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6 SECURITY PARAMETERS OF THE INNOVATIVE ECOSYSTEM

Yuliia Bocharova, Oksana Chernega,
Oleksandr Ishchenko, Yuliia Lyzhnyk

ABSTRACT

It is substantiated that at the present stage of development there is a significant scientific and practical interest in the development of innovative ecosystems, which is due to the importance and role of innovative ecosystems in ensuring the further socio-economic development of countries, their competitiveness and national security. The author's approaches to understanding the essence of the concept of «innovative ecosystem» are analyzed. Two main approaches to understanding the concept of «innovative ecosystem» that have developed in the scientific literature are identified. The links between the concepts of «innovative ecosystem», «innovative infrastructure» and «national innovative system» are analyzed, their common and distinctive features are determined. The author's approach to understanding the essence of the concept of «innovative ecosystem» is proposed. Existing approaches to understanding the life cycle, components and varieties of innovative ecosystems are analyzed and systematized. Approaches to determining the characteristics of security, markers of the effectiveness of innovative ecosystems are analyzed and summarized. A more representative indicator of the development of innovative ecosystems has been identified. A comparative analysis of the characteristics of the functioning and development of innovative ecosystems of the states-leaders of innovative development (top 15 states) was carried out: Switzerland, Sweden, the United Arab Emirates, Great Britain, the Republic of Korea, the Netherlands, Finland, Singapore, Denmark, Germany, France, China, Japan, Hong Kong, Israel. The markers of the effectiveness of innovative ecosystems and their security parameters are determined.

KEYWORDS

National security, innovative development, innovative ecosystem, innovative infrastructure, national innovative system, security parameters.

6.1 THE INNOVATIVE ECOSYSTEM AND ITS ROLE IN ENSURING NATIONAL SECURITY

Modern global risks (Climate action failure, Extreme weather, Biodiversity loss, Social cohesion erosion, Livelihood crises, Infectious diseases, Human environmental damage, Natural resource crises, Debt crises, Geoeconomic confrontation, Digital inequality, etc.) [1] of the world community and individual states to level them, update the issues of ensuring national security for all actors of global interaction both in the short (up to 2 years), and in the medium (2–5 years) and long-term (5–10 years) periods.

Content analysis of works [2–6] allows us to state that:

1) national security – protection and prevention of internal and/or external risks, threats, actions that directly harm and/or threaten national interests (vital values, the implementation of which guarantees the state sovereignty of the country and its progressive development) in economic, scientific, technical , political, as well as in other areas;

2) under the influence of a change in the context of development, both the national interests themselves and the components of national security change.

Study of a number of international institutions [7–13], incl. World Economic Forum (WEF), International Institute for Management Development (MIDM), World Bank (WB), United Nations (UN), Organization for Economic Co-operation and Development (OECD), International Telecommunications Union (ITU), European Commission (EC), McKinsey Global Institute, etc. objectively prove that at the present stage of development of the world community, national interests and national security certainly contain innovative and digital components, which is due to the axiomatic significance of innovations and digital transformations for ensuring socio-economic development.

The innovative and digital components of national security in terms of national interests are described at the present stage of development by the concept of «innovative ecosystem». This is due to the fact that «In the age of non-linear innovation and digital technologies, innovation can be better nurtured within a special, innovation-conducive environment. Such an environment may be seen as an ecosystem meant for co-creation of value through collaboration» [14].

Thus, ITU experts note that «Developing strong innovative ecosystems is a key component of national development, as innovation … is a driver of economic competitiveness and growth in modern economies» [8], «…any country needs three types of ecosystems, i.e. national innovative ecosystem, entrepreneurship ecosystem, and technology ecosystem, to actualize innovation during their journey to reach digital transformation. These three interconnected ecosystems not only support an innovative environment from brainstorming to marketing but also serve as a complement to the Industry's Innovative ecosystem of any country» [15].

WEF specialists are convinced that in the context of the global crisis that arose under the influence of the global COVID-19 pandemic, in order to increase competitiveness and overcome the crisis, countries should focus on 4 issues:

1) reviving and transforming the enabling environment;

2) reviving and transforming human capital;

3) reviving and transforming markets;

4) reviving and transforming the innovative ecosystem [7].

It should be noted that the WEF experts are convinced that in order to overcome the consequences of the crisis, economies should focus their efforts on improving the efficiency of the functioning of innovative ecosystems through «Expand public investments in R&D, and incentivize venture capital and R&D in private sector and the diffusion of existing technologies that support the creation of new firms and employment in «markets of tomorrow» [7]. At the same time, the priorities for the transformation of economies should be Incentivize and expand patient investments

in research, innovation and invention that can create new «markets of tomorrow». Incentivize firms to embrace diversity, equity and inclusion to enhance creativity [7].

In the EU, the development of innovative ecosystems is seen as a tool and mechanism aimed at facilitating the download of companies, support the scaling of companies, encourage innovation and stimulate cooperation among national, regional and local innovation actors [13]. At the same time, the EU has introduced the EU Innovative ecosystem Development Program. contains actions under three (3) destinations: CONNECT (focus on building interconnected, inclusive innovative ecosystems across Europe by drawing on the existing strengths of national, regional and local ecosystems and encouraging the involvement of all actors and territories to set, undertake, and achieve collective ambitions towards challenges for the benefit of society, including green, digital, and social transitions and the European Research Area); SCALEUP (focus on reinforcing network connectivity within and between innovative ecosystems for sustainable business growth with high societal value); INNOVSMES (will support the European Partnership on Innovative SMEs, which will help innovative SMEs to increase their research and innovation (R&I) capacity and productivity and successfully embed in global value chains and new markets) [16]. Budget for the EU Innovative ecosystem Development Program 2021–2022 is 141.63 million EUR [16]. This program is part of the EU Framework Program for Research, Technology and Innovation 2021–2027, a component of the Innovative Europe subprogramme, which accounts for 14 % of the total budget of the said framework program, which is 13.597 million EUR. In total, the development of the EU innovative ecosystem has an allocation of 527 million EUR, which is 0.5 % of the total budget of the EU framework program on research, technology and innovation of the EU for 2021–2027 [10].

Legislators of Ukraine consider the innovative ecosystem as a condition «…ensuring the rapid and high-quality transformation of creative ideas into innovative products and services, increasing the level of innovation of the national economy, which involves creating favorable conditions for the development of the innovation sphere, increasing the number of implemented developments, increasing the economic return from them, attracting investment in innovation activity» [17].

Despite the significant scientific and practical interest in the development of innovative ecosystems, at the present stage of development of science and practice there are a number of opponents of this concept, there is no generally accepted approach to understanding the essence of the concept of «innovative ecosystem», which, on the one hand, is due to the fact that this the concept is relatively new (**Fig. 6.1**), on the other hand, the presence of a number of concepts similar in content, incl. «national innovative system» (NIS), «innovative infrastructure», etc.

Thus, in the Strategy for the Development of the Sphere of Innovation Activity of Ukraine for the period up to 2030, the innovative ecosystem is understood as «a set of institutions, relationships, as well as various types of resources involved in the process of creating and applying scientific knowledge and technologies that ensure the development of innovative activity» [17].

Komorowski Marlen argues that «Innovative ecosystems are … as the structures that are formed between actors that pursue technology development and innovation as one of their objectives» [18]. At the same time, he notes that «The definition is intentionally kept broad as

innovative ecosystems are dynamic structures with multiple and changing actors and actions meaning they are highly complex systems» [18].

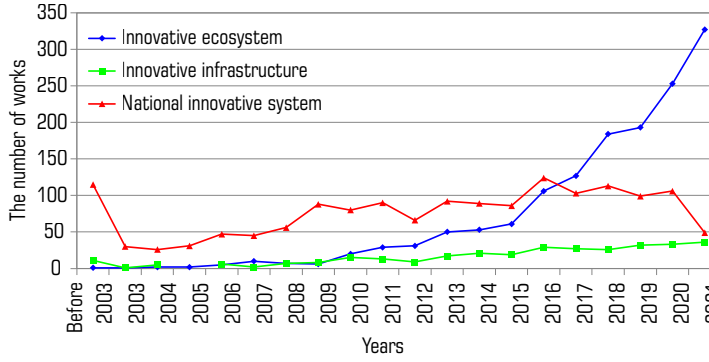

Fig. 6.1 The number of works published in indexed publications in Scopus containing the keywords «innovative ecosystem», «innovative infrastructure», «national innovative system»
Source: compiled by the authors based on data from [19]

Adner, R. is convinced that the innovative ecosystem is «…the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution» [20].

Santos, G. and Zen, A., Bittencourt, B. at the same time note that «an innovative ecosystem can be defined as a set of interdependent actors with conflicting technical, social, economic and political interests, but also converging goals, priorities, expectations and behaviors that cooperate and compete concomitantly in a specific geographical location. Thus, innovative ecosystems are hybrids of different networks and systems with fractal, multilevel, multimodal, multinodular and multilateral configurations, with tangible and intangible dynamic assets designed to promote innovation in a territory» [21].

Bo Liu, Yun-Fei Sha, Guowei Li, and Debing Ni prove that «an innovative ecosystem is a dynamic co-evolutionary network composed of interconnected relationships and interactions among multiple actors. These simultaneously competitive and cooperative interactions foster ecosystem co-evolution toward innovation capabilities, technologies or skills, resources integration, and motivate actors to co-create value and achieve benefits» [22].

Higgins, A. convinced that «An innovative ecosystem is a network of individuals, entities, resources, and structures that join forces in away that catalyzes new products, ideas, methods, systems, and even ways of life» [23].

Smorodinskaya, N., Russell, M., Katukov, D., Still, K., based on the analysis of the economic literature of 2005–2016 devoted to the functioning of ecosystems, incl. Innovative, state that the innovative ecosystem is «networks of sustainable linkages between individuals and organizations,

which emerge from a shared vision of desired transformations and provide an economic context (milieu) to catalyze innovation and growth» [14]. It is noted that «…innovative ecosystems may be treated both as business networks and as communities meant for innovation. They may assume different scale and design, functioning as regional innovation hubs, nation-wide innovation communities, local inter-firm networks, very small network-based ad-hoc groups of individuals, or global wide networks» [14].

According to the approach of WEF experts, «Innovative ecosystems are a complex process that span the generation of ideas, their translation into products, and the commercialization of these products to a large scale. The success of this progression depends on multiple factors, such as a business culture that rewards entrepreneurship, risk-taking and a will to embrace change, a set of regulations and administrative norms that incentivize this attitude, a strong knowledge-generation sector (universities, research centres and laboratories), and collaboration between these knowledge centres and commercial businesses» [7].

Pidoricheva, I. states that an innovative ecosystem means open dynamic network (non-hierarchical) environments consisting of organizations, people and institutions interacting in the creation, use and dissemination of innovations [24].

As ITU experts note, the concept of «innovative ecosystem» should be understood as «system or network of interconnecting and interacting organizations and stakeholders, from multiple sectors, who come together and address the problems people are facing within their communities» [8].

As noted by Anmar Kamalaldin, David Sj odin, Dusana Hullova, Vinit Parida, an innovative ecosystem is «not only a multiplicity of partners, but also a set of relationships that are not decomposable to an aggregation of bilateral interactions» [25]. Thus, the concept of «innovative ecosystem» is most often understood from the standpoint of two approaches: static (as a network of certain institutions and actors, a system) and dynamic (as a process, an affiliated connection).

As for its connection with such concepts as «innovative ecosystem» and «NIS», the content analysis of works [6,14, 24, 26–32] allows us to state that the concepts of «NIS» and «innovative ecosystem» are very similar in terms of At its core, however, if the NIS usually includes institutions and institutions located within certain geographical boundaries, relatively static and regulated by the state, then the innovative ecosystem focuses on dynamics, the interaction of actors, does not have a clear link to geographical boundaries, the main trigger for innovation is the industry, self-regulating [4, 14, 32]; the concept of «innovative ecosystem» is broader than the concept of «innovative infrastructure», the innovative infrastructure is a component of the innovative ecosystem. Thus, the concepts of «innovative ecosystem», «innovative infrastructure» and «NIS» are not synonymous, the innovative ecosystem – a new generation NIS, characterized by openness, dynamism, self-regulation, focuses not so much on its elements themselves and their spatial characteristics, but rather on their interaction. As Gouthanan Pushpananthan and Maria Elmquist note, «Innovative systems are often based on geographical boundaries, labelled using constructs suchas national or regional innovative systems. In contrast, innovative ecosystems allow for cross-sectoral and cross-regional examination of innovation activities» [31].

As noted by Smorodinskaya, N., Russell, M., Katukov, D., Still, K. «…national or regional innovative systems were seen as static structures regulated by government bodies, with successful performance depending on a critical mass of involved actors and intentional infrastructure. As a departure, innovative ecosystems …are considered dynamic and agile collaborative structures that enjoyтself-governance as a necessary prerequisite for interactive innovation… an innovation-conducive environment, comprised of ecosystems and networks, can increase the likelihood that «softer» innovation takes place [14]. At the same time, Pooya Namaayande, Behrouz Zarei emphasize that «An innovative ecosystem models the economic rather than the energy dynamics of the complex relationships that are formed between actors or entities whose functional goal is to enable technology development and innovation. These innovative ecosystems highlight the dynamic nature of innovation in order to create innovative results and innovation performance» [15].

The analysis of sources [26–43] also shows that in scientific, business and political circles there is no consensus not only regarding the understanding of the essence of the concept of «innovative ecosystem», but also its components and varieties, life cycle.

Most often, the life cycle of an innovative ecosystem is presented as a phasic process containing 4 main stages of development: birth (there is a shared understanding among the actors on what are the common objectives, thus assuring the collaboration among them and the delivery of value), expansion (the relationships between the actors are strengthened and the ecosystem grows. The growing ecosystem starts to be competitive and to compete against other ecosystems), leadership (the ecosystem is a leader in one or more features, being more and richer in networks and generating value, as the competitiveness and complexity grow, the issues related to the coordination of the ecosystem improve simultaneously), and self-renewal or death (the ecosystem must explore new knowledge to invigorate or be terminated due to not being competitive anymore) [20, 31]. In this case Bo Liu, Yun-Fei Sha, Guowei Li, and Debing Ni. They stated that «Ecosystems arise when there is a balance between centripetal and centrifugal forces, that is, when there are benefits of coordination as well as benefits of autonomy» [22].

Anmar Kamalaldin, David Sj ödin, Dusana Hullova, Vinit Parida argue that ecosystems in general, including the innovative ecosystem, include 4 main elements:

1) activities, which specify the discrete actions to be undertaken in order for the value proposition to materialize;

2) actors, which are the entities that undertake the activities (a single actor may undertake multiple activities; conversely, multiple actors may undertake a single activity);

3) positions, which specify where in the flow of activities across the system actors are located and characterize who hands off to whom;

4) links, which specify transfers across actors (The content of these transfers can vary-matériel, information, influence, funds. Critically, these links need not have any direct connection to the focal actor) [25].

Gouthanan Pushpananthan, Maria Elmquist come to similar conclusions, noting that «…the term «innovative ecosystem» includes all value creating activities performed by an evolving network of actors

integrating their products and services on a technology platform. In such collaborative networks, interaction among firms is both complex and critical, and combines cooperation and competition» [31].

So, the main elements of innovative ecosystems are actors and their roles, connections between actors.

The diversity of innovative ecosystems is explained by the plurality of approaches for scientists to understand the essence of the concept of «innovative ecosystem», the plurality of criteria for their differentiation.

So, Pidoricheva, I. identifies four types of innovative ecosystems: ecosystems organized around a focal (central) firm; ecosystems as «structures» built around a focal value proposition (focus innovation); ecosystems as certain environments (spaces) formed at different levels – from local to global; ecosystems as platforms around which the activities of various stakeholders are organized» [24].

Gouthanan Pushpananthan, Maria Elmquist note that the varieties of innovative ecosystems depend on who is its founder, noting that «an ecosystem comprises of a set of actors with varying degrees of multilateral, non-generic complementarities that are not fully hierarchically controlled». The activities of the actors within an ecosystem are orchestrated by the ecosystem leader(s) or keystone firm(s). A keystone firm is responsible for the ecosystem's overall 'health' and ensures that value is shared amongst the ecosystem participants… Typically, the interactions in an innovative ecosystem are organized around a technology platform with a modular architecture» [31]. Higgins, A. distinguishes 3 types of innovative ecosystems: City innovative ecosystem, Industry innovative ecosystem, Corporate innovative ecosystem [23].

Komorowski Marlen notes that «…innovative ecosystems are highly divers and there are no clear archetypes of innovative ecosystems, but rather a multitude combining very divers criteria» [18]. In this regard, the author proposes to differentiate innovative ecosystems based on 9 criteria (Number of innovative ecosystem actors, Types of actors involved, Expertise and industry sectors, Development stage, Scale of operation, Central entity (organised or unorganised), Leading/initiating actor(s), Actions/goals), but notes that these 9 criteria, although they are basic, are not exhaustive [18]. Komorowski Marlen notes that «…innovative ecosystems are often built around technology parks and integrate research organisations and public agencies. Innovative ecosystems in medium-sized cities have often large enterprises involved, municipalities and are larger small ecosystems of less than 50 actors. Large cities often host innovative ecosystems that are built around formal networks, which involve formal networks and integrate more than 1000 actors. Innovative ecosystems in very large cities integrate actors like universities and more often also venture capital and banks are involved. Cluster organisations are in place. These four archetypes are just highlighting which kind of combinations of the criteria of the model developed above are found often together» [18].

MTS experts identify varieties of innovative ecosystems by specialization, noting that the most important and influential today are innovative ecosystems specializing in ICT development, digital innovative ecosystems [8].

The team of authors of [21] proposes to differentiate innovative ecosystems according to specific models and/or strategies of state regulation [21]. As noted by Santos, G. and

Zen, A., Bittencourt, B. «The simplest mode is shared governance, where a group of organizations collectively works as a network despite not possessing a structure of exclusive and formal management. The second mode is the lead organization-governance, which typically occurs in relationships formed by a bigger, more powerful organization and a set of lesser, weaker firms (Provan & Kenis, 2008). The third mode is the network administrative organization (NAO), where an administrative entity is created, especially to manage thenetwork and its activities» [28].

Consequently, innovative ecosystems can be differentiated by: size and spatial position, level of development, structure-forming institution, specialization, etc. Depending on the approach to understanding the essence of the concept of «innovative ecosystem», its varieties, approaches to understanding the key actors and stakeholders in the scientific literature differ significantly. Thus, MTS identifies the following stakeholders of the innovative ecosystem: Academia, Entrepreneurs, Entrepreneurial support networks, Financiers, Private sector, Public sector [8]. At the same time, Pooya Namaayande, Behrouz Zarei single out such «…the four key actors of an innovative ecosystem are: equipment providers; network operators; content and app providers, and end users. Except for the vertical relationships between the actors that determine the overall shape of the ecosystem, horizontal relationships in each layer of the ecosystem are of special importance» [15]. Rissola, G., Haberleithner, J. note that the actors of innovative ecosystems depend on the ecosystem itself. They divide the actors of the innovative ecosystem into the following groups: the four key actors of an innovative ecosystem are: equipment providers; network operators; content and app providers, and end users. Except for the vertical relationships between the actors that determine the overall shape of the ecosystem, horizontal relationships in each layer of the ecosystem are of special importance» [15]. Thus, most researchers define the actors of the innovative ecosystem based on the Quadruple Helix Model and argue that the relationships between the actors within the innovative ecosystem are symbiotic.

6.2 SUCCESS PARAMETERS OF INNOVATIVE ECOSYSTEMS

Despite the fact that innovative ecosystems in one form or another have been formed and are functioning in all countries of the world, they differ significantly in terms of efficiency, which affects their ability to ensure the achievement of national interests and, consequently, ensure national security.

As WEF experts note, «Over the past 20 years, large cross-country innovation divides have not diminished. Just five countries today produce together over 70 % of global patent activity, and the top 10 countries generate over 85 % of global patent shares. These levels of concentration have remained in place for the past 20 years, with the exception of China and Korea» [7]. As the WEF experts note, «This adds to the widening of the productivity divide between top companies and the rest – and leading to economies that are increasingly polarized and unequal» [7].

Merhaba, A., Thuriaux-Alemán, B., Ghanem, E., Aebi, T., Takchi, Y., Alsalloum, N. come to similar conclusions, arguing that «Innovation is key in driving social and economic development and bridging the wealth gap between emerging and developed countries. Over the last 50 years, only a few

countries, such as South Korea and Singapore, have succeeded in unlocking the full benefits of nation-wide innovation. Instrumental to their success is a systematic approach tackling innovation in a holistic manner that captures policy, governance, innovation engines and innovation enablers to shape their innovative ecosystem and bridge systemic and market gaps» [26].

Content analysis of sources [8, 15, 18, 25, 26, 30, 42] suggests that the performance or efficiency parameters of innovative ecosystems are quite different. Proponents of a dynamic approach to understanding the essence of the concept of «innovative ecosystem» propose to evaluate the effectiveness of an innovative ecosystem based on the breadth of the ecosystem itself, the number of participants in it, supporters of a static approach – based on its ability to create value, innovation.

At the same time, MTS experts emphasize that «Out of the estimated 300 million start-ups in the world, very few of them will become high-growth firms because their ecosystems are missing essential elements for success» [8]. They are convinced that in order to ensure competitiveness, any ecosystem, including innovation, must ensure the effectiveness of four main elements: (a) governance; (b) linkages; (c) capacity and (d) focus [8].

Komorowski Marlen notes that «Innovative ecosystems are highly complex structures. A one size fits all strategy for ecosystem development does not exist» [18], but it convincingly proves that ecosystems characterized by a certain set of parameters are relatively more successful than others. According to the results of a comparative study by Komorowski Marlen, the most successful are: innovative ecosystems that operate on a national or international level (around 70 % of experts); innovative ecosystems that have an incubator as central entity (around 80 % of experts); innovative ecosystems that were initiated by a single leading individual (100 % of experts); innovative ecosystems focusse its actions and goals on innovation and technology development, industry growth and firm creation, or provision of education and training (more than 60 % of ecosystems) [18]. At the same time, Komorowski Marlen notes the need to use the 7 P framework (Place, Proximity, Population, Profile, Path-dependency, Policy, Performance) [18] in the analysis of innovative ecosystems [18].

Erkko Autio, Llewellyn D. W. Thomas note that «A healthy ecosystem is productive, in that it consistently transforms technology and other inputs to innovation into lower costs and new markets, and robust, i.e., capable of surviving disruptions such as unforeseen technological change and able to create niches to increase meaningful diversity» [42].

Experts from The International Development Innovation Alliance (IDIA) argue that successful innovative ecosystems are those that have been able to achieve the following nine goals:

1. Building informed human capital.
2. Ensuring accessibility of finance for innovation processes.
3. Establishing supportive research, markets, energy, transport, and communications infrastructure.
4. Creating enabling policies and regulations.
5. Nurturing a culture supportive of innovation and entrepreneurship.
6. Supporting networking assets that enable productive relationships between different actors.
7. Ensuring equal and inclusive ecosystem governance and participation.

8. Creating smoother pathways to scale for specific innovations.

9. Mobilising a collective ecosystem approach to address a particular development challenge» [11].

Analysis and systematization of the parameters of the success of innovative ecosystems allows us to state that they are manifested in the indicators and results of the innovative development of countries, the parameters of the functioning and development of the innovative ecosystems themselves, incl. the number of enterprises engaged in innovative activities included in the innovation process, the volume of innovative export/import, the volume of production and sales of innovative products, etc.

6.3 DIAGNOSTICS OF INNOVATIVE ECOSYSTEMS OF THE LEADING COUNTRIES OF INNOVATIVE DEVELOPMENT

An analysis of works [8, 11, 14, 18, 24, 26, 30–42] shows that today the most representative and authoritative indicator that can be used to assess the effectiveness of innovative ecosystems, determine their safe parameters, is the Global Innovation Index (GII).

According to the Global Innovation Index ratings, at the present stage of development, the most effective innovative ecosystems are countries such as: Switzerland, Sweden, the United Arab Emirates, Great Britain, the Republic of Korea, the Netherlands, Finland, Singapore, Denmark, Germany, France, China, Japan, Hong Kong, Israel. Almost all (the exception is China) leading countries in the development and efficiency of the innovative ecosystem are countries with high per capita incomes, most of them are European countries (**Table 6.1**).

Table 6.1 Leading countries Global Innovation Index ratings

Rank	2015	2021	Leading countries in 2015–2021
1	Switzerland	Switzerland	Switzerland, United Kingdom, Sweden, Netherlands, United States of America, Finland, Singapore, Denmark, Hong Kong, Germany, Republic of Korea
2	United Kingdom	Sweden	
3	Sweden	United States of America	
4	Netherlands	United Kingdom	
5	United States of America	Republic of Korea	
6	Finland	Netherlands	
7	Singapore	Finland	
8	Ireland	Singapore	
9	Luxembourg	Denmark	
10	Denmark	Germany	
11	Hong Kong	France	
12	Germany	China	
13	Iceland	Japan	
14	Republic of Korea	Hong Kong, China	
15	New Zealand	Israel	

Source: compiled by the author based on data [43]

The leading countries of innovative development, despite the specific features of the formation and development of innovative ecosystems, are characterized by relative similarity. Thus, in all these countries, relatively high indicators of the effectiveness of the institutional conditions for the development of innovative ecosystems are recorded (**Table 6.2**).

The average value for this indicator for the leading countries of innovative development is 84.8 (100-point scale, 0 is the minimum value, 100 is the maximum), the coefficient of variation of the parameter value within the specified group of countries is 9.1 %, which indicates an insignificant level variations in country estimates for the specified parameter.

As evidenced by the analysis of the institutional environment of the leading countries of innovative development, these countries are characterized by a stable political environment and favorable to innovative transformations (business environment).

Thus, the average indicator for the «Political and operational stability» (Government effectiveness) parameter for the leading countries of innovative development is 85 (100-point scale, 0 is the minimum value, 100 is the maximum), the coefficient of variation of the parameter value is within the specified group of countries 9.8 %, which indicates an insignificant level of variation in the estimates of countries for this parameter (**Table 6.3**).

The average indicator for the parameter «Business environment» (Ease of starting a business; Ease of resolving insolvency) for the leading countries of innovative development is 84.6 (100-point scale, 0-minimum value, 100-maximum), coefficient of variation of the value parameter within the specified group of countries is 6.7 %, which indicates an insignificant level of variation in country estimates for this parameter. At the same time, attention should be paid to the fact that the leading countries in innovative development are characterized by relative variability in the regulatory environment. Thus, the average indicator for the «Regulatory environment» parameter (Regulatory quality; Rule of law; Cost of redundancy dismissal) for the leading countries of innovative development is 84.8 (100-point scale, 0-minimum value, 100-maximum), coefficient variation in the value of the parameter within the specified group of countries is 15.6 %, which indicates an average level of variation in the estimates of countries for the specified parameter.

In addition, the leading countries in innovative development are characterized by a relatively high average score for the Market sophistication parameter. Thus, the average value for this indicator for the leading countries of innovative development is 65.1 (100-point scale, 0 is the minimum value, 100 is the maximum), the coefficient of variation of the parameter value within the specified group of countries is 12 %, which indicates an average level variations in country estimates for the specified parameter.

A detailed analysis of the components of the «Market sophistication» parameter of the leading countries of innovative development suggests that these countries are characterized by comparative efficiency and similarity in terms of the «Trade, diversification, and market scale» parameter (Applied tariff rate, weighted avg., %; Domestic industry diversification; Domestic market scale, bn PPP$). Thus, the average rating of the leading countries in innovative development for the above parameter is 82.4, the coefficient of variation is 8.1 %, which indicates a low level of variation in the assessments of these countries (**Table 6.4**).

● **Table 6.2** Features of the functioning of innovative ecosystems of the leading countries in innovative development in 2021

Countries	Institutions		Human capital and research		Infrastructure		Market sophistication		Business sophistication		Knowledge and technology outputs		Creative outputs	
	grade	place	grade	place	grade	place	grade	place	grade	place	grade	place	grade	place
Switzerland	87.3	13	60.7	6	62.7	2	71.5	6	62.6	4	63.9	1	60.2	2
Sweden	88.8	9	64.1	2	62.6	3	64.6	11	68.1	1	60.3	2	52.9	5
UAE	78.4	30	49.9	22	58.1	14	56.7	26	47.2	22	22.2	59	33.8	40
Great Britain	86.6	15	58.2	10	59.7	10	78.1	4	49.7	21	52.3	10	54.4	4
The Republic of Korea	79.5	28	67.4	1	59.2	12	60	18	60.1	7	54.5	8	52.1	8
Netherlands	88.9	6	55.9	14	57.7	16	55.2	31	61	5	54.8	7	52.2	7
Finland	93.3	2	62.4	2	59.5	11	58.7	19	61	6	56.5	5	42.9	16
Singapore	95.1	1	58.7	9	57.8	15	75.9	5	62.7	3	48.1	13	42.9	17
Denmark	88.8	8	62.3	5	60.8	5	68	7	55.2	11	47.6	14	47.7	13
Germany	84.3	17	62.7	3	55.6	21	57.8	20	54.5	12	53.3	9	50	11
France	83.4	19	55.4	15	57.1	17	61	17	50.4	19	44.3	16	52.6	6
China	64.4	61	50.3	21	54.6	24	61.5	16	54.3	13	58.5	4	46.5	14
Japan	88.8	7	50.8	20	59.8	9	62.1	15	57.3	10	48.3	11	42.1	18
Hong Kong	88.1	11	48.6	25	60.3	6	78.7	3	45.2	24	21.6	62	64.7	1
Israel	76.2	34	51.6	19	50.2	40	66.8	8	58.7	8	55.9	6	36.3	30
Mean	84.8	17.4	57.3	11.6	58.4	13.7	65.1	13.7	56.5	11.1	49.5	15.1	48.8	12.8
Variation coefficient	9.1	89.8	10.5	71.9	5.5	70.5	12.0	61.0	11.4	66.5	24.9	125.0	17.1	83.3

Source: compiled by the author based on data [43]

Table 6.3 Features of innovate ecosystems of the leading countries in innovative development in 2021 («Institutions» parameter)

Countries	Institutions		Political environment		Regulatory environment		Business environment	
	grade	place	grade	place	grade	place	grade	place
Switzerland	87.3	13	92.4	3	93.9	7	75.5	47
Sweden	88.8	9	89.4	8	90.5	13	86.3	16
UAE	78.4	30	78.6	24	84.5	21	72	61
Great Britain	86.6	15	80	21	92.4	9	87.4	12
The Republic of Korea	79.5	28	82.1	18	68.2	57	88.1	10
Netherlands	88.9	6	88.4	9	88.9	14	89.4	5
Finland	93.3	2	90.9	5	95.9	5	93.1	1
Singapore	95.1	1	100	1	99.1	1	86.3	17
Denmark	88.8	8	92.8	2	84.6	20	88.9	6
Germany	84.3	17	85.2	14	81.1	29	86.7	14
France	83.4	19	79.9	22	86.3	17	83.9	22
China	64.4	61	65.3	47	49.9	106	78.1	39
Japan	88.8	7	87	11	91.4	11	88.2	9
Hong Kong	88.1	11	86.3	12	96.1	4	81.9	28
Israel	76.2	34	76.6	28	68.6	53	83.4	24
Mean	84.8	17.4	85.0	15.0	84.8	24.5	84.6	20.7
Variation coefficient	9.1	89.8	9.8	81.4	15.6	114.3	6.7	81.3

Source: compiled by the author based on data [43]

At the same time, according to such parameters as «Credit» (Ease of getting credit; Domestic credit to private sector, % GDP; Microfinance gross loans, % GDP) and «Investment» (Ease of protecting minority investors, Market capitalization, % GDP; Venture capital investors, deals/bn PPP$ GDP; Venture capital recipients, deals/bn PPP$ GDP), the assessments of the leading countries in innovative development vary significantly and are not characterized by a high level of efficiency – the average assessment of this group of countries is 58.7 and 54.2, respectively, the coefficients of variation are 19.9 % and 35.4 %, respectively. Thus, the assessments of countries vary the most in the Investment parameter. Leading countries in innovative development have comparative success in infrastructure development, which contributes to innovative development. Thus, the average rating of the leading countries in terms of the Infrastructure parameter is 58.4, the coefficient of variation is 5.5 %.

● **Table 6.4** Features of innovative ecosystems of the leading countries innovative development in 2021 (parameter «Market sophistication»)

Countries	Market sophistication		Credit		Investment		Trade diversification and market scale	
	grade	place	grade	place	grade	place	grade	place
Switzerland	71.5	6	69.2	7	70.6	10	74.6	46
Sweden	64.6	11	57.6	17	54.8	16	81.4	24
UAE	56.7	26	50.6	28	41.1	34	78.4	34
Great Britain	78.1	4	65.3	10	80	5	89.1	3
The Republic of Korea	60	18	64.2	12	31.5	65	84.2	16
Netherlands	55.2	31	43	57	39.5	37	83	20
Finland	58.7	19	49.4	34	48.2	22	78.5	32
Singapore	75.9	5	62.5	13	88.4	1	76.6	39
Denmark	68	7	68.5	8	58.6	13	76.9	37
Germany	57.8	20	51.2	27	32.5	60	89.8	2
France	61	17	47.2	43	48.2	21	87.6	8
China	61.5	16	51.7	26	35.9	44	96.9	1
Japan	62.1	15	64.2	11	34.3	51	87.9	5
Hong Kong	78.7	3	87.5	2	75.2	6	73.5	51
Israel	66.8	8	48	39	74.4	7	77.9	36
Mean	65.1	13.7	58.7	22.3	54.2	26.1	82.4	23.6
Variation coefficient	12.0	61.0	19.9	70.7	35.4	80.6	8.1	72.2

Source: compiled by the author based on data [43]

The leading countries of innovative development in terms of infrastructure have achieved the greatest success in the development of information and telecommunications infrastructure, which is quite logical, because in order to ensure effective interaction between the elements of the innovative ecosystem, advanced information and telecommunications technologies are needed. Thus, the average score of the leading countries in innovative development in the parameter «Information and communication technologies technologies «ICTs» (ICT access; ICT use; Government's online service; E-participation) is 87.5, the coefficient of variation is 5.9 % (**Table 6.5**).

Despite the comparative effectiveness of measures aimed at the development of innovation-friendly infrastructure, the infrastructure in the leading countries of innovative development still requires significant attention, first of all it concerns the «General infrastructure» (Electricity output, GWh/mn pop.; Logistics performance; Gross capital formation, % GDP). Thus, the average

assessment of the leading countries in terms of the General infrastructure parameter is 44.3, while the assessments of countries are characterized by an average level of variability in these parameters – the coefficient of variation is 15.2 %.

As for «Ecological sustainability» (GDP/unit of energy use; Environmental performance; ISO 14001 environmental certificates/bn PPP$ GDP), the leading countries should also pay attention to it. The average assessment of the leading countries in innovative development in this parameter is 43.3 %, the coefficient of variation is 19.5 %.

The next feature of the innovative ecosystems of the leading countries in innovative development is their comparative efficiency in terms of the «Human capital and research» parameter. The average rating of the leading countries in innovative development for this parameter is 57.3, the coefficient of variation is 10.5 % (**Table 6.6**).

Table 6.5 Features of innovative ecosystems of the leading countries innovative development in 2021 (Infrastructure parameter)

Countries	Infrastructure		Information and communication technologies (ICTs)		General infrastructure		Ecological sustainability	
	grade	place	grade	place	grade	place	grade	place
Switzerland	62.7	2	87.8	15	42.1	24	58.1	2
Sweden	62.6	3	84.8	22	53.3	6	49.6	17
UAE	58.1	14	88.8	12	52.9	7	32.7	51
Great Britain	59.7	10	93.4	2	34.7	40	50.9	14
The Republic of Korea	59.2	12	94.8	1	49.4	11	33.4	50
Netherlands	57.7	16	90.8	4	41.1	29	41.3	34
Finland	59.5	11	86.8	17	48.8	12	42.9	30
Singapore	57.8	15	90.5	7	46.7	15	36.3	42
Denmark	60.8	5	91	3	39.6	31	51.7	11
Germany	55.6	21	80.2	32	44.2	20	42.3	32
France	57.1	17	87.7	16	42.2	23	41.4	33
China	54.6	24	79.4	34	54.4	5	29.9	59
Japan	59.8	9	90.1	8	46	16	43.2	28
Hong Kong	60.3	6	89.6	10	35.4	39	55.7	4
Israel	50.2	40	76.6	45	33.7	45	40.3	35
Mean	58.4	13.7	87.5	15.2	44.3	21.5	43.3	29.5
Variation coefficient	5.5	70.5	5.9	85.8	15.2	60.2	19.5	58.3

Source: compiled by the author based on data [43]

● **Table 6.6** Features of innovative ecosystems of the leading countries innovative development in 2021 (parameter «Human capital and research»)

Countries	Human capital and research		Education		Higher education		Research and Development	
	grade	place	grade	place	grade	place	grade	place
Switzerland	60.7	6	61.3	24	45.1	21	75.8	3
Sweden	64.1	2	74.3	4	43.9	25	74.1	5
UAE	49.9	22	52	61	59.2	3	38.6	28
Great Britain	58.2	10	59.7	28	47.4	18	67.7	9
The Republic of Korea	67.4	1	61.5	22	51	13	89.8	1
Netherlands	55.9	14	62.4	20	40.1	39	65	11
Finland	62.4	2	69.6	9	51.1	12	66.6	10
Singapore	58.7	9	54	54	63.1	2	59.1	15
Denmark	62.3	5	74.2	5	43.3	30	69.5	7
Germany	62.7	3	60.1	27	54.7	5	73.2	6
France	55.4	15	60.5	26	42.0	38	63.7	12
China	50.3	21	66.7	12	25.2	83	59.8	14
Japan	50.8	20	54.1	53	24.1	87	74.3	4
Hong Kong	48.6	25	58.1	37	51.1	11	36.4	30
Israel	51.6	19	58.1	38	28.6	77	68	8
Mean	57.3	11.6	61.8	28.0	44.7	30.9	65.4	10.9
Variation coefficient	10.5	71.9	11.0	63.4	25.9	93.7	20.8	77.0

Source: compiled by the author based on data [43]

Compared with the greatest success, the leading countries of innovative development have achieved the parameter (Researchers, FTE/mn pop.; Gross expenditure on R&D, % GDP; Global corporate R&D investors, top 3, mn US$; QS university rating, top 3). Thus, the average assessment of the leading countries in innovative development for this parameter is 65.4 %, the coefficient of variation is 20.8 %.

The next level of achievement among the leading innovative development countries is education (Expenditure on education, % GDP; Government funding/pupil, secondary, % GDP/cap; School life expectancy, years; PISA scales in reading, maths and science; Pupil-teacher ratio, secondary). Thus, the average rating of the countries-leaders of innovative development in the «Education» parameter is 61.8, the coefficient of variation is 11 %.

As far as higher education is concerned, the leading countries in innovative development have much smaller and more scattered successes. Thus, the average assessment of the leading

countries in innovative development in terms of the «Higher education» parameter (Tertiary education; Tertiary enrolment, % gross; Graduates in science and engineering, %; Tertiary inbound mobility, %) is 44.7, the coefficient of variation is 25.9 %.

In addition, the leading countries in the innovation rating are characterized by relatively high indicators that determine business sophistication. Thus, the average score of the leading countries in innovative development in terms of the Business sophistication parameter is 56.5, and the coefficient of variation is 11.4 % (**Table 6.7**).

● **Table 6.7** Features of innovative ecosystems of the leading countries innovative development in 2021 (parameter «Business sophistication»)

Countries	Business sophistication		Knowledge workers		Innovation linkages		Knowledge absorption	
	grade	place	grade	place	grade	place	grade	place
Switzerland	62.6	4	71.4	5	63.9	4	52.4	11
Sweden	68.1	1	77.3	3	70.3	2	56.6	6
UAE	47.2	22	51.4	26	42.5	21	47.7	16
Great Britain	49.7	21	61.2	14	47	17	40.7	27
The Republic of Korea	60.1	7	78.1	1	48.3	15	54	8
Netherlands	61	5	61.4	13	54.8	10	66.9	2
Finland	61	6	66	7	70.1	3	46.7	17
Singapore	62.7	3	65.3	10	52	13	70.7	1
Denmark	55.2	11	65.8	8	58.6	7	41.1	26
Germany	54.5	12	65	12	54.2	12	44.3	21
France	50.4	19	61	16	40.9	23	49.3	13
China	54.3	13	77.7	2	31.3	32	53.9	9
Japan	57.3	10	65.2	11	46.4	18	60.3	3
Hong Kong	45.2	24	44.6	35	40.8	24	50.1	12
Israel	58.7	8	61.2	15	82.1	1	33	48
Mean	56.5	11.1	64.8	11.9	53.5	13.5	51.2	14.7
Variation coefficient	11.4	66.5	14.2	76.4	25.3	68.2	19.4	83.5

Source: compiled by the author based on data [43]

The leading countries of innovative development achieved the greatest success in the direction of providing business sophistication in terms of the «Knowledge workers» (Knowledge-intensive employment, %; Firms offering formal training, %; GERD performed by business, % GDP; GERD financed by business, %; Females employed w/advanced degrees, %), which indicates the

success of structural transformations of economies countries of this group – their innovative reorientation. Thus, the average assessment of the leading countries in innovative development for this parameter is 64.8 %, the coefficient of variation is 14.2 %.

In addition, the leading countries in innovative development demonstrated comparative performance in the direction of the development of Innovation links. Thus, the average rating of the leading countries in innovative development in terms of the Knowledge workers» (Knowledge-intensive employment, %; Firms offering formal training, %; GERD performed by business, % GDP; GERD financed by business, %; Females employed w/advanced degrees, %) is 53.5, the coefficient variations – 25.3 %.

Comparative success of the leading innovative development countries in terms of ««Knowledge absorption» (Intellectual property payments, % total trade; High-tech imports, % total trade; ICT services imports, % total trade; FDI net inflows, % GDP; Research talent, % in businesses) is not very high. Thus, the average score of the countries of this group in terms of the Knowledge absorption parameter is 51.2, the coefficient of variation is 19.4 %.

Comparison of the performance of the leading countries in innovative development in terms of «Knowledge and technology outputs» and «Creative outputs» suggests that the leading countries in innovative development are more successful in the first parameter. Thus, the average rating of the leading countries in the innovation rating for the Knowledge and technology outputs parameter is 49.5, and for the Creative outputs parameter – 48.8. However, the scores of countries in the Knowledge and technology outputs parameter differ more in the averages of this group than the scores in the Creative outputs parameter, 24.9 % and 17.1 %, respectively (**Table 6.8**).

The innovation leader countries achieved the greatest success in terms of «Knowledge creation» (Patents by origin/bn PPP$ GDP; PCT patents by origin/bn PPP$ GDP; Utility models by origin/bn PPP$ GDP; Scientific and technical articles/bn PPP$ GDP; documents H-index). Thus, the average assessment of this group of countries for this parameter is 56.7, the coefficient of variation is 37.4, which indicates that the assessments of countries are quite differentiated in this parameter. In addition, innovative leader countries are relatively successful in knowledge diffusion. Thus, the average assessment of the leading countries of innovative development in terms of the Knowledge diffusion parameter is 49.1, the coefficient of variation is 34 %.

Compared with a lower level of efficiency, the efforts of the leading countries in innovative development are characterized by the «Knowledge impact» (Labor productivity growth, %; New businesses/th pop.; Software spending, % GDP; ISO 9001 quality certificates/bn PPP$ GDP; High-tech manufacturing, %) – the average score is 42.6, coefficient of variation – 14.7 %. Such results give grounds to assert that, despite significant asymmetries in the levels of success of the leading countries in innovative development in terms of the Knowledge creation and Knowledge diffusion parameters, they are characterized by fairly similar results in the Knowledge impact parameter.

Innovative leader countries are quite successful in terms of «Intangible assets» (Trademarks by origin/bn PPP$ GDP; Global brand value, top 5,000, % GDP; Industrial designs by

origin/bn PPP$ GDP; ICTs and organizational model creation). The average rating of the group of countries-innovation leaders for this parameter is 54.3 points, the coefficient of variation is 25.2 %. In addition, some of the leading countries are characterized by certain successes in the «Online creativity» parameter (Generic top-level domains (TLDs)/th pop. 15–69; Country-code TLDs/th pop. 15–69; Wikipedia edits/mn 15–69, Mobile app creation/bn PPP$ GDP (**Table 6.9**).

The average rating of the leading countries in the innovation rating for this parameter is 49.2 %, the coefficient of variation is 41.5 %. The leading countries in the innovation rating are mainly characterized by average scores for the «Creative goods and services» (Cultural and creative services exports, % total trade; National feature films/mn pop. 15–69; Entertainment and media market/th pop. 15–69; Printing and other media, % manufacturing; Creative goods exports, % total trade) – 37.5, coefficient of variation 30 %.

Table 6.8 Features of innovative ecosystems of the leading countries in innovative development in 2021 (Knowledge and technology outputs parameter)

Countries	Knowledge and technology outputs		Knowledge creation		Knowledge impact		Knowledge diffusion	
	grade	place	grade	place	grade	place	grade	place
Switzerland	63.9	1	86.6	1	55.4	2	49.7	12
Sweden	60.3	2	78.4	2	44.1	14	58.4	6
UAE	22.2	59	5.9	105	29.5	65	31.3	32
Great Britain	52.3	10	65	8	43.1	19	48.9	15
The Republic of Korea	54.5	8	66.1	7	40.0	23	57.2	7
Netherlands	54.8	7	67.7	6	43.1	18	53.5	8
Finland	56.5	5	62.5	9	39.2	26	67.9	3
Singapore	48.1	13	35.5	28	46.7	11	62.1	4
Denmark	47.6	14	61.5	10	45.1	13	36.2	24
Germany	53.3	9	69.5	5	43.8	15	46.5	19
France	44.3	16	44.8	19	41.5	22	46.7	18
China	58.5	4	70.5	4	52.2	5	52.9	9
Japan	48.3	11	58.3	11	35.1	43	51.5	11
Hong Kong	21.6	62	24.2	40	38.4	31	2.3	128
Israel	55.9	6	53.8	12	42.2	21	71.8	2
Mean	49.5	15.1	56.7	17.8	42.6	21.9	49.1	19.9
Variation coefficient	24.9	125.0	37.4	147.6	14.7	71.5	34.0	156.3

Source: compiled by the author based on data [43]

Table 6.9 Features of innovative ecosystems of the leading countries in innovative development in 2021 («Creative outputs» parameter)

Countries	Creative outputs		Intangible assets		Creative goods and services		Online creativity	
	grade	place	grade	place	grade	place	grade	place
Switzerland	60.2	2	63.4	5	47.5	3	66.3	4
Sweden	52.9	5	57.3	8	33	19	63.7	7
UAE	33.8	40	33.1	55	55.5	2	18.4	64
Great Britain	54.4	4	56	10	44.8	6	59	10
The Republic of Korea	52.1	8	74.1	1	32.4	20	28.1	37
Netherlands	52.2	7	51.4	16	36	18	70.1	3
Finland	42.9	16	44.4	32	24.1	41	58.8	11
Singapore	42.9	17	40.2	40	39	13	52.1	19
Denmark	47.7	13	47.2	23	32.1	21	64.3	6
Germany	50	11	58.4	6	25.6	36	57.9	13
France	52.6	6	68.9	3	27.5	30	45.3	25
China	46.5	14	70.9	2	40	11	4.3	125
Japan	42.1	18	56.9	9	29.6	25	24.9	46
Hong Kong	64.7	1	64.7	4	63.7	1	65.7	5
Israel	36.3	30	27.5	75	31.2	23	59	9
Mean	48.8	12.8	54.3	19.3	37.5	17.9	49.2	25.6
Variation coefficient	17.1	83.3	25.2	114.6	30.0	67.9	41.5	127.7

Source: compiled by the author based on data [43]

Thus, the innovative ecosystems of the leading countries in innovation ratings are characterized by the comparative effectiveness of the institutional component, primarily the stability of the political and business environment; relatively high efficiency of the functioning of the infrastructure, which contributes to the innovative development, first of all, of the information and telecommunications infrastructure; relatively high efficiency of market development, primarily Trade, diversification, and market scale; relatively high efficiency of the policy aimed at the development of human capital and research, in the first place, funding for research and development from both the state and enterprises.

Taking into account all of the above, the effectiveness of the institutional and business environment, the efficiency of infrastructure functioning, incl. innovative; the effectiveness of economic restructuring and market development and the effectiveness of the state policy for the

development and use of human capital. Therefore, the security parameters of innovative ecosystems are determined by the peculiarities of the innovative development of countries, the ability of the innovative component to serve as a source of ensuring the implementation of national interests and national security. Under such conditions, the gap between the parameters of functioning and development of innovative ecosystems of the countries of the world and the corresponding parameters of the leading countries in innovative development is an important indicator of the country's ability to ensure the implementation of national interests in the face of escalating competition in the geo-economic and geopolitical arena. The smaller the gap, the more the country has a chance to realize its national interests and ensure national security, and vice versa, the larger the gap, the greater the risk of inability to ensure the implementation of national interests, national security.

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