Global Trends in Formation of Regional Innovative Entrepreneurial Ecosystems in the Context of Rapid Development of Artificial Intelligence Technologies

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Abstract

Within article, peculiarities of the origin, formation, functioning and development of innovation ecosystems are examined. The main participants (research institutions and universities, business structures and corporations, investors and governments) are identified, and three main levels (business ecosystem, communities and platforms) are allocated. The comparison is made between open and closed, regional and sectoral innovation ecosystems. The global practice of clustering is considered and the rating of innovation clusters is analysed on this basis.Based on the study of the analysis of the best world practices of creation and implementation of innovation ecosystems, the authors propose the model of implementation of the existing experience in the practice of formation of innovation ecosystems in the region, which includes description of initial provisions of formation of the innovation ecosystem; identification of the main actors in formation of the innovation ecosystem; determination of the expected results of interaction of the main actors in formation of the innovation ecosystem.

The article pays special attention to the study of involvement of artificial intelligence tools in strategic development of innovation ecosystems. The author emphasises the breadth of these opportunities - from market analytics and decision support under uncertainty to automated intellectual property management and investor search. To quantify the maturity of the regional innovation ecosystem, the authors propose the IEMI index, the analytical tool that takes into account five key components: science, human resources, cooperation, financing and regulatory environment.The authors investigate how artificial intelligence technologies manifest trends in changing approaches to formation and strategic development of regional innovative entrepreneurial ecosystems. The authors emphasise the key role of universities in these processes, which in the context of digital transformation act not only as centres of education and science, but also as active providers of the innovation economy. The article provides examples of how global and Ukrainian universities are implementing smart technologies in knowledge transfer and partnership building.

Keywords: Innovation Ecosystem, Innovative Strategy, Regional Development, Artificial Intelligence, Technology Transfer, Universities, Industrial Enterprise, Strategic Management, Innovation Centres, Knowledge Commercialisation, Sustainable Development, Digital Transformation, Digitalization.

Introduction

The digital revolution does not just exist, it is accelerating every day. The scope, scale and prevalence of digital processes are truly impressive. Under these conditions, the university environment is a systemic source of innovation and has prerequisites for generating new ideas, creating new products and transferring knowledge from academic science to the real sector of the economy. The innovation ecosystem refers to the environment for searching for innovations; that is, to the set of conditions that ensure sustainability of emergence, transfer and commercialization of innovations in the interconnected socio-economic system.

Analyzing global trends in formation and strategic development of regional innovative business ecosystems, today we can already testify to involvement of artificial intelligence (AI) as a strategic management tool. It is AI resources that today allow us to provide analytical basis for decision-making in the dynamic, multifactorial, difficult-to-predict environment. Modern tools of this kind are of particular importance for regional or local innovative ecosystems, which are characterized by functioning at the level of coordination of business, educational and societal (state) interests.

Literature review

Research results (Zhaoxi Han et al., 2025) prove that the sustainable innovation ecosystem involves maintaining innovation potential in conditions of uncertainty and external shocks, accelerates innovation, increases efficiency of innovation and contributes to sustainable economic and social progress. The authors argue that gaps in sustainability between regions are gradually decreasing, and each region has its own strengths and weaknesses.

Ferreira João J. et al. (2024) consider the region's innovation ecosystem from perspectives of sustainable urban development. Zhao Yanan et al. (2024) analyze cross-border regions and innovation ecosystems. GongXiaohui et al.(2023) analyzed the interdisciplinary approach to sustainable economic development based on the use of biocapacity, natural resources, technological innovation, institutional quality and trade in resource-rich countries. The authors recommend strategic solutions aimed at activating investment in environmental sustainability, strengthening the quality of institutions, diversifying economic activities, regulating the use of natural resources and promoting technological innovation as the basis for formation of innovation ecosystems in the region.

Cao Y. et al. (2023), Roscani V. et al.(2023) argue that European entrepreneurial ecosystems face increasing global competition, but bridging the innovation gap between European countries and regions is still a necessity to provide educational programs and support mechanisms for youth and startups.Pöntinen V. et al. (2023) detail benefits of innovation ecosystems and knowledge, current trends in business innovation, and their importance for the regional economy.

Lombardini G. et al. (2023), Schwabe O. et al. (2023) conducted the comparative analysis of methods for assessing the ecosystem, spread of innovations, sustainable development, and intellectual capital as the basis for formation of the regional innovation ecosystem.

As part of the study (Ujwary-Gil A. et al., 2022), the research was conducted on the dual-mode network of digital innovation centers operating in Poland, understood as ecosystems and centers of competence, to support digital transformation of industrial enterprises in the region.Peterková Jindra et al. (2022), Grama-Vigouroux S. et al. (2022) outlined specifics of the innovation ecosystem characterized by similar economic and socio-cultural developments.

Artificial intelligence plays a significant role in shaping their innovation ecosystems. Cricchio Jacopo et al. (2025), Long Yuntao et al. (2024) point out that through technological innovation, artificial intelligence, cost reduction, productivity improvement, and application demonstration, the way has been opened for revolutionary innovation and improvement of the level of AI research and

applications in China, which will become the fundamental factor in development of innovative business ecosystems.The study (Hu R. et al., 2024) proves that both construction of innovation provinces and artificial intelligence have significant positive impact on the sustainability of regional innovation ecosystems, and also mitigates the impact of artificial intelligence on sustainability of regional innovation ecosystems.Roundy P.T. et al. (2024) conducted the study of AI ecosystems and provided relevant recommendations for effective functioning of innovation ecosystems.

Articles (Secundo G. et al., 2024; Marhasova V. et al., 2024, Jakubek P.et al., 2023) prove that in the digital transformation era, technologies that optimize decision-making processes, especially with introduction of artificial intelligence, significantly expand the potential for cooperation within innovation ecosystems, but formation of mechanisms for state management of development of digital technologies as the basis for ensuring national security remains important.

Taking into account existing research, the issue of analyzing global trends in formation of regional innovative entrepreneurial ecosystems in the rapid development of AL technologies is extremely relevant and requires further research, which is due to the speed of technological change, uniqueness of specific characteristics of regions, relationship with global trends, need for innovative developments, taking into account modern opportunities, challenges and risks, and the environmental focus of business.

Methodology

An important area of application of AI in the management of innovation ecosystems is the modeling of strategic development scenarios, involving machine-learning tools in the analysis of the retrospective and predicting on this basis prospective effects of consequences of strategic decisions. As basic information, we can offer the analysis of the level of success of startups, dynamics of investment attraction, degree of integration of educational institutions into regional business activity, level of scientific activity in universities as participants in the innovation ecosystem, etc. (Miller Romaine, 2023).

As the comprehensive indicator, we propose to define the Maturity Index of the Regional Innovation Ecosystem(Innovation Ecosystem Maturity Index, IEMI):

$$IEMI=w1\cdot R+w2\cdot H+w3\cdot C+w4\cdot I+w5\cdot E$$

where R – scientific research activity (number of patents, R&D, scientific publications per 100 thousand population of the region; number of implemented technologies with commercialization);

H – human resource potential (share of employment in high-tech sectors, percentage of STEM graduates per 100 thousand population, level of emigration of young specialists (brain drain));

C –level of cooperation in the triad "business-science-society" (number of joint projects, number of public-private partnership projects, success of technology transfer, number of joint incubation programs, availability of innovation centers);

I– investment capacity (volume of venture financing for regional innovations, number of startups that received investments, amount of grants attracted, budget volume of regional innovation support funds);

E – development of the institutional environment (availability of the regional innovation strategy, number and budget of implemented measures to support innovation activities, duration of startup registration, ease of doing business index);

w1,w2,...,w5 – weighting factors that are determined by experts or based on factor analysis.

Calculation of the IEMI index will help determine the degree of the infrastructure development of the innovation ecosystem, effectiveness of its functional load, outline strengths and bottlenecks, and provide possibility of the comparative analysis of regional ecosystems for the purpose of developing the state innovation policy. The result of this analysis is strategic decisions on optimizing and planning the development of the innovation infrastructure, in particular, in terms of financing, identifying and strengthening systemic bottlenecks, identifying risks and measures to reduce them.

Results

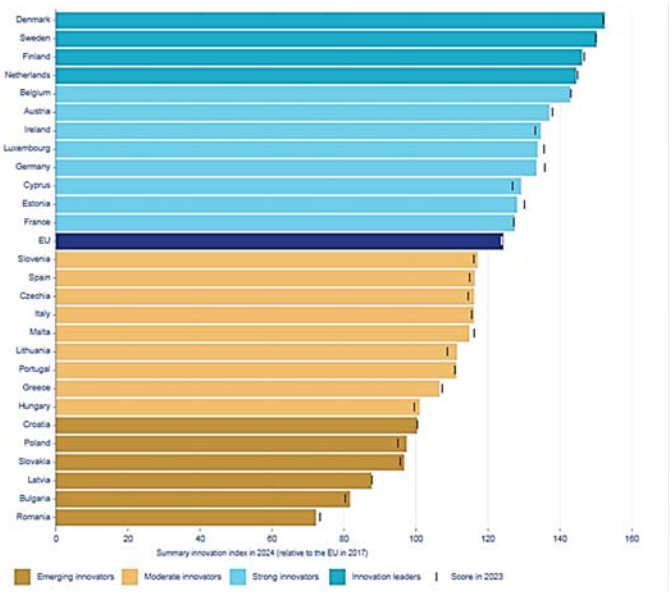
The conceptual history of the term "innovation ecosystem" gained popularity after the publication of the study by R. Adner. He defines the innovation ecosystem as " collaborative arrangements through which companies combine their individual offerings into the coherent, customer-centric solution" (AdnerR., 2006). This concept was based on the term "business ecosystem" used by J. Moore (1993) and others.

Gomes et al. (2008) argue that the concept of the innovation ecosystem arose in part as reaction to the focus on value capture and competition that had characterized research on business ecosystems, and that the concept of innovation ecosystems implied value creation and collaboration. J. Moorenotes: "In the business ecosystem, companies jointly develop capabilities around a new innovation: they work both collaboratively and competitively to support new products, satisfy customer needs, and ultimately enable the next round of innovation" (Moore J., 1993).

O. Granstranda and M. Holgersson provided new interpretation of the innovation ecosystem: "The innovation ecosystem is an evolving set of actors, activities and artifacts, as well as institutions and relationships, including complementary and substitutive relationships that are important for the innovation activity of an individual actor or group of actors. In this definition, artifacts include products and services, tangible and intangible resources, technological and non-technological resources, and other types of input and output elements of the system, including innovations" (GranstrandaO.etal., 2020). Similarly P. Budden and F. Murray define innovation ecosystems as: "places that involve five types of stakeholders (research institutions, entrepreneurs, corporations, investors, and governments) linked by strong social structure of mutual interests, needs, and complementary resources and trust" (BuddenP. etal. (2022).

Figure 1 shows current trends in innovative development of EU countries in terms of innovation indicators, 2023.

Fig 1. Current trends in innovative development of EU countries in terms of innovation indicators, 2023



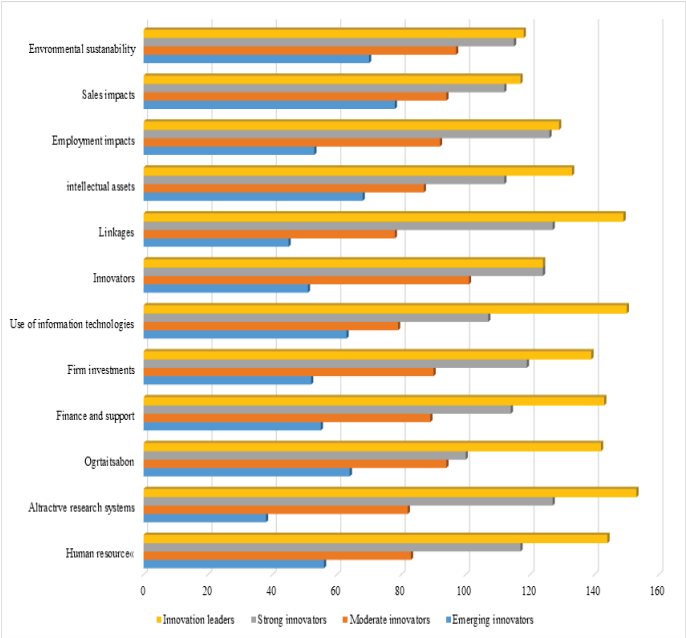
Source: europa.eu (2024)

Taking into account global experience, the innovation ecosystem can be divided into three main levels:

- business ecosystem – a set of participants interacting within certain economic environment, in particular, market agents, companies, organizations and institutions that receive economic benefits from participating in innovative activities. Within this ecosystem, businesses, scientific institutions, government bodies and other stakeholders jointly develop innovations, create new technologies, products or services that contribute to economic growth and social development;
- communities – groups of people or organizations that unite to achieve common goals within the certain ecosystem. They can be components of innovation ecosystems and include participants who have similar interests, abilities and opportunities to solve scientific and technical problems or develop specific areas in business and technology. Ecosystem communities can be connected throughjoint activities, cooperation, exchange of knowledge and resources;
- platforms are tools, software and hardware, as well as

organizational resources that allow coordinating joint activities of the ecosystem participants, providing them with the opportunity to interact, exchange knowledge, resources and achieve common goals. Platforms ensure creation and maintenance of network effects, that is, the more participants use the platform, the greater its value for all participants and for the ecosystem as a whole. They can be both technological (for example, software platforms for product development or for scientific research) and organizational (for example, platforms for joint innovation or technology commercialization). Platforms can be closed or open, which depends on the level of access to resources and knowledge, as well as on business models (for example, based on subscription or licenses). For successful functioning of the innovation ecosystem, it is important to have platforms that allow connecting different levels of participants, including scientists, entrepreneurs, corporations and government agencies, and provide conditions for effective cooperation.Fig. 2 presents statistical data on indicators of the innovation activity in various areas in 2024.

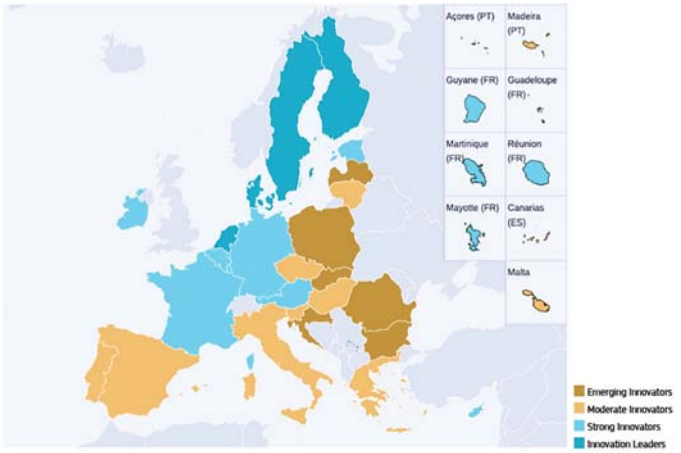
Fig 2. Indicators of innovative activity in various areas, 2024



Source: europa.eu (2024)

Results of research on international practices at the level of universities, corporations and the state regarding commercialization of technologies at the early stages of their development, it is appropriate to note that R. Florida (2014) focuses on connection between innovativeness in technology transfer and economic growth. Y. Cai et al. (2019) identify the main levels and factors of effective knowledge and technology transfer. The above confirms that universities are important centers of innovation clusters, thanks to close cooperation between education, science and business. They act as generators and suppliers of new knowledge and skills, which contributes to development of creative abilities and students' readiness to implement innovations. In the leading countries of the world, universities have long played important role in development of innovations.Figure 3 presents main indicators of the innovation activity in EU countries.

Fig.3. Key indicators of the innovation activity, EU countries



Source: europa.eu (2024)

Results of research into the world experience have made it possible to identify several types of innovation ecosystems, each of which has its own unique features:

1. Closed innovation ecosystems are a type of innovation structure in which control over development, creation and implementation of innovations is concentrated in the hands of a single company or a limited number of participants, usually corporations or their partners. The main feature of these systems is that access to resources, information and technologies is strictly controlled, and

it is difficult or even impossible for third-party participants to join the innovation process without appropriate permissions or agreements.

The key characteristics of closed innovation ecosystems are:

access control – only selected companies or organizations have the right to participate in development of new products or technologies;

intellectual property protection – focused on maximum protection of innovative solutions through patents, trademarks and other legal instruments;

high interdependence of participants – participants in this ecosystem (partners, suppliers) have clearly defined roles and tasks, their interaction is strictly regulated;

"inner circle" innovations - the main innovation processes take place within the company or its close circle of partners, decisions are made at higher levels of management and only then can they be transferred for implementation to lower levels or to partners;

closed innovation cycle – new ideas and products are developed, tested and brought to the market within the company or group of companies without involving external players, thus, all resources are concentrated on the specific company, which allows for better control over the quality and pace of development.Apple is an example of the company that uses a closed innovation ecosystem. They tightly control the entire process of creating their products, from design to hardware and software development, which allows them to maintain high level of quality, protect their technology, and offer unique products to the market. Closed innovation ecosystems are most effective for companies operating in highly competitive industries where intellectual property protection and market control are critical success factors.

2. Open innovation ecosystems are models that encourage broad participation by diverse stakeholders to co-develop and share innovations. They aim to engage external stakeholders such as startups, researchers, academic institutions, developer communities, governments, NGOs, and individual enthusiasts to create new products, technologies, and solutions. Open ecosystems are the opposite of closed ecosystems, as their goal is to foster co-development and collaboration rather than restrict access to innovation.

The main characteristics of open innovation ecosystems are:

open participation – any participant can join the ecosystem, regardless of whether it is a company, an individual entrepreneur, an academic institution, or even public; contributions to innovation can include new ideas, technical solutions, funding, or partnerships;

collaboration and knowledge sharing – built on the idea that collaborative work between different participants provides more effective problem solving, allowing companies to use external sources of knowledge and resources to accelerate innovation processes;

reducing barriers to entry – participants are not limited by strict criteria for participation, which allows for attraction of innovative solutions from various sources;

collective value creation – instead of focusing on competition, participants in the open ecosystem usually work together to achieve the common goal or solve the specific problem;

intellectual property protection – in open ecosystems, intellectual property issues can be addressed through various mechanisms, such as open access licensing or shareable patents;

flexibility and adaptability – open ecosystems allow for rapid adaptation to new ideas and market changes, as new participants are free to join and contribute to the ecosystem. An example is: Linux Foundation is the global ecosystem that enables developers and companies around the world to collaborate on development of open technologies, such as the Linux operating system ; AstraZeneca Open Innovation is an initiative of the pharmaceutical company AstraZeneca , which invites external participants, scientists, startups and other companies to collaborate on development of new medicines and medical technologies; Tesla – announced that it is opening up access to its patents on electric vehicle technology to promote development of the industry.

3. Regional innovation ecosystems are systems that bring together diverse actors within geographic region to create innovation and foster economic development. These ecosystems often include universities, research institutes, startups, large corporations, government agencies, and other organizations that interact with each other to support and develop innovation.

   The main characteristics of regional innovation ecosystems are:

   geographical localization – all participants in innovation are located within certain region or city;

   concentration of talents and resources – regional ecosystems are often centers of concentration of human resources, knowledge and capital;

   support for local institutions and government;

   cooperation between sectors– involve close collaboration between academic institutions, business, government and civil society organizations. For example, Y. Cao et al. (2023) proposed the methodology for developing the regional innovation ecosystem in the Beijing-Tianjin- Hebei region.

4. Industry innovation ecosystems are innovation systems that focus on the specific industry or the sector of the economy. They involve participants working within the single sector, such as technology, healthcare, energy, agribusiness , and others, to develop and implement innovations that can contribute to development of that industry.

   The main characteristics of industry innovation ecosystems are:

industry specialization – participants work on developing new products, technologies or services that can be implemented in this industry;

specific technologies and knowledge – focus on development and implementation of innovative technologies that have direct impact on productivity, efficiency and competitiveness of companies in the industry;

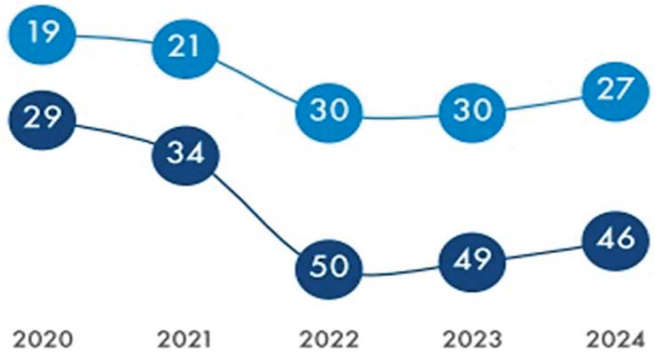
role of large players – often in these ecosystems, large corporations or institutions play significant role, which can set the direction of innovation in the industry;

Governments often provide special regulatory and financial incentives to foster industry innovation. O. Carneiro et al. (2023) developed the analytical framework for the innovation ecosystem in the public sector.

Therefore, the considered types of ecosystems allow different players to interact, develop innovations and promote economic growth in various fields of activity.

Considering the dynamics of development of the startup ecosystem in Ukraine, it is appropriate to note positive dynamics for the second year in a row. Ukraine rose 3 positions in the ranking and occupies 46th place (Fig. 4). The Ukrainian map is represented by 633 technology companies, two of which managed to cross the $ 1 billion mark and gain unicorn status (startups Grammarly and People.ai). Well-known Ukrainian startups, such as People.ai, Grammarly, Gitlab and Ahrefs, have the big user base worldwide.

Fig. 4. Dynamics of the startup ecosystem rating in Ukraine



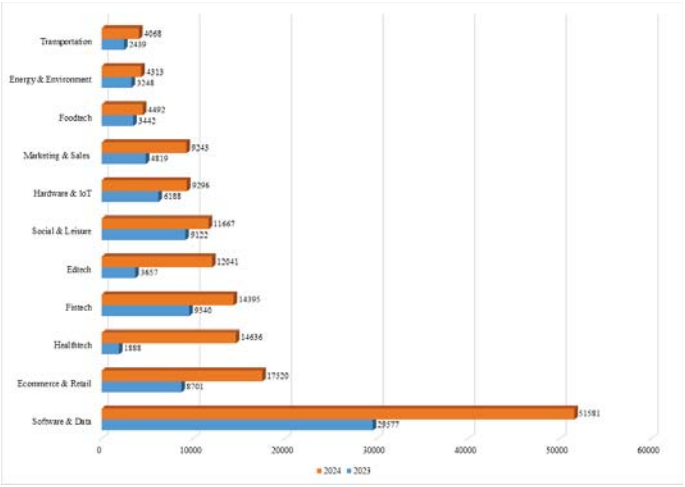
Source: Fintech Insider (June 12, 2024);startupblink (2024)

Since Ukraine is in extremely difficult military conditions, it is quite difficult to predict how quickly physical and economic infrastructure will be restored (Fig. 5).

Fig. 5. Volume of financing raised by Ukrainian startups and number of deals

Software and data are the most relevant areas for startups (Fig. 6). According to StartupBlink, this industry accounts for 33.7% of startups in the world.

Fig. 6. Number of startups by industry in 2023 and 2024



Source: StartupBlink

Building the regional innovation ecosystem is not always easy. There are real challenges associated with working across sectors, but they can be overcome with effective strategies.

1. Aligning different goals and timelines . Academia, business, and government often operate on different time frames. Academic research can take years, while private companies need faster returns, and public policy often follows its own timeline. That is, it is important to establish clear, shared goals from the beginning. When there is agreement on final aspects of the project and the overall picture of success, it is easier to coordinate and implement the project , even if some stages take longer for one party than the other. The key is flexibility - creating the structure that allows each participant to contribute at their own pace, while still moving towards a common goal.

2. Overcoming cultural differences. Every sector has its own culture. In academia, the emphasis is on rigor and deep research into complex problems, while the private sector often values efficiency and speed. The public sector adds another layer of complexity with extensive bureaucracy, regulatory requirements, and political considerations. Therefore, it is beneficial to develop open communication from day one. This does not always mean formal meetings – sometimes it is informal conversations that help to analyze all possible alternatives for solving the tasks at hand. By creating opportunities for teams to communicate and build trust, it becomes easier to overcome these cultural gaps.

3. Navigating the complexities of funding. Securing funding is always a challenge, especially when multiple sectors are involved. Public funding can be accompanied by bureaucratic hurdles, and private investors often want to make the faster return than research-related projects can provide. One strategy that can be effective is to use tiered funding models. Public funding can support early stages of research, and once the project reaches certain level of maturity, private investment can be attracted to scale it up. This approach reduces financial pressure on any single sector and allows projects to develop at sustainable pace.

The indicator that takes all of the above into account on a global scale is the Global Innovation Index (GII). Table 1 provides the fragment of the world's innovation cluster ranking for 2024. It should be noted that the list of the top 100 global clusters remains unchanged from year to year.

Table 1. World Innovation Cluster Rankings in 2024

Rank	Cluster name	Economy	Top applicant	Top organization
1	Tokyo–Yokohama	JP	Mitsubishi Electric	University of Tokyo
2	Shenzhen–Hong Kong–Guangzhou	CN/HK	Huawei	Sun Yat Sen University
3	Beijing	CN	BOE Technology	Tsinghua University
4	Seoul	KR	Samsung Electronics	Seoul National University
6	San Jose–San Francisco, CA	US	Google	Stanford University
12	Paris	FR	L'Oréal	Sorbonne Université
21	London	GB	Nicoventures Trading	University College London
22	Munich	DE	BMW	Technical University of Munich
25	Taipei–Hsinchu	TW*	Hewlett-Packard	National Taiwan University
50	Zürich	CH	ETH Zürich	ETH Zürich
90	Warsaw	PL	Samsung Electronics	University of Warsaw

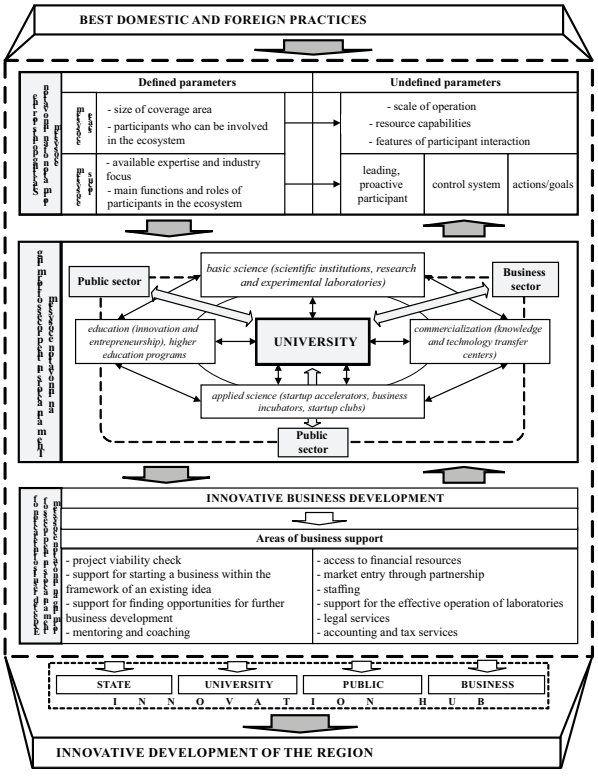
Source: WIPO Statistics Database (2024)

Analyzing the full ranking in terms of grouping of economies of individual countries, it can be noted that the leaders are China (26 clusters), the USA (20 clusters) and Germany (8 clusters); India and the Republic of Korea have 4 clusters each; France, the United Kingdom, Japan, Canada and Australia each have three clusters in the ranking.

Based on the conducted research and analysis of the best global practices in creating and implementing innovation ecosystems, we'd like to offer the model for implementing existing experience into the practice of forming innovation ecosystems in the region, which includes:

1. Starting points for formation of the innovation ecosystem.
2. Main actors in the process of forming an innovation ecosystem.
3. Expected results of interaction between the main actors in forming the innovation ecosystem (Fig. 7).

Figure7. Model of implementation of the world experience into the practice of forming regional innovative entrepreneurial ecosystems



Source: author's development

The starting points for formation of the regional innovative entrepreneurial ecosystem demonstrate that at initial stages only the main parameters are determined, such as the size of the coverage area, participants who can be involved in the ecosystem, available expertise and industry focus, main functions and roles of participants in the ecosystem. Some key elements, such as the scale of operation, resource capabilities, features of interaction between participants, identification of leading participants and the management system, as well as outlining the main goals and objectives, still need to be clarified and detailed.

Defined parameters :

1. Size of the coverage area is the scale at which the ecosystem operates. An important component is access to the number of participants in a certain area.
2. Participants who can be involved – determines the possibility of involving different participants in the ecosystem.
3. Existing expertise and industry focus – the level of knowledge and experience that already exists within the ecosystem, as well as clear focus on specific industries.
4. Main functions and roles of participants – justification of the set of main functions that must be performed by individual ecosystem participants for stable and effective development.

Undefined parameters :

1. Scale of functioning, resource capabilities, and features of interaction between participants - involves specifying parameters that will later characterize the ecosystem, but are not yet clearly defined at the first stage.
2. The leading, proactive participant – the main player who initiates or manages the ecosystem – remains undefined.
3. The governance system is central structure or organization that manages the ecosystem.
4. Actions/goals – goals, objectives, or directions of development that the ecosystem must achieve and implement, which may change during the ecosystem creation stage.

The presented model is based on the analysis of domestic and foreign experience, covers the most influential criteria that affect functioning of the innovation ecosystem, and at the same time provides guidance on how innovation ecosystem managers can define their own innovation systems, considering dependencies and points that can be influenced.

The main actors in forming the innovation ecosystem - outlining the main elements and relationships between the public sector, the public sector, the business sector and universities. Their relationships look like this:

1. The public sector interacts through education (innovation and entrepreneurship) and training programs, cooperating with universities. The public sector, through the higher education system, promotes development of innovation and entrepreneurship. Training programs in higher education institutions (HEIs) are aimed at preparing students for work in innovative sectors of the economy.
2. Universities are engaged in fundamental and applied science. Universities are actively involved in development of fundamental science through scientific and research institutions, laboratories and experimental laboratories. This research provides the basis for innovation and technological progress. Applied science includes creation and support of startup accelerators, business incubators and startup clubs. Applied research is aimed at practical implementation of scientific developments and introduction of innovative technologies into business. Universities are also involved in commercialization of scientific achievements through knowledge and technology transfer centers. This allows scientific developments to be translated into real products or services available on the market.
3. The business sector includes commercialization – knowledge and technology transfer centers. The business sector attracts financial resources (investment capital) necessary for the development of innovative projects and startups.

An important element of the ecosystem are entrepreneurial structures that can use results of applied science to develop businesses and create new market offerings.

4. The public sector is actively involved in project initiatives, thereby ensuring effective formation of the innovation ecosystem.

Thus, the innovation ecosystem is built on close cooperation between the state, public sectors, and business through universities, which act as a generator of knowledge and innovative solutions, which certainly contributes to the innovative development of the region.

This block of forming an innovation ecosystem focuses on establishing relationships between actors of the process and analyzing its impact on the innovative development of business.

Expected results of interaction between key actors in forming the innovative entrepreneurial ecosystem in the regioninvolvescreating viable innovative business proposals, launching startups, and developing business in the region.

The main areas of business support are:

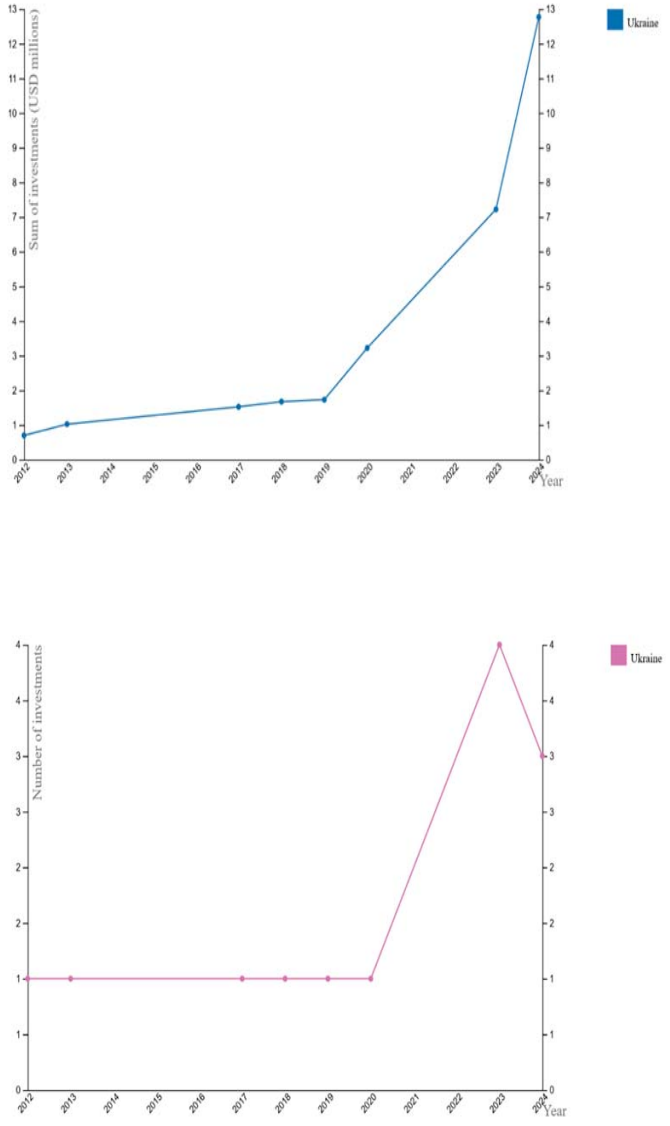
- project viability check – evaluation of innovations or ideas in the market to determine their potential success and viability;
- support for starting the business within the framework of the existing idea– assistance in developing ideas to the stage of their practical application for opening new businesses;
- support in finding opportunities for further business development – analysis and search for additional market or technological opportunities for business scaling;
- mentoring and coaching– professional mentoring for entrepreneurs to develop their ideas and businesses;
- access to financial resources – assistance in attracting investments or obtaining financing for the business;
- market entry through partnerships – finding partners who will help companies enter new markets or improve their positions in existing ones;
- staffing – assistance in finding the necessary personnel for development of startups or existing businesses;
- supporting effective operation of laboratories –

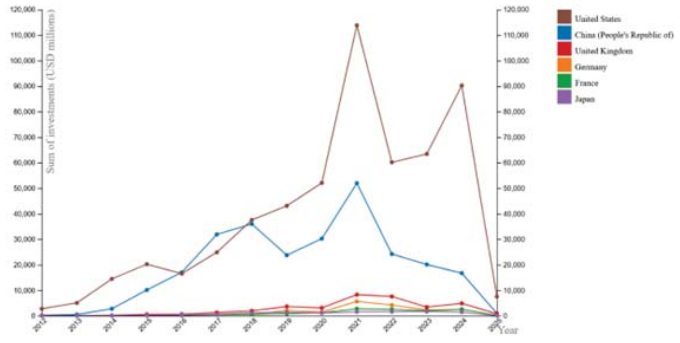
ensuring effective operation of the laboratory, infrastructural support for scientific research and project development;

- legal services – providing legal support to enterprises, including issues of business registration, intellectual property protection, etc.;
- accounting and tax services – financial consulting, including bookkeeping, tax optimization and tax reporting.

When making strategic decisions, AI tools will help achieve transparency and validity in distribution of financial resources, personnel management, cross-sectoral cooperation, and compliance with interests of all participants. Managing ecosystem development requires constant monitoring of the process, which can be provided by AI-based analytical panels in real time with the collection of necessary information and calculation of indicators and recommendations for adjusting strategic trajectory. Therefore, it is very useful to involve AI for an early warning system for violations of sustainable innovation ecosystem and prevention of crisis phenomena. For example, using intelligent cluster analyses, it is possible to identify signs of imbalances between sectors (for example, a decrease in investor activity or a weakening of the role of universities), which requires timely response from the management system. This approach creates conditions for preventive response, minimizes negative consequences, and increases overall adaptability of the ecosystem to external challenges. Currently, there are studies that demonstrate that AI has the potential to increase the speed, quality and scale of strategic analysis, and also allows the use of new approaches, such as virtual simulations of strategies. Thus, AI contributes to optimization of communication processes within the innovation ecosystem. Thanks to this, the goals of participants are aligned and degree of uncertainty of strategic decisions is reduced. Integration of AI as the infrastructure element of the innovation ecosystem not only provides new opportunities, but also requires certain efforts from all participants. We attach particular importance in this process to universities, which are the core of the regional innovation ecosystem. They are generators of new knowledge, form an innovative culture, provide methodological and personnel basis for development and create environment for combining intelligent technologies with traditional branches of science, technology and business. Therefore, it is universities that have the leading role in implementing AI tools, the process of which we consider it appropriate to divide into three levels: education, scientific activity and knowledge transfer. Let's consider them separately.Fig. 8 shows venture investments in artificial intelligence (millions of US dollars) in Ukraine since 2012.

Fig. 8 Venture investments in artificial intelligence in Ukraine and by individual countries of the world, million USD





Source:OECD (2024).

Statistical data indicate a 13-fold increase in the investment volume in AI over 12 years of observation, and rapid growth over past two years, despite the war in the country. The Ukrainian AI investment market is insignificant - ranging from 1 to 4 in 2023. The leader in terms of the AI investments volume is the USA, but it should be noted that the maximum value in most countries fell on 2021.

In educational activities, universities today are actively using capabilities of AI. It is obvious not only that the content of educational programs is increasingly paying attention to formation of digital and analytical competencies of students of all specialties (Drach I. et al., 2023), but also AI is actively used by methodologists to develop educational programs themselves and their individual components (Biberman-Shalev L., 2025). World educational leaders are successfully integrating AI into individual disciplines and educational programs: Stanford University (key courses "Artificial Intelligence: Principles and Techniques", "Machine Learning", "Decision Making under Uncertainty"), Massachusetts Institute of Technology (program "Artificial Intelligence and Decision Making"), University of Oxford (MSc in Advanced Computer Science - Artificial Intelligence Pathway; key modules: Probabilistic Machine Learning, Ethics and Governance of AI, Explainability in AI), ETH Zurich (Master in Data Science and Artificial Intelligence program), Tsinghua University (China) - Bachelor and Master in Artificial Intelligence program; Carnegie Mellon University (USA) one of the first full-fledged bachelor's programs in the world: BS in Artificial Intelligence. Ukrainian universities are developing and implementing both training courses in machine learning, data processing, AI ethics and algorithmic literacy, as well as entire educational programs. Uzhhorod National University (UzhNU) and Kyiv National Economic University (KNEU) – Master's program "Artificial Intelligence Systems"; National Technical University "Kharkiv Polytechnic Institute" (NTU "KhPI") – Bachelor's program "Artificial Intelligence", Kharkiv Aviation Institute (KHAI) – program "Artificial Intelligence and Information Systems". Thanks to this, a new generation of specialists is being formed, capable of working effectively in the field of high technologies and innovative entrepreneurship. Educational initiatives in the field of artificial intelligence not only improve student training, but also contribute to development of critical thinking necessary for assessing the risks associated with implementation of intelligent systems, preparing future specialists for flexibility and adaptation of their professional skills in a digital society.

Research activities, including those conducted at universities, are also being actively transformed under the influence of AI (HAI, 2025), which allows scientists to perform automated analysis of large amounts of information, process experimental data to obtain results, build connections, and generate hypotheses with a high level of validity. A new phenomenon in this context is formation of the so-called "AI-driven science" (Raeini, Mohammad, 2025), which involves integration of intellectual tools for deeper study of the subject and object of research, as well as formation of substantiated conclusions on this basis. The Stanford AI Index 2025 report noted an increase in the number of articles written with the participation of AI by 62% compared to 2023. Another report, AAAI-2025 Report. Future of AI Research(AAAI, 2025), predicts that by 2030, 40% of fundamental discoveries in STEM sciences will be initiated by AI systems. The authors of this study believe that AI is becoming a tool not only for data analysis, but also for generating fundamentally new scientific knowledge.

The outlined aspects of formation of the innovation ecosystem are aimed at creating favorable conditions for starting and developing the business, from initial consulting to providing necessary services for scaling

startups. For effective cooperation, creation and commercialization of innovative projects , we consider it advisable to create an Innovation Hub, and within the framework of its activities to establish effective cooperation between the state, university, public and business, which will have significant impact on the innovative development of the region.

Therefore, the model of implementing existing experience into the practice of forming regional innovative entrepreneurial ecosystems includes three interconnected and sequential blocks, which are characterized by cyclicity, creating an innovative spiral of development of innovative projects that contribute to sustainable and innovative development of both regions and the country as a whole.

The technology transfer process is acquiring new approaches to commercializing scientific research results through the use of AI capabilities. Existing research and forecasts in this area suggest that intelligent systems will be able to verify innovative developments, assess their market potential, identify focus audiences, and offer effective strategies for entering market segments. Technology and knowledge transfer centers established at universities are already integrating AI to automate the procedure of patent analysis, intellectual property management, partner search, and venture capital. In particular, the following technology transfer centers at universities have successful cases of involving AI for these procedures: MIT Technology Licensing Office (USA), Stanford Office of Technology Licensing (OTL) (USA), University of Cambridge – IdeaSpace & Cambridge Enterprise (UK), Technical University of Munich (TUM) – TUM ForTe (Germany), ETH Zurich – ETH Transfer Office (Switzerland), University of Tartu – UT Startup Lab / TTO (Estonia), KPI named after Igor Sikorsky – Center for Innovation and Technology Transfer (Ukraine). This provides additional efficiency and transparency to innovation processes, also reduces the time of evolution from the birth of an idea to market entry, and also strengthens the position of universities as participants in the innovation ecosystem.

Conclusion

Formation and development of the regional innovative entrepreneurial ecosystem brings a number of significant benefits that positively affect the economy, society, business and science, the main ones being:

1. **Economic development:**

- GDP growth – the innovative ecosystem stimulates development of new technologies and businesses, which contributes to the increase in the country's GDP;
- Attracting investment – the ecosystem creates attractive conditions for investors, as innovative projects have the potential for high profitability. This attracts investment capital from both local and international investors;
- job creation – innovative companies and startups contribute to creation of new jobs in various sectors, especially in technology, engineering and science.

2. **Increasing competitiveness:**

- Companies operating in the innovative environment have a greater chance of introducing new products and services, which allows them to remain competitive in global markets;
- The innovation ecosystem provides support to new businesses in the form of mentoring , funding, business incubators and accelerators. This facilitates creating and developing startups.

3. **Development of science and technology:** thanks to the innovation ecosystem, results of scientific research are more easily transformed into real products or technologies that have practical application in the market, and universities and research centers gain access to resources and funding, which contributes to a more active development of fundamental and applied research.

4. **Social benefits: I**nnovation leads to the creation of new technologies and services that improve the quality of life of the population, particularly in the areas of health, transport, energy and utilities; ecosystems that support inclusive development can reduce economic and social inequality by creating opportunities for different

groups of the population, in particular for youth and entrepreneurs from remote regions.

5. **Strengthening cooperation between sectors:**

- public-private interaction – the innovation ecosystem stimulates cooperation between the public and private sectors, in particular through joint projects , investments and research;
- international integration – enterprises and scientific institutions within the innovation ecosystem can easily cooperate with international partners, which opens up access to new markets and technologies.

6. **Environmental sustainability -** development of "green" technologies, innovative ecosystems contribute to development of technologies aimed at preserving the environment and reducing negative environmental impacts.
7. **Flexibility and adaptability –** innovation ecosystems allow business and society to adapt more quickly to changes in the market or in technology, which is critically important in today's dynamic world.

Therefore, formation of the regional innovative entrepreneurial ecosystem has powerful multiplier effect, contributing to comprehensive economic and social development, as well as scientific progress.

Formation of the regional innovation ecosystem is not without difficulties, but the benefits definitely outweigh them. By combining strengths of universities and the public, civil society and business sectors, it is possible to create the environment where innovation flourishes and society benefits from technological progress. Collaboration, flexibility, adaptability, innovation and clearly set goals are key factors for the success and effective functioning of an innovation ecosystem.

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