	1985584,3	2133375,2	86
Advanced training of personnel in the field of water management	2545,3	2714,1	3971,5	4462,3	4885,0	92
%	0.2	0.2	0.3	0.2	0.2	0.0
Leadership and management in the field of water management	10049,3	10598,7	18754,9	27379,4	32912,6	227
%	0.9	0.9	1.2	1.4	1.5	0.7
Applied scientific and scientific and technical developments, performance of works under the state order in the field of water management	147,8	168,2	196,1	196,1	196,1	33
%	0.013	0.015	0.013	0.010	0.009	0.0
Operation of the state water management complex and water resources management	975274	1089172	1468920	1743108	1960182	101
%	85.3	94.0	94.2	87.8	91.9	6.6
Development and improvement of the ecological state of irrigated and drained systems	0,0	30000,0	0,0	0,0	50000,0	100
%	0.0	2.6	0.0	0.0	2.3	2.3

Analyzing the structure of budget expenditures for the development of water management, it should be noted that 91 % are the costs of operating the state water management complex and managing water resources. During the study period, the share of this sex increased by 6.6 %. A negligible share of the costs of innovative developments in the field of water management is negative. Thus, the costs for the development of applied scientific and scientific and technical developments, the execution of work under the state order in the field of water management during 2015–2020 is only 0.013–0.09 %.

In dynamics (**Fig. 4.4**), there is a significant increase in capital investments in the protection and reproduction of water resources. Over the past 10 years, the volume of investments has grown by 115 %, which has a positive impact on the state of water bodies. However, given the high level of depreciation of the water infrastructure, which, according to the State Statistics Service, is on average 63 % of the available investments, it is not enough for the transition of the water sector to an innovative model of sustainable development, in addition, studies have shown that more than 98 % of investments are directed primarily to elimination of current problems in the water sector and almost no funds are invested in the development of innovative activities in this area.

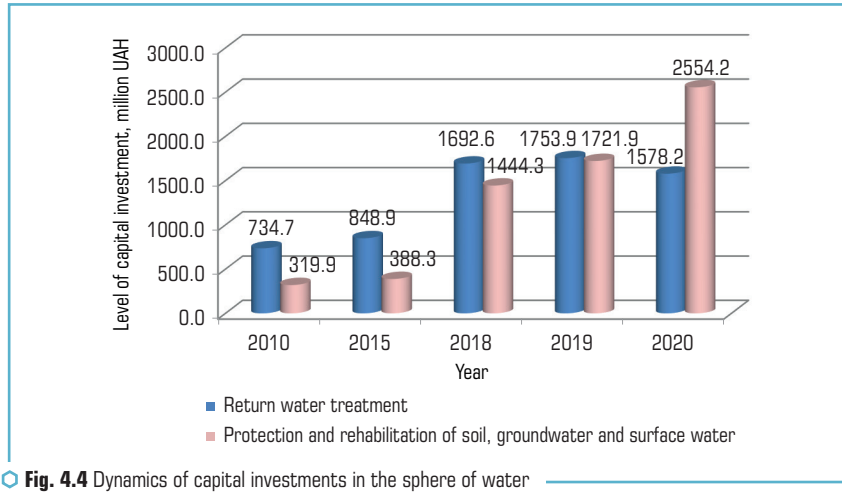

Fig. 4.4 Dynamics of capital investments in the sphere of water management of Ukraine, million UAH [9]

The Black Sea region of Ukraine is characterized by different trends in capital investment in the development of water resources by region (**Table 4.4**).

In the last 10 years there have been significant changes in the volume and structure of investments in the development of water management in the regions of the Black Sea region. In absolute terms, the largest volumes of capital investments in water consumption and protection

of water resources were attracted in the Mykolaiv region (54 million UAH in 2020). At the same time, their size increased by more than 5 times, although the specific share in the structure of capital investments in environmental protection decreased by 11 % and amounted to 16.5 % at the end of 2020. This indicates the production of an active regional policy in the field of protection and reproduction of natural resources in the region.

Table 4.4 Dynamics of capital investments in the field of water management in the Black Sea region of Ukraine [11]

Period	Mykolaiv region		Odesa region		Kherson region	
	Thousand UAH	% in total investment	Thousand UAH	% in total investment	Thousand UAH	% in total investment
2010	8718.9	27.9	31902.9	57.6	1219.2	43.3
2011	22956	40.4	34216.2	41.6	2028.2	58.3
2012	9702.4	15.4	16013.1	50.3	1572.0	75.2
2013	8880.2	26.6	20320.6	57.1	5100.7	64.0
2014	6315.9	12.2	2112.1	21.6	3471.9	51.5
2015	5403	5.5	12958.4	48.9	4065.2	51.7
2016	19890.2	16.2	3654.0	20.8	1935.0	84.9
2017	36228.7	30.7	10405.2	10.9	2135.6	66.5
2018	63169	45.8	22221.9	30.2	12590.1	82.3
2019	56581.6	45.6	33684.8	49.9	5539.1	75.3
2020	54814.9	16.5	34424.4	27.6	6847.9	62.1
Growth, %	528.6	–11.4	7.9	–30.0	461.6	18.8

Analyzing the dynamics and structure of capital investments in the development of the industry in the Odesa region, it should be noted a slight increase in the volume of attracting investments in the water sector and a significant reduction (30 %) of their share in gross investments directed to environmental protection. Opposite tendencies are observed in the Kherson region. Thus, during the studied period, the total volume of capital investments in the field of return water treatment and the protection and rehabilitation of soil, surface and groundwater increased by more than 4 times and amounted to 6.8 million UAH at the end of 2020, and their share of total investments increased by 18.8 % and amounted to 62 %.

Obviously, the growth of investment in the industry needs to diversify the relevant sources. According to the authors of [10], the diversification of investment support for the sphere of water use should include the use of the following sources of financing: State and local budgets, including special and reserve funds, as well as off-budget funds; own funds of enterprises, organizations

and institutions, including water management organizations, received on the basis of the provision of paid water management and ecosystem services; funds of foreign business structures, governments of foreign states, international financial and credit structures, including as part of the financing of global environmental projects provided for by environmental conventions; credit unions, financial and banking institutions, insurance organizations, pension funds, public organizations; revenues accumulated as a result of joint activities of water management entities and business structures on the basis of public-private partnership agreements; financial resources obtained as a result of the sale of local loan bonds and mortgage lending secured by land inseparably from water facilities and hydraulic structures.

Effective tools for attracting private investment in the development and reproduction of water resources used in countries with developed economies include public-private partnerships. In Ukraine, there are certain prerequisites for the introduction of the mechanism of public-private partnership in the field of water supply and sewerage, in particular:

– guaranteed sales markets for enterprises as a result of a monopoly position in the water and sewer services market, which is an important advantage for private business;

– a significant potential for reducing costs associated with the provision of centralized water supply and sanitation services through the introduction of resource-saving and energy-saving technologies;

– state guarantees and investments from the budget for the modernization of infrastructure;

– distribution of financial risks by the state.

At the same time, the analysis of data on the implementation of public-private partnership projects in Ukraine showed that this tool in the field of development and use of infrastructure, in particular public utilities, is at an early stage. The total number of public-private partnership projects in Ukraine is growing, but at a very slow pace. In particular, "According to the data of central and local executive authorities in Ukraine, as of January 01, 2021, 192 agreements were concluded on the terms of PPP, of which 39 agreements are being implemented (29 concession agreements, 6 agreements on joint activities, 4 other contracts), 153 contracts are not implemented (118 are not implemented, 35 are terminated/expired) [12].

Among the main problems in the implementation of public-private partnerships in the field of water supply and sanitation in Ukraine (which is typical for all infrastructure projects), scientists note:

– lack of a logical and understandable system of legal regulation of the relevant relations (inconsistency between the laws "On Public-Private Partnership", "On Concessions" and several laws regulating concession agreements in the areas of construction of roads, heat supply and water supply facilities of a communal form of ownership, projects of the fuel and energy complex state form of ownership, its infrastructure);

– uncertainty of investors;

– caution and uncertainty of public authorities;

– low institutional capacity of central and local authorities;

– lack of public awareness in this area;
– high risks [13];
– unsettled mechanisms for setting tariffs for the provision of services;
– dependence of economic relations on changes in the political situation;
– high level of corruption, in particular in the sphere of licensing activities;
– instability of legislation and the uncertainty of the economic prospects of Ukraine.

According to [14], the development of PPPs in the form of ESCO contracts is promising in the field of the use of natural resources and natural monopolies. The scientist gives the following advantages of this form of development of public-private partnership:

a) firstly, they ensure the involvement of small and medium-sized businesses in the DPP mechanism due to the low barrier to entry into the PPP;

b) secondly, the productive part of these projects has a social orientation, since it is implemented on the basis of communal and municipal property and is aimed at guaranteed provision of energy consumption standards by these facilities;

c) thirdly, the ESCO formula itself determines the level of innovative result that the GSP private partner must achieve;

d) fourthly, PPP projects from ESCO contracts contain an environmental component, since the conditions of this form of PPP include requirements to reduce greenhouse gas emissions, etc.

The uniqueness of PPP projects with ESCO contracts lies not only in combining the interests of the state and a private partner in solving a common technical and economic problem. The main principle of ESCO is a completely new legal structure of relations between PPP partners, which determines the direct dependence of the private partner's profit on the degree of achievement of control results in terms of quantity and quality, as well as its direct motivation to achieve these results. It is possible to add that the development of such forms of public-private partnerships in regions and small towns can become one of the tools for the gradual transition of the water use and sanitation sector to an innovative model, since innovations diffuse faster within small projects.

A promising area for the sustainable use of freshwater resources and attraction of investments in the industry is the production of aquaculture. The development of this type of activity is one of the global trends that allows the rational use of natural and artificial reservoirs for the production of fish and other aquacultures, contributes to the economic development of the territories and the receipt of additional funds in the regional water development fund through appropriate rent payments and plays an important role in strengthening food security in the region.

The population of Ukraine consumes fish and fish products almost two times less than the average worldwide. At the same time, the volume of production of fish and fish products is declining every year. Despite the reduction in the total consumption fund, the import of this product is growing every year. In particular, as of the end of 2019, the total volume of imports of fish products amounted to more than 400 thousand tons, with a reduction in domestic production to 128 thousand tons. The dynamics of production, export and import of aquaculture to Ukraine is shown in **Fig. 4.5**.

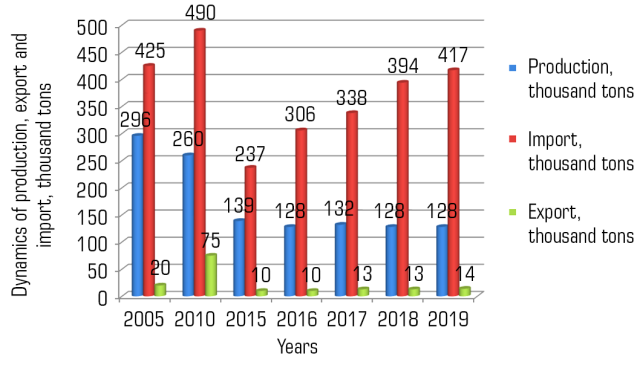

Fig. 4.5 Dynamics of production, export and import of aquaculture to Ukraine [15]

The low level of internal supply of the fish products market in Ukraine and high import dependence leads to a decrease in the economic accessibility of this product for the population. According to experts, "Currently, in the structure of obtaining all aquatic biological resources, the share of aquaculture fish products is only 21.8 % of the total. At the same time, as world experience shows, it can be more than doubled by introducing innovative achievements of domestic and foreign science" [15, 16].

Taking into account the significant capacity of the domestic market of fish products and other aquacultures, as well as the growing trends in the development of the world market, this type of economic activity is classified as one of the four most investment-attractive in Ukraine. Additional factors of investment attractiveness are:

– duty-free and quota-free access to the EU market;

– the presence of numerous water bodies that can be used for this purpose;

– fisheries and aquaculture is considered the most efficient form of converting vegetable proteins into animal proteins, since fish do not need to expend energy to heat them;

– no waste and minimization of feed, since aquaculture farms can be designed to have multiple layers, thus minimizing feed loss.

One of the promising areas for diversifying funding and organizing individual work aimed at improving the environmental situation of water resources, information activities on sustainable environmental management and certain clearly defined problems of the industry in the territory of a particular region is the involvement and support of public organizations. The projects that were carried out in the field of water management, together with public organizations, were successfully implemented in the Lviv, Volyn and Cherkasy regions (**Table 4.5**).

The given data show that the practice of financing regional programs in the field of sustainable water use together with public organizations in Ukraine has not yet become widespread. In our

opinion, it is the regional authorities and local communities that should initiate programs aimed at the efficient use of water resources and attract a variety of sources for their financing, among which may also be funds from regional funds for environmental protection.

Table 4.5 Financing of targeted regional projects and programs in the field of protection and rational use of water resources with the participation of public organizations in 2018–2019 [17]

Region	Program	Amount, UAH
Cherkasy region	Public organization "Kolooborot"; the project "Forgive life to springs" (the importance of preserving water resources was popularized by clearing and ordering the sources "Cossack", "Devichye"; restoration of a dried-up pond, which was created by two sources; printing and popularization of the legend about the sources, establishing an index sign to the source	24 900
Volyn region	Public utility information-analytical center "Volynenergosoft"; project – production of an interactive map of water bodies of the Volyn region	100 000
Lviv region	Public organization "Association of producers of the fishing industry" (measures to combat the harmful effects of water through biological reclamation of water bodies within the framework of the project "Protection and rational use of wildlife resources")	100 000
	Public organization "Grebeniv Society" (overhaul of the existing storm sewer on Shevchenko St. to drain rain and melt water on the territory of the Grebeniv Village Council of the Skole District within the framework of the "Grebeni for a Clean Environment" project)	90 000

Unfortunately, the current mechanism for allocating the environmental tax to the environmental fund and its interbudgetary distribution leads to an inefficient redistribution of financial resources for the implementation of environmental protection measures. In most cases, funds are spent either on solving urgent problems that arise in a particular region, or on long-term financing of projects that in some cases are not brought to completion. This violates the principle of subsidiarity, that is, the solution of problems at the level at which they arise.

The ideal solution to the problem, according to EHR analysts, is to create, following the example of the EU countries, the "Environmental Protection Fund" as a separate legal entity, similar to the Pension Fund or the Social Insurance Fund. The entire environmental tax should be credited to this fund. And the allocation of funds for solving local environmental problems will be organized through its regional territorial divisions. The independence of this fund from the management of the Ministry of Natural Resources will allow minimizing subjective factors when making a decision on the allocation of funds. And the main advantage of the existence of this fund will be the ability to provide long-term guaranteed financing (for several years) of strategic environmental activities and the allocation of funds for activities at the beginning of the year, and not at the end of it, which is impossible with the current system of distribution of budget funds for environmental activities [18]. Such distribution, with the organization of transparent public control, will help ensure the principle of subsidiarity, as well as the targeted spending of funds for the implementation

of environmental activities in accordance with the environmental problems of the territories. In addition to the environmental tax, the fund may receive grant funds, funds within the framework of international programs.

Regional targeted programs aimed at eliminating the most acute problems in the field of water management have been developed in almost all areas. An example of such a program is the Program for the Conservation and Restoration of Water Resources in the Basin of the Kuyalnyk Estuary of the Odesa Region for 2019–2023. For the implementation of the program from the regional budget, 30280.0 thousand UAH are provided, as of the end of 2020, 700.0 thousand UAH were financed, the balance is 29580.0 thousand UAH.

An important source of financing and investment in the industry is the creation of a water fund in each region, which should be filled with rent payments, local taxes on the use of water resources and discharges of polluted water from users that affect water quality or change the water regime. The accumulated funds should be directed, first of all, to the restoration of the region's water management infrastructure, the introduction of innovative technologies and equipment. At the same time, it is important to organize transparent reporting on the functioning of the fund and the possibility of public control.

In [19], it is noted that "one of the ways to regulate rational nature management is the use of taxes, which allow the withdrawal of part of the rent in order to use it to finance the needs of the reproduction of natural resources and create prerequisites for stimulating the efficient and economical use of resources. The system of penalties also plays an important role. However, it is not only the size of the fine that matters, but also the possibility of its application.

Table 4.6 defines the main goals of rational water use and the instruments for their financing. As can be seen from the above data, the use of taxes is one of the ways to regulate the rational use of natural resources, which allows, for the purpose of use, to exclude part of the rent to finance the needs of the reproduction of environmental resources and create prerequisites for stimulating their efficient and economical use. The system of penalties also plays an important role. However, it is not only the size of the fine that matters, but also the likelihood of its application.

The analysis shows that, despite a certain increase in investments from both public and private sources in the field of water management, the level of innovative activity in the industry remains extremely low. Ensuring the transition to sustainable water use on an innovative basis requires not only the development of mechanisms for attracting additional financial resources and investments, but also the creation of conditions for their priority innovative direction.

In [20], it is noted that the investment and innovation mechanism of rational nature management should be considered as:

"– the process of changing the investment and innovative attractiveness of certain objects of nature management and involves a dynamic analysis of the phenomenon in space and time;

– an economic phenomenon that reflects the current state of the attractiveness of nature management objects for investment and development of the latest technologies for investment and innovation from different sources of investment and their origin at different levels of management".

Table 4.6 Objectives of optimal water use and instruments for their financing [4]

Objective	Financing instruments	Financing sources
Comprehensive research and analysis of the state of water resources, formation of a water cadastre and interactive databases	Financing instruments	Taxes
Carrying out environmental protection measures on water bodies, ensuring flood control measures	Budget financing	Special funds
Modernization of centralized water supply systems	Budget financing (priority programs)	Local taxes, penalties, tariffs
Treatment of already polluted waters, consisting in the elimination of undesirable substances from surface waters	Regional budget (municipal, UTC)	Taxation, penalties
Installation of innovative wastewater treatment and filtration equipment, water reuse technologies, and drip irrigation technologies	Funds from the Water Fund, incentives for investors	Taxation, penalties
Application of closed-loop water consumption schemes with the aim of saving water resources and preventing pollution of the hydrosphere, in particular, and the natural environment in general		
Formation of a monitoring network with modern equipment and laboratories	Funds from the Water Fund	Taxation, penalties
Creation of new and preservation of existing water reserve zones, preventing their transfer to private ownership	Direct government regulation	Penalties

The activation of investment processes and their direction in the innovation sphere requires an improvement in the investment climate both in the economy as a whole and in the industry. Improving the investment climate in Ukraine will primarily help end the military conflict and establish sustainable peace in Ukraine, which will create prerequisites for establishing stability and predictability for further economic development, reducing the level of potential dangers, military, economic and man-made dangers. The key factors for improving the investment climate are also:

– further unification of legislation in the field of investment and innovation activities, as well as in the regulation of property rights in accordance with the norms in force in the EU;

– providing state guarantees for the succession in the execution of the law and protecting investors from political influence on changes in legislation or the tax code during the payback period of projects, in particular in innovative areas;

– effective implementation of reforms in the judiciary and building an effective anti-corruption system;

– formation of effective institutional, financial and legal mechanisms for the development of investment and innovation activities, reducing the level of uncertainty and avoiding duplication

in the distribution of regulatory, supervisory and other administrative functions between government bodies of different levels and areas;

– implementation of digital technologies in the provision of administrative services; optimization and simplification of tax, customs and other administrative procedures;

– activation of public-private partnership programs;

– expanding the rights of territorial communities in terms of a set of tools to stimulate investment and innovation activity of business entities in the regions;

– development of a rational system of innovation infrastructure;

– state regulation of tariff and price policy in life-supporting sectors of the economy.

The environmental tax is an important instrument of financial support for sustainable environmentally balanced management of freshwater resources. The legislative base of the country provides for amendments to the Budget Code by reducing the percentage of local budgets increasing the percentage of environmental tax crediting from 25 to 30 percent of such tax crediting to the state fund. At the same time, for the regional budgets, it is planned to increase the percentage of tax credits from 30 to 50 percent, and for the cities of Kyiv and Sevastopol – from 55 to 80 percent (also due to a decrease in the percentage of this tax credited to the state fund) [17].

It is important to support the initiative to increase the share of environmental tax that falls into the budgets of communities to the level of 50 %. After all, this will ensure the establishment of a correspondence between the financial capabilities and the environmental load of different territorial units. An objective need is to increase the share of environmental tax deductions to local government budgets up to 50 %, which will ensure the possibility of preventing and eliminating the consequences of pollution of natural resources at the basic level of territorial communities, which is closer to ordinary citizens in terms of addressing environmental safety issues.

"As of November 1, 2019, 2,938 payers were registered in the Odesa region, who sent 26.3 million UAH to the budget over the ten months of this year environmental tax. Compared to the corresponding period in 2018, revenues increased by 3.6 million UAH. In turn, out of the total amount, 13.7 million UAH of environmental tax was sent to the state treasury, and 12.6 million UAH to local budgets" [4].

An increase in the share of environmental tax deductions to the budgets of the local self-government level will strengthen the upward trend in revenues to the local budgets of the Odesa region due to environmental payments.

It should be noted that in comparison with other regions of Ukraine, the share of environmental tax in tax revenues of local budgets in the context of the Odesa region for 2014–2016 was quite insignificant (**Fig. 4.6**).

One can agree with the opinion that "preserving the environmental friendliness of the environment for present and future generations is without a doubt what a modern developed society should take care of. The environmental tax is a manifestation of this attitude and helps to reduce the harmful emissions of enterprises and increase the financing of costs for improving the ecological state of the country" [17].

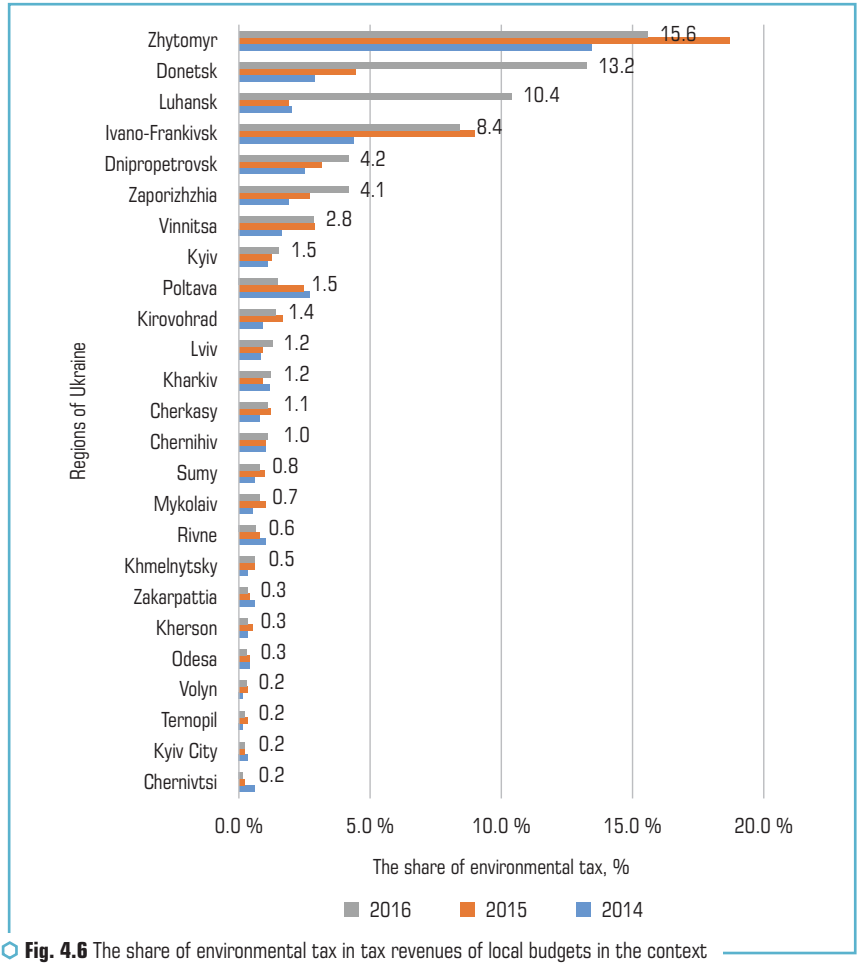

Fig. 4.6 The share of environmental tax in tax revenues of local budgets in the context of individual regions of Ukraine [21]

Improving the investment climate in the field of use, protection and distribution of freshwater resources requires, before the completion of the industry reform processes, a clear distribution of functions, powers and sources of funding between governments at all levels, improvement of the system of economic relations between participants in the water market by establishing clear, unambiguous and transparent rules games", clarification of priorities for the development of water resources in the field of their protection, distribution and use. It is important to create conditions for cooperation between scientific institutions, educational institutions and business entities on

request, development and transfer of technologies, as well as their implementation in the water industry, training specialists in the field of water management, taking into account the needs of the present, establishing an effective dialogue with the public.

4.3 IMPROVING MODELS OF FRESHWATER RESOURCES MANAGEMENT ON AN INNOVATIVE BASIS IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

The efficient use of freshwater resources is an extremely urgent problem in the regions of the Black Sea region due to their uneven distribution across the territory, the high level of strategic needs and the difficult environmental situation.

It should be noted that in terms of the level of water supply, the Mykolaiv and Odesa regions belong to the regions with an average specific level of water supply, and the Kherson region belongs to the regions with a high level. **Table 4.7** shows the main indicators of the region's water supply by regions.

Table 4.7 Indicators of provision of the Black Sea region of Ukraine with water resources at the beginning of 2019 [4]

Indicators	Ukraine	Mykolaiv region	Odesa region	Kherson region
Specific provision with river runoff, thousand m^3/year per 1 person	4.980	3.550	4.200	52.560
Specific supply of groundwater (operational reserves)				
Per 1 person, thousand m^3/year	0.136	0.025	0.052	0.325
Based on 1 km^2 area, thousand m^3/year	9.470	1.170	3.740	11.820
Specific supply of groundwater (forecast reserves)				
Per 1 person, thousand m^3/year	0.535	0.143	0.114	1.735
Based on 1 km^2 area, thousand m^3/year	37.300	6.550	8.080	63.660
Groundwater abstraction				
Per 1 person, thousand m^3/year	0.060	0.016	0.015	0.078
Based on 1 km^2 area, thousand m^3/year	4.240	0.730	1.080	2.840
Operating reserve utilization level, %				
Per 1 person, thousand m^3/year	44.118	64.000	28.846	24.000
Based on 1 km^2, thousand m^3/year	44.773	62.393	28.877	24.027
The level of use of the predicted reserve, %				
Per 1 person, thousand m^3/year	11.215	11.189	13.158	4.496
Based on 1 km^2 area, thousand m^3/year	11.367	11.145	13.366	4.461

As the data in the table show, within the Black Sea region (excluding the Autonomous Republic of Crimea, whose territory is temporarily occupied), there is a different level of water supply, which is due to natural and geographical factors. Thus, the level of specific provision of the population with river runoff compared to the average value for the regions of Ukraine is 72 % (Mykolaiv region), 85 % (Odesa region) and 95 % (Kherson region).

An important role in the water supply of the population and the economy is the presence of a sufficient supply of groundwater, the use of which allows diversifying the supply of water resources in areas characterized by a lack of sufficient surface water. These tables indicate that the Mykolaiv and Odesa regions do not have a sufficient supply of underground water resources. In particular, per inhabitant, the specific operational availability of groundwater in the Mykolaiv region is 0.025 thousand m^3, which is 18 % of the average for Ukraine, and in the Odesa region – 0.052 thousand m^3 (38 %). The level of groundwater availability in the Kherson region is higher than the average Ukrainian indicator by 39 %. At the same time, in the regions, the current situation regarding groundwater abstraction for operational needs is better than the average indicators for the regions, and the level of use of predicted reserves is on average 10 %. That is, it is possible to say that there is a certain potential in providing the region with freshwater resources, but its volume and return depend on the effectiveness of their protection and rational use.

Despite the different levels of provision of territories and the population with freshwater resources in the context of regions, the region is characterized by a number of common problems regarding the state of water supply and the efficiency of using water potential, including:

– uneven distribution of surface freshwater reservoirs and river flows across the territory of the region;

– high level of wear and tear of equipment of pumping stations and other water infrastructure facilities;

– imperfect control system and significant volumes of pollutant discharges;

– poor quality of drinking water for the population;

– irrational use of freshwater resources, pollution by household waste, runoff from industrial enterprises, agricultural waste, etc.

The problems of restoration and modernization of the water supply and sanitation infrastructure are most acute at the present time in the Black Sea region. In particular, according to the regional state administration of the Odesa region, "There are 47 sewage treatment plants in the region, of which 30 are located in small towns, towns and villages, they work inefficiently and do not provide proper sewage treatment. Of the 129 water pumping stations, 30 % are in need of major repairs and reconstruction, and of the 126 sewage pumping stations, almost 60 % are in need of reconstruction. Most of the sewage treatment facilities, mainly located in the settlements and villages of the region, do not provide regulatory requirements for the quality of sewage treatment. 98 % of the settlements of the region are provided with round-the-clock water supply, including 96 % of the population. In 53 settlements of the region, water supply is carried out according to the schedule" [22]. A similar situation is also observed in Mykolaiv and Kherson regions.

Analyzing the dynamics of indicators of the use of freshwater resources in the context of the regions of the Black Sea region, both positive and negative trends can be identified.

Positive trends include a reduction over the past 10 years in the volume of fresh water use in Mykolaiv (–15.8 %) and Odesa (–14.2 %) regions. In contrast, in the Kherson region, this figure increased by 29 %. In 2019, water withdrawal from surface water bodies in the Odesa region decreased by 60 % compared to 2010. Among the main reasons are the increase in the number of groundwater abstraction facilities and the increase in their capacity, as well as the introduction of new technologies in enterprises that allow more rational use of water. In the Kherson region, the volume of water intake has increased over the past 9 years by 137 %, which is primarily due to the growing needs of the region's agriculture due to climate change. For irrigation in the Kherson region, more than 92 % of the volume of withdrawn water is used. The comparative structure of water use in the context of the main sectors of the economy in the regions of the Black Sea region is shown in **Fig. 4.7**.

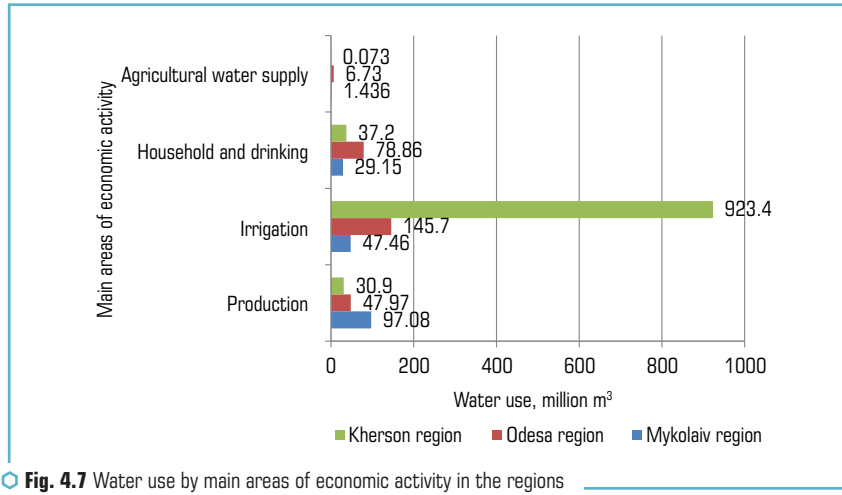

Fig. 4.7 Water use by main areas of economic activity in the regions of the Black Sea region for 2019, million m^3 [23–25]

As positive trends, one should also note the reduction in the volume of discharges of polluted return waters into surface water bodies in all regions of the region, in particular: in the Odesa region by 75 %, Mykolaiv region – 31 % and Kherson region – by 50 %.

Negative trends are the decrease in the volume of recycled and consistently (re)used water in the region by an average of 42 % in the Black Sea region. Among other things, this indicates a gradual reorientation of the region's economy from industrial to agricultural production. There is also a decrease in the capacity of treatment facilities, especially in the Mykolaiv region.

The analysis of the state of provision and trends in the use of freshwater resources in the Black Sea region showed the impact of structural changes in the economy, namely, the reorientation from industrial to agricultural specialization to varying degrees on the use of water resources and the nature of their environmental pollution. The region is unevenly provided with water resources, and the existing potential requires the introduction of innovative models focused on resource saving, improvement of technologies in all processes related to the provision, use and purification of used water.

It should be noted that the formation of innovative models in the field of water management in one aspect or another is reflected in the regional strategies of the regions of the Black Sea region. Thus, in the development strategy of the Odesa region until 2027, the formation of a system of rational water use and the provision of clean drinking water is one of the strategic goals in the context of Strategic Priority 2 "Ecotransformation". In the strategy of the Mykolaiv region, ensuring the rational management of water resources is noted in the operational goal 3.2.2 (implementation of measures to restore the water content of water bodies and protect and protect forests in the forest fund), which is a strategic goal 3 "Conservation and development of territories" as well as an operational goal (promoting the construction, reconstruction and modernization of irrigation systems in Mykolaiv region) within the framework of Strategic Priority 1 "Sustainable Economic Growth of a Diversified Economy", Operational Goal 2.3.1 (development of the drinking water supply and sanitation system). Unfortunately, clear indicative indicators of the implementation of these goals in the context of the planning period have not been established. So, despite the achievements and increased activity of government bodies in the field of water resources development, the problem remains the lack of a clear and integrated approach to the management of freshwater resources in the regions, priority areas for their effective use, control, protection, monitoring, infrastructure development, etc.

Table 4.8 shows the Sustainable Development Goals in the context of the main indicators in the regions of the Black Sea region at the starting positions (2015), as well as the level of their compliance with the average value for Ukraine. These tables highlight the main problems of the region at the initial stage of implementation, which should be addressed by both the efforts of regional governments and the state, as well as the benefits, the development of which should be supported.

While the indicators differ significantly in each region, the vast majority of indicators are higher than the average Ukrainian value. This indicates a relatively good start in the region.

The most problematic in varying degrees for all areas are:

1) a high level of water intensity of GDP, especially in the Kherson region, where this indicator exceeds the average value by 90 times;

2) compliance with sanitary standards of communal water supply sources, which indicates certain problems in the water supply systems, more than 60 % worn out;

3) the level of provision of the population in rural areas with centralized drainage.

Table 4.8 Objectives and indicators of sustainable development in the Black Sea region [4]

Indicators	Mykolaiv region		Odesa region		Kherson region	
	2015	relative to the average for Ukraine (+;–)	2015	relative to the average for Ukraine (+;–)	2015	relative to the average for Ukraine (+;–)
6.1 Ensure the availability of quality safe drinking water services						
Compliance with sanitary standards of rural drinking water sources, %	7.8	0.2	8.7	1.3	2.8	–4.8
Water use for drinking and sanitary needs, m^3 per person	26.7	0.9	35	1.18	36.4	1.23
Compliance with sanitary standards of communal water supply sources, %	3.8	–0.8	7	2.4	2.8	–1.8
Share of rural population with access to centralized water supply, %	57	32.8	35.4	11.2	85	60.8
Share of urban population with access to centralized water supply, %	100	10.6	95.3	5.9	100	10.6
6.2 Ensure the availability of modern drainage systems, construction and reconstruction of water intake and sewage treatment facilities using the latest technologies and equipment						
Share of rural population covered by centralized sewerage, %	3	–1.1	19	14.9	1	–3.1
Share of urban population with access to centralized sewerage systems, %	100	27	85	12	100	27
6.3 Reduce the volume of untreated wastewater discharges, primarily through the use of innovative water treatment technologies at the state and individual levels						
Discharged polluted (without treatment and insufficiently treated) wastewater into water bodies, million m^3	0	0	44	0.05	0	0
Share of discharges of polluted (polluted without treatment and insufficiently treated) wastewater into water bodies in the total volume of discharges, %	0	–87.81	25	3.36	0	–6.67
6.4. Improve water use efficiency						
Water consumption GRP, m^3 of used water per 1000 UAH of GDP (in actual prices)	4.83	1	7.62	1.56	45.51	935

To simplify the implementation of sustainable development indicators in the regional planning system, as well as to improve the information support system for the formation of a model of sustainable innovative development of the water management of the regions, an improvement in

methodological approaches to measuring and evaluating sustainable water use is proposed. The proposed methodological approaches include the following steps:

1) systematization of indicators of water use and their addition in accordance with the three vectors of sustainable development: environmental, social and economic. At the same time, the basic indicators are taken as a basis, since this will allow benchmarking and determining the degree of critical inconsistencies with respect to the accepted benchmarks. The system of characteristics of sustainable water use and relevant indicators is shown in **Fig. 4.8**;

2) analytical assessment tools include a number of calculation steps. The first stage of the calculation is the standardization of the indicators of the region relative to the average value of the corresponding indicators achieved in all regions in the comparative period or the target indicator for this period according to the formulas:

– for indicators that are stimulators of sustainable development:

$$N_{ir} = \frac{I_{ir}^{t}}{\overline{I}_{i}^{t}}; \tag{4.1}$$

– for indicators that are stimulators of sustainable development:

$$N_{ir} = \frac{\overline{I}_{i}^{t}}{I_{ir}^{t}}, \tag{4.2}$$

I_{ir}^{t} – the value of the indicator of sustainable development of water resources in the analyzed year; $\overline{I}_{i}^{t}$ – average (or planned) value of the indicator of sustainable development of water resources in the year under review.

At the next stage, let's determine the growth of indicators in the sustainable development of water resources in the region and on average in Ukraine relative to the base level using the formulas:

– for indicators that are stimulators of sustainable development:

$$\Delta I_{ir} = \left(\frac{I_{ir}^{t}}{I_{ir}^{t_0}} - \frac{\overline{I}_{i}^{t}}{\overline{I}_{i}^{t_0}} \right); \tag{4.3}$$

– for indicators that are stimulators of sustainable development:

$$\Delta I_{ir} = \left(\frac{\overline{I}_{i}^{t}}{\overline{I}_{i}^{t_0}} - \frac{I_{ir}^{t}}{I_{ir}^{t_0}} \right), \tag{4.4}$$

where ΔI_{ir} – the increase in the value of the indicator of sustainable development of water resources in the comparative year relative to the base year and in comparison with the average increase in all regions; $I_{ir}^{t_0}$ – the value of the indicator of sustainable development of water resources in the region in the comparative year; $\overline{I}_{i}^{t_0}$ – average value of the indicator of sustainable development of water resources in the region in the comparative year.

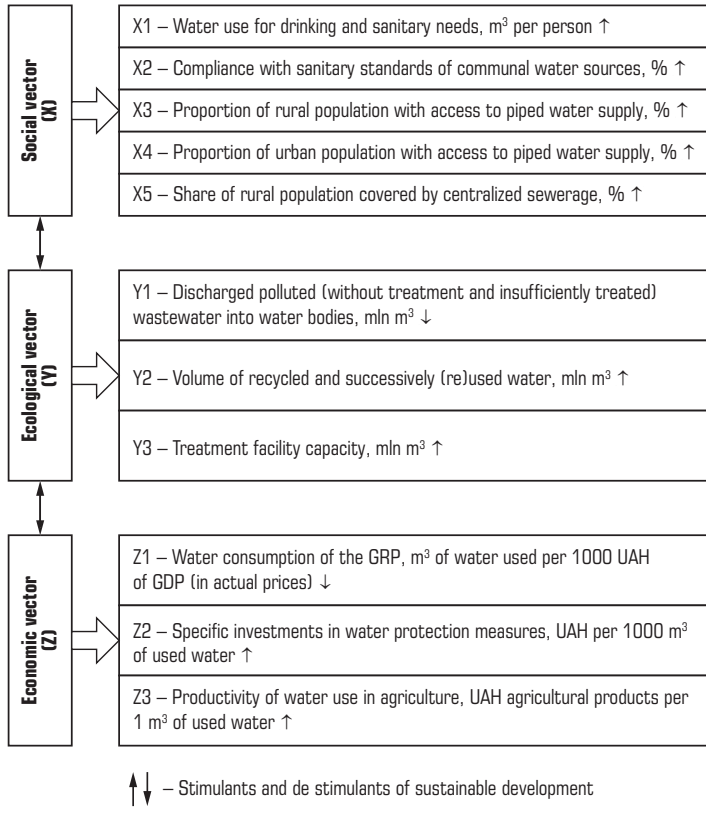

Fig. 4.8 Indicators for assessing the use of water resources in the region in the context of sustainable development [4]

This stage allows to determine the degree of advance or lag of the region in terms of the indicator in comparison with other regions or the degree of lag or advance in achieving planned values.

At the third stage, let's determine the vector of movement of the region, showing its achievements on the path of sustainable development according to a certain indicator relative to the comparative year and other regions according to the formula:

$$V_{ir} = \Delta I_{ir} \times N_{ir}, \tag{4.5}$$

where V_{ir} – the vector of movement of the region according to the i^{th} indicator.

At the last stage, let's determine the degree of achievement of the goals of sustainable development of the region in the context of the social, environmental and economic components. To ensure comparability of the results for each component, the assessment of which may involve a different number of indicators, it is proposed to use a weighting factor. The weighting factor (k) can be determined in accordance with the priority of indicators in the assessment system or by the formula:

$$k_i = \frac{1}{n};\ k \in (0;1), \tag{4.6}$$

where n – the number of indicators.

To determine the total length and direction of the sustainable development vector, the following formula is proposed:

$$X = \sum_{i=1}^{n} V_{ir} \times k_i; \tag{4.7}$$

3) evaluation of results. The results of calculations at each stage make it possible to determine the strengths and weaknesses of the region according to certain indicators. Generalizing indicators highlight the main direction of movement (progress or regression) and the speed of the region's movement in the process of achieving sustainable development goals in comparison with general trends in Ukraine.

Using the proposed approaches, monitoring of the implementation of the goals of sustainable development of water resources in the regions of the Black Sea region for the period 2015–2019 was carried out. The initial data for the calculations are presented in **Table 4.9**.

Indicators and indicators of sustainable development of water resources in Ukraine and regions of the Black Sea region are divided into:

– social vector (X);

– environmental (U);

– economic (Z).

For monitoring, let's calculate indicators and indicators of sustainable development of water resources in Ukraine and the regions of the Black Sea region according to **Fig. 4.8** according to the State Statistics Service of Ukraine.

According to **Table 4.9** and, accordingly, formulas (4.1)–(4.7), the main indicators and indicators of sustainable development of freshwater resources in the Black Sea region were calculated (**Table 4.10**).

In general, the results of the calculations showed that in all areas there is some progress in the context of the transition of the management system of freshwater resources to an innovative model of Sustainable Development. This is evidenced by the obtained values of the vectors, which together characterize the movement as progressive. In the context of individual indicators, one can analyze the position of the region relative to others, as well as the comparative speed of ongoing reforms in the industry. In the context of the implementation of the social vector, it can be

concluded that certain positive developments are observed in all areas. The scores obtained do not differ. The largest number of achievements in this area is in the Odesa region (2.84). Comparatively strong positions of Mykolaiv (5.95) and Odesa regions (2.76) in terms of the vector of economic development are typical, provided by the relatively low water intensity of the GRP, investments in water treatment and a fairly high equal productivity of water use in agriculture. In the Kherson region, the given indicators are below the normative value, and progress in their improvement is insufficient over the past 5 years, which has led to a negative value of the economic vector.

Table 4.9 Indicators and indicators of sustainable development of water resources in Ukraine and Black Sea region [7]

Indicators		Ukraine		Mykolaiv region		Odesa region		Kherson region	
		2015	2019	2015	2019	2015	2019	2015	2019
SOCIAL VECTOR X									
X1	Water use for drinking and sanitary needs, m^3 per person	29.6	27.2	26.7	26	35	33	36.4	36
X2	Compliance with sanitary standards of communal water sources	2.4	2.5	3.8	3.9	7	6.8	2.8	2.5
X3	Proportion of rural population with access to piped water supply	24.2	24.1	57	58	35.4	36	85	84
X4	Proportion of urban population with access to piped water supply	89.9	26	100	100	95.3	97	100	100
X5	Share of rural population covered by centralized sewerage	4.1	4.8	3	3.8	19	21	1	1.8
ECOLOGICAL VECTOR Y									
Y1	Discharged polluted (without treatment and insufficiently treated) wastewater into water bodies, mln·m^3	35,58	18,75	21	20	44	36	0.2	1
Y2	Volume of recycled and successively (re)used water, mln·m^3	1670	1393	3141	3353	120	72	21	18
Y3	Treatment facility capacity, mln·m^3	214,3	203,7	67	56	281	276	102	137
ECONOMIC VECTOR Z									
Z1	Water consumption of the GRP, m^3 of water used per 1000 UAH of GDP (in actual prices)	23.85	10.3	4.83	2.5	7.62	4.39	45.51	42
Z2	Specific investments in water protection measures, 1000 UAH/m^3 of used water	87.5	157.9	23.4	242.7	6.2	38.2	2.4	1.8
Z3	Productivity of water use in agriculture, UAH agricultural products /1 m^3 of used water	37.4	51.5	74.6	86.4	27.9	27.4	7.8	6.2

Table 4.10 Calculation of vectors for sustainable use and development of freshwater resources in the Black Sea region [4]

I	*ki*	Mykolaiv region			Odesa region			Kherson region		
		N_{ir}	ΔI_{ir}	V_{ir}	N_{ir}	ΔI_{ir}	V_{ir}	N_{ir}	ΔI_{ir}	V_{ir}
X1	0.2	1.0	0.06	**1.01**	1.2	0.03	**1.26**	1.3	0.08	**1.41**
X2	0.2	1.6	–0.02	**1.54**	2.7	–0.07	**2.65**	1.0	–0.15	**0.85**
X3	0.2	2.4	0.02	**2.43**	1.5	0.02	**1.51**	3.5	–0.01	**3.48**
X4	0.2	3.8	0.71	**4.56**	3.7	0.73	**4.46**	3.8	0.71	**4.56**
X5	0.2	0.8	0.10	**0.89**	4.4	–0.07	**4.31**	0.4	0.63	**1.00**
X				2.09			2.84			**2.26**
Y1	0.2	0.94	–0.43	**0.51**	0.52	–0.29	**0.23**	18.75	–4.47	**14.28**
Y2	0.4	2.41	0.23	**2.64**	0.05	–0.23	**–0.18**	0.01	0.02	**0.04**
Y3	0.4	0.27	–0.11	**0.16**	1.35	0.03	**1.39**	0.67	0.39	**1.07**
Y				1.22			0.53			**3.30**
Z1	0.4	4.12	–0.09	**4.03**	2.35	–0.14	**2.20**	0.25	–0.49	**–0.25**
Z2	0.4	1.54	8.57	**10.11**	0.24	4.38	**4.62**	0.01	–1.05	**–1.04**
Z3	0.2	1.68	–0.22	**1.45**	0.53	–0.40	**0.13**	0.12	–0.59	**–0.47**
Z				5.95			2.76			–0.61

The results of achieving the Goals of sustainable development of water resources in the regions of the Black Sea region by the main vectors are illustrated in **Fig. 4.9**.

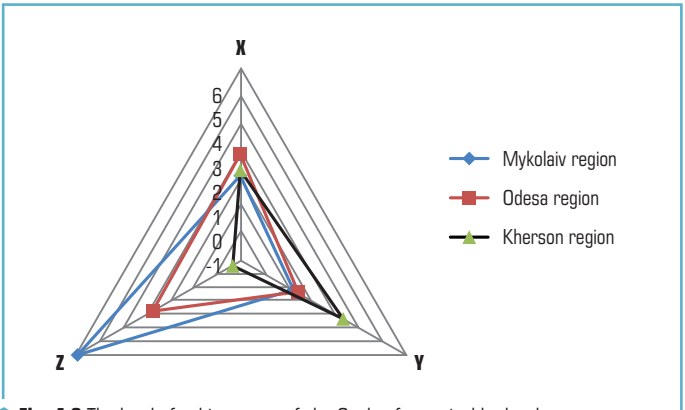

Fig. 4.9 The level of achievement of the Goals of sustainable development of water management in the Black Sea region [4]

Fig. 4.9 clearly shows that management activities aimed at the development and sustainable use of freshwater resources in the region are not sufficiently balanced. The most organic growth within the main vectors is provided in the Odessa region. As it is possible to see, the main priorities in providing water resources to the population and the economy of the region are observed. The high economic return on water use makes it possible to increase investments and current expenditures for the development of water management infrastructure. Somewhat less attention is paid to the environmental component compared to other regions, which should be taken into account when formulating a strategy and regional programs for the development of water resources.

The main priorities of the Mykolaiv region in water management are focused on providing the region's economy with water resources. The social vector also has a positive value, which indicates progress in the water supply system for the population, especially in rural areas. Problematic issues remain the ecological state of surface waters and water bodies associated with large volumes of insufficiently treated wastewater discharged from enterprises and agriculture. An additional problem is also climate change, which makes it necessary to revise the existing irrigation technologies.

Despite the high level of water resources in the Kherson region, their use in the economy and to meet the needs of the population is not effective enough. In the region, the worst among other regions are the implementation of the Sustainable Development Goals in the field of providing the rural population with central water supply and sanitation systems, as well as the quality of water supplied to the population for domestic and sanitary needs.

Thus, the analysis showed that, despite certain positive shifts towards the sustainable use of freshwater resources on the example of the regions of the Black Sea region, it is possible to see that significant progress on this path can only be achieved by enhancing innovation and attracting investment to the industry.

To implement the model of regional management of freshwater resources in the innovative plane, in addition to updating the system of investment and financial support, it is important to use innovative forms of interaction in the field of water use, in particular public-private partnerships. Public-private partnership in the field of water use should comply with the concept of decentralized management of the natural resource potential of territorial development, which is based on the balanced use of financial resources aimed at preserving and restoring natural benefits (**Fig. 4.10**).

Satisfaction of the personal needs of the population in water and the water supply of the economic sphere depend on the management system of water management facilities, which explains the impossibility of completely transferring the latter to the sphere of private property. Therefore, it is necessary to develop the possibility of spreading state ownership with the involvement of entrepreneurial capital in the field of freshwater resources management, which will allow commercializing water management activities and maintaining state control in the water supply system, because the main management tools (taxation, state orders, tariff policy, control over the state of natural resources and the quality of the provided services in the field of water management) remain permanently within the competence of state bodies.

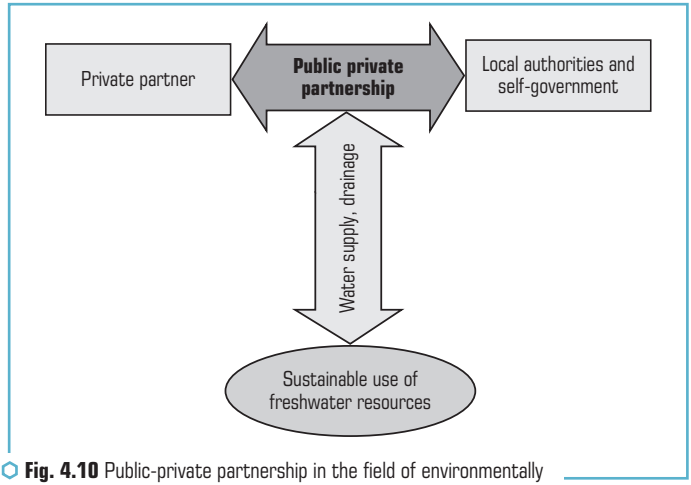

Fig. 4.10 Public-private partnership in the field of environmentally sustainable management of freshwater resources [20]

In the context of decentralization of power in the field of freshwater management, the initiative of local self-government to develop public-private partnerships is activated, because it is the territorial communities that become interested in increasing financial self-sufficiency and efficient use of resources on their territory in order to meet the needs not only for the present, but also for the future generations.

The formation of an innovative model of regional management of freshwater resources in the context of sustainable development requires the transformation of the targets for the functioning of the water management complex in the direction of meeting the needs of present and future generations in freshwater resources, ensuring a safe environment and protection from the natural possibilities of water, which should contribute to the necessary institutional and structural transformations. regions, districts and communities. Consequently, guidelines for the strategic development of the system of regional management of freshwater resources are being formed, in accordance with which social activity acquires significant weight, ensuring a balanced use of natural and economic resources, including human capital, based on the diversification of innovative forms of relationships in the management system itself in the context of institutional transformations.

An innovative model of regional management of freshwater resources in the context of sustainable development should be fully consistent with the goals of sustainable development, i.e. the conceptual unity of the goals of sustainable development and the goals of the development of freshwater territorial systems should be monitored (**Fig. 4.11**).

Sustainable management of freshwater resources lies not only within the framework of the concept of sustainable development of Ukraine and the states of the world, but also in the system of sustainable management of water resources, for which the Ministry of Environmental

Protection and Natural Resources of Ukraine is responsible in our state. "State management of water resources is an activity aimed at overcoming existing water and environmental threats in the country, creating favorable conditions for sustainable, environmentally safe water use, reproduction and protection of all water resources in the country, taking into account their transboundary significance, as well as water ecosystems" [26].

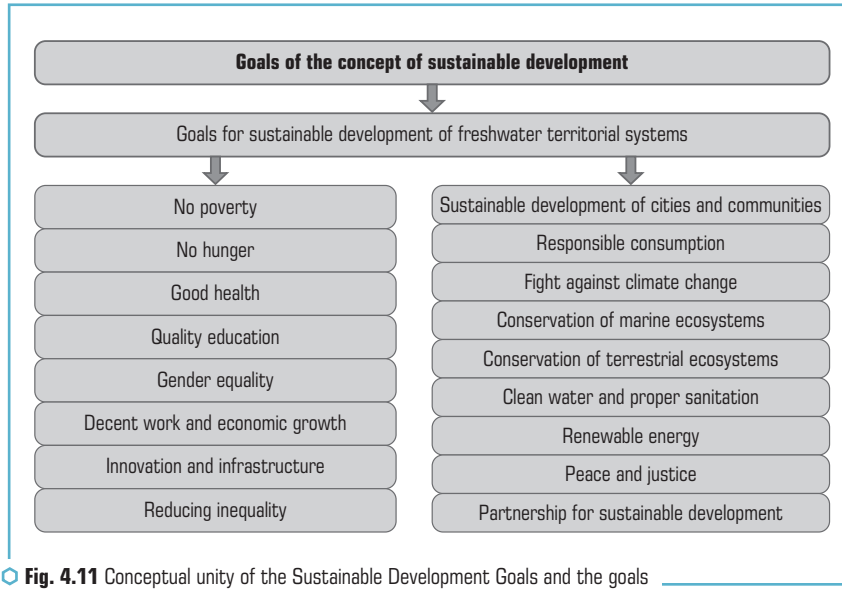

Fig. 4.11 Conceptual unity of the Sustainable Development Goals and the goals of the development of freshwater territorial systems [27]

The socio-humanitarian component in the formation of an innovative model of regional management of freshwater resources, which meets the principles of sustainable development, acquires great importance. In the model of regional management of freshwater resources in the context of sustainable development, there should be a structural subordination of subject-object relationships to objective natural-ecological and economic laws, taking into account the specific manifestations of water management activities (**Fig. 4.12**).

For the effective development of regional environmentally balanced management of freshwater resources, it is important to preserve the laws of proportionality of economic and social development, the use and reproduction of natural resources, the evolution of production relations and the laws of the functioning of the water resource potential of the regions, as the basis for sustainable life support and sustainable economic development.

An equally important direction in the formation of an innovative model of water management is the further implementation of reforms in the management of the industry, as well as the

development and implementation of digital technologies. Such technologies, which are actively used in the system of accounting, monitoring and regulation of water resources, include BIG DATA technologies in countries with developed economies. They make it possible to form a single and interactive platform for accounting for water resources and their use in the context of regions, territories and individual economic entities, which combines data on the ecological state and water balance under the influence of natural phenomena. Integrated GIS-technologies into the system of the cadastre of water resources simplify the accounting systems for water resources in the regions, their quantitative and qualitative characteristics, and also determine their territorial distribution, which will create prerequisites for more effective spatial planning of the development of territories, optimization of housing and communal services, development of agriculture and industry.

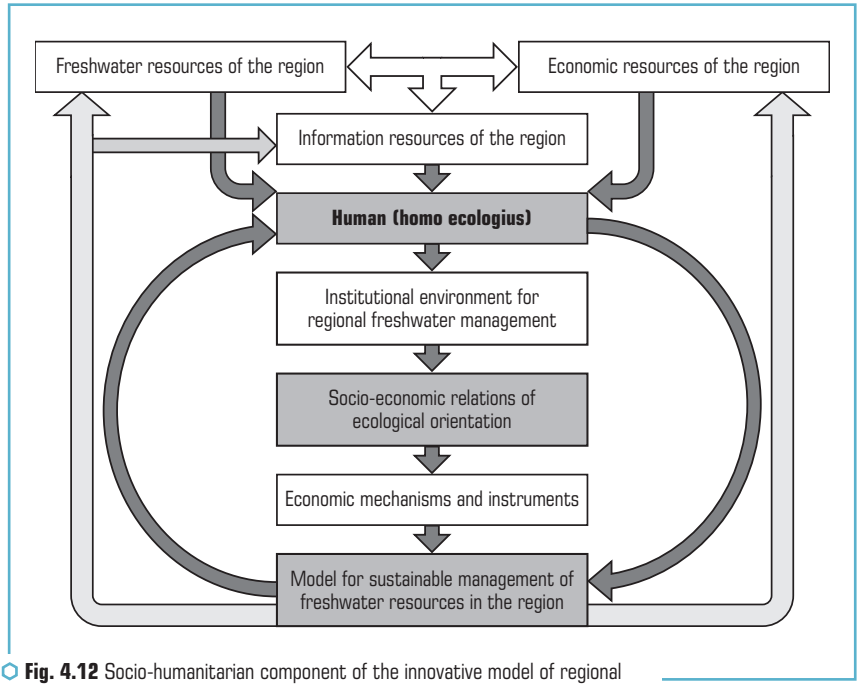

Fig. 4.12 Socio-humanitarian component of the innovative model of regional environmentally balanced management of freshwater resources [4]

Economic innovations create the prerequisites for the growth of funding for the water sector and increase investment, contribute to the growth of public and business confidence in ongoing activities and projects, and stimulate the rational, environmental and conservation use of fresh water in everyday life and production.

CONCLUSIONS

Based on the results of the study, the following conclusions were drawn:

1. It is noted that the effective management of freshwater resources is implemented through the appropriate management functions, which together contribute to the implementation of certain goals for the development of the water complex, ensuring a balance of interests of all subjects of water use, as well as sustainable use of the existing potential in the context of meeting the current needs of the population and the economy, and in the long term.

2. It is substantiated that at the present stage of development of the national economy in the context of global trends, environmental forecasts and social challenges, the obvious and uncontested goal of managing freshwater resources is to ensure a balance between the three vectors of sustainable development (economic, environmental and social), which are the triune imperative of the state and regional policies in the field of development and protection, distribution and use of national resources. The implementation of this goal requires the development of a unified strategy that defines the main imperatives of water policy, which are guidelines for decision-making at all levels, create framework conditions and criteria for using the available water potential, and uniform rules for all participants in the water market.

3. The main components of the national water strategy (regional, sectoral and resource) are identified and characterized, which together will contribute to its implementation in various areas of water management and at different levels of management.

4. The ecological situation and features of the use of freshwater resources in the Black Sea region are analyzed. It has been established that, despite the different levels of provision of territories and the population with freshwater resources in the context of regions, the region is characterized by a number of common problems regarding the state of water supply and the efficiency of using water potential, including: uneven distribution of surface freshwater reservoirs and river flows across the territory of the region; high level of wear of equipment of water infrastructure facilities; poor quality of drinking water for the population; unsustainable use of freshwater resources, household waste pollution, etc.

5. To simplify the implementation of sustainable development indicators in the regional planning system, as well as to improve the information support system for the processes of forming a model of sustainable innovative development of the water management of the regions, methodological approaches to measuring and evaluating sustainable water use have been improved. The proposed approaches include: a detailed system of indicators for assessing the process of sustainable water use in the context of the main vectors of sustainable development, mathematical tools for assessing the progress of the region on the path of sustainable water use and identifying the main problems in the context of individual indicators and indicators, which can become an analytical basis in the process of developing regional strategies for balanced use of resources.

6. The use of the proposed methodological approaches made it possible to assess the sustainable development of freshwater resources in the context of the regions of the Black Sea region,

determine the level of balance in water policy and determine the main strategic tasks for the future. In general, the results of the calculations showed that in all areas there is some progress in the context of the transition of the management system of freshwater resources to an innovative model of sustainable development.

7. The main directions for improving the system of investment support for the innovative development of water management systems in the region are outlined, including: improvement of regulatory and legal support and development of public-private partnerships, including in the form of ESCO contracts; the use of freshwater resources for aquaculture production, which will increase the economic efficiency of the use of surface water bodies, will help attract investment in the industry and strengthen food security; creating conditions for attracting foreign investment, in particular, in the construction and modernization of infrastructure; intensification of work to attract international finance: grants, participation in international programs for the protection and restoration of water resources, etc.

8. A model of sustainable socio-humanitarian and environmentally balanced management of freshwater resources at the regional level has been developed, taking into account innovative forms of interaction in the field of water use (corporatization, clustering, concession, capitalization, creation of holdings and associations) and the important role of public-private partnerships. The proposed model requires the transformation of the target guidelines for the functioning of the water management complex in the direction of meeting the needs of present and future generations in freshwater resources, ensuring a safe environment and protection from the natural possibilities of water, which should contribute to the necessary institutional structural transformations at the level of regions, districts and communities.

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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Mykola Serbov, Inna Irtyshcheva, Olena Pavlenko

Collective monograph

Technical editor I. Prudius
Desktop publishing T. Serhiienko

PC TECHNOLOGY CENTER
Published in December 2022
Enlisting the subject of publishing No. 4452 – 10.12.2012
Address: Shatylova dacha str., 4, Kharkiv, Ukraine, 61165
