THEORETICAL AND METHODOLOGICAL APPROACHES AND TOOLS FOR THE STUDY OF ENTREPRENEURIAL ECOSYSTEMS: SYSTEM AND NETWORK ANALYSIS

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Abstract

The following paper looks into the development of a comprehensive toolkit for analyzing entrepreneurial ecosystems. The work is examines in the context of the modern digital economy, based on a theoretical and methodological approach.

The dynamic conditions of digital transformation, against the backdrop of global economic instability, have sparked both scientific and practical interest in studying entrepreneurial ecosystems (EEs).

The authors critically examine approaches to defining the essence of entrepreneurial ecosystems, as well as the directions of applied and fundamental research that shape the core areas of related scientific interests. Systematizing the spheres of academic focus within the context of EE research, the authors conclude that, in Russia, particular attention is paid to regional entrepreneurial system development, sustainable development principles, and the assessment of the impact of the digital environment.

The following work studies key ideas underlying ecosystem concepts such as evolutionary theory, organizational ecology, neo-institutional theory, dynamic capabilities theory, and as well as the modular structure. The authors of this paper conclude that an entrepreneurial ecosystem is a complex interaction system, carried out through the creation of network effects and a special connection between cooperation, competition, innovation etc.

It is also essential to mention that by examining the key components of EEs and the fundamental principles of their functioning, the authors of the work outlined major research tracks related to core aspects of entrepreneurship ecosystems:

Access to resources and startup support,

The role of government influence on EE development,

Innovation issues and the commercialization potential of innovative products.

The authors were able to develop a theoretical and methodological approach to studying entrepreneurial ecosystems and classify EEs based on key characteristics.

Keywords: entrepreneurial ecosystems, theoretical and methodological approach, ecosystem actors, classification features of PES, ecosystem concepts

I. Introduction

The current conditions of digital transformation and global economic instability have fueled interest in studying the concept of entrepreneurial ecosystems as one of the mechanisms for business and innovation development. Modern research on entrepreneurial ecosystems progresses in various directions, reflecting a wide spectrum of scientific interests. The main areas can be grouped by themes, as presented in Fig. 1.

1. General Concept of Entrepreneurial Ecosystems

- Application of ecosystem concepts in economic and management research (Ramenskaya L.A.): This work offers theoretical foundations and methodological approaches for analyzing ecosystems in management, including the role of interactions between participants.
- Meaningful analysis of innovation, business, and entrepreneurial ecosystem concepts (Burda Ye.D. et al.): This study covers a conceptual analysis of innovation and entrepreneurial ecosystems, emphasizing innovation and entrepreneurship within ecosystems

2. Entrepreneurial Ecosystems in the Post-Crisis Economy

- A New Entrepreneurial Policy for Russia After the 2020 Crisis (Zemtsov S.P. et al.): The authors examine the opportunities and challenges for the development of entrepreneurial ecosystems in Russia following the COVID-19 pandemic.
- The Role of Entrepreneurship in the Sustainable Development of Rural Areas in Russia (Polbitsyn S.N.): This study focuses on the development of rural areas through entrepreneurship, emphasizing the importance of ecosystems in ensuring sustainable growth.

3. Regional Features and Ecosystem Development in Russia

- Rural Entrepreneurial Ecosystems of Russia (Polbitsyn S.N.): The paper analyzes regional aspects of ecosystem development in rural areas.
- Assessing the Links Between Entrepreneurial Ecosystems and Economic Development Levels in Russian Regions (Ovchinnikova A.V., Zimin S.D.): This study focuses on analyzing the relationship between entrepreneurial ecosystems and the economic development of regions.

4. Technological Entrepreneurship

- Technological Entrepreneurship as a Factor in Russia's Development (Zemtsov S.P.): The research highlights the importance of technological entrepreneurship for long-term economic growth and innovation in Russia.

5. Post-Socialist Economies

- *Entrepreneurial Ecosystems in Post-Socialist Economies* (Chepurenko A.): This work focuses on the specifics of ecosystem development in post-socialist countries, where the institutional environment differs from Western models.

6. Digital Environment Factors

- *The Influence of Digital Environment Factors on the Development of Entrepreneurial Ecosystems in Russia's Regions* (Yakimova V.A., Pankova S.V.): This study addresses the impact of digitalization on the development of entrepreneurial ecosystems, with a focus on regional characteristics

7. International Cooperation and Investments

- *Stimulating Local Entrepreneurship Through Foreign Investments* (Machtama A., Sauka A.): This research analyzes the role of foreign investments in developing entrepreneurial ecosystems in various countries.

8. Innovation and Business Incubators

- *Business Incubators in Russia: A 2020 Survey in International Comparative Perspective* (Slesarev M.A.): This study examines the role of business incubators in Russia and their effectiveness in an international context.

Figure 1: *Systematization of scientific interests in the context of EE research*

Scholarly consensus on the essence of entrepreneurial ecosystems reveals that they are complex systems of interaction between various actors: entrepreneurs, government institutions, investors, and even educational institutions. Together, these entities create the conditions for the

emergence and sustainable development of new business structures. The systemic approach applied to studying EEs allows for the identification of key factors influencing the dynamics and stability of such business structures and defines the roles of various participants in creating a favorable environment for entrepreneurial activity.

The relevance of the study is driven by the need to develop a comprehensive toolkit for analyzing entrepreneurial ecosystems in the modern digital economy. Integrating various methodological approaches, including systems analysis, network methods, and institutional theory, offers a deeper understanding of the relationship between actors and the conditions of their interaction. This article proposes a theoretical and methodological framework for researching entrepreneurial ecosystems, with a focus on identifying key structural elements and factors contributing to the development of entrepreneurship.

Thus, research on entrepreneurial ecosystems covers a wide range of aspects, from theoretical and methodological foundations to practical cases of ecosystem development in regions and specific industries. In Russia, particular attention is given to regional development, sustainable entrepreneurship in rural areas, and the impact of the digital environment. Innovation and technological entrepreneurship play a crucial role, particularly in post-crisis economies and post-socialist markets.

II. Methods

Several key methods were applied in the study, including bibliographic analysis, network analysis, and case study methods. The bibliographic analysis allowed for identifying the main scientific discourses and approaches to studying entrepreneurial ecosystems, based on publications from the last two decades. Network analysis was used to map interactions between ecosystem participants, revealing central actors and determining the structure of connections. The case study method, based on the study of specific ecosystems, such as Silicon Valley and Russian technoparks, allowed for a deeper examination of their functioning and the identification of critical success factors.

III. Results

The concept of an entrepreneurial ecosystem involves the creation of a network of autonomous organizations that jointly create value through cooperation and some degree of interdependence. Ecosystems can include various types of participants (commercial organizations, government agencies, NGOs, startups, and other entities) united by the idea that they interact for mutual benefit. However, competition remains, though it is governed by cooperative principles.

Let us examine the key ideas underlying the ecosystem concept:

1. Evolutionary theory and organizational ecology traditionally view ecosystems as biological analogs where participants compete and cooperate, adapting to changes. By applying concepts like "natural selection" and "ecological niches" to the life cycle of EEs, one can explain how these systems are created, survive, and evolve.

2. Neo-institutional theory distinguishes entrepreneurial ecosystems from other forms of systemic interaction, such as markets or entrepreneurial hierarchies. Applying this theory to EEs leads to an understanding of the role of institutions in coordinating system elements and reducing transaction costs through inter-institutional cooperation.

3. Dynamic capabilities theory emphasizes the ability of companies within ecosystems to adapt and transform their development strategies in response to ecosystem changes. This adaptability is key to achieving long-term competitiveness.

4. Modular structure suggests that while ecosystems consist of independent modules, they nonetheless exhibit a degree of interdependence a symbiosis that allows EE participants to create value together, even while maintaining their economic and legal autonomy. This trait is

particularly important for platform ecosystems, where large companies are embedded in a unique interaction architecture filled by its participants as individual modules.

Thus, an entrepreneurial ecosystem is a complex interaction system, where cooperation, competition, and innovation create network effects. The ecosystem enables the participating organizations (the system's modules) to jointly create products and services, discover new business models and solutions, reduce costs, and adapt their activities to external changes.

Let us consider and characterize the main components of the PES (Figure 2).

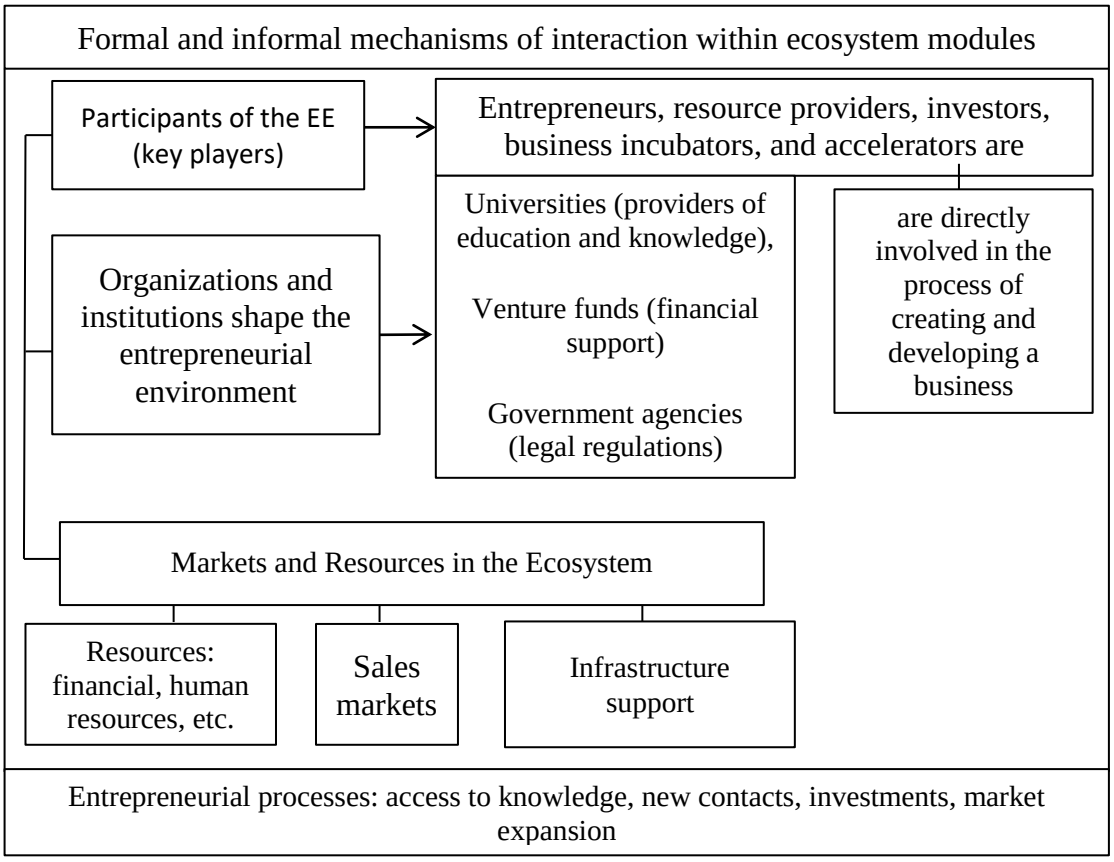

Figure 2: *Key Components of EEs*

The components of an EE, presented in Figure 2, interact based on several principles:

Interconnectedness and Interdependence;

Leadership;

Value Creation;

Flexibility and Adaptability

A classic example of an entrepreneurial ecosystem, which can serve as an academic model, is Silicon Valley. This ecosystem includes system modules such as entrepreneurs, investors, universities, technology companies, and startup creators. Through interaction, these components work together to create a favorable environment for innovation and technological entrepreneurship.

In Russia, analogous structures can be found in technoparks and innovation clusters, where the government provides funding through grants and other support programs.

IV. Discussion

Research into EEs develops along several lines, driven by regional context and the scientific interests of the authors. We have identified three main tracks, which systematize the body of research regarding the fundamental aspects of entrepreneurial ecosystems:

1. Research on access to resources and startup support as the main driver of innovation and project development. This track examines the availability of resources such as finances, knowledge, and connections.

2. Research on the role of government in the development of EEs and the possible or necessary degree of state control over EEs. In this context, the government is viewed as an actor that either facilitates or hinders the creation of conditions for the development of the ecosystem through a system of restrictions, regulations, and support.

3. Innovation and commercialization of innovative products: This track focuses on the innovative entrepreneurial activity of all ecosystem components. The reason for emphasizing this group of studies is that, through synergy, such structures create a collaborative effect that promotes the generation and implementation of new ideas, enhancing their chances of commercialization.

Based on the components of EEs and the principles by which these systems are created, operate, and evolve, as well as the basic research tracks, it is proposed that when creating a theoretical and methodological foundation for the study of these systems, the complex and multi-component nature of the ecosystem approach should be considered. This approach systematically links the connections between ecosystem participants, institutionalizing them and taking into account the processes the system undergoes throughout its lifecycle.

The proposed theoretical and methodological approach to EE research incorporates both theoretical and empirical methods, which will allow for the study of the dynamics, structure, and factors of successful ecosystem functioning.

1. Theoretical and Methodological Foundation of EE Research

1.1 Key Theories (Foundation of Research):

- Ecosystem Theory (Iansiti, Levien, 2004): This theory suggests that ecosystem participants are interdependent, develop together dynamically, and that their co-evolution contributes to value creation;

- Network Approach Theory (Granovetter, 1985): This theory emphasizes the importance of network connections between participants, forming channels for the exchange of resources, knowledge, and technologies;

- Innovation Systems Theory (Lundvall, 1992): This theory primarily considers innovation ecosystems as a key part of the entrepreneurial environment. It highlights the importance of creating such systems for startups and small companies, leveraging networks of partners and their resources to drive innovation;

- Institutional Theory (North, 1990): This theory underscores the role of institutional conditions (through the establishment and enforcement of legal, regulatory, cultural, and other norms) in entrepreneurial ecosystems. Established institutions support the entrepreneurial environment by providing access to resources and reducing transaction costs;

1.2 Research Principles:

- cystematicity: The ecosystem is viewed as a holistic system that includes interdependent elements (entrepreneurs, institutions, resources, infrastructure);

- multilevel Approach: This principle calls for conducting research on the ecosystem at different levels: micro (enterprises, entrepreneurs, startups), meso (local and regional systems), and macro (national ecosystem);

- interactivity: This principle is crucial due to the dynamic nature of EEs, which requires an analysis of the interactions between actors in the exchange of resources, knowledge, and support;

- adaptability: This principle reflects the constant variability of EEs, necessitating the application of flexible approaches to their study and management.

2. Research Methods and Tools

The research methods include both qualitative (descriptive) and quantitative methods.

2.1 Qualitative Methods may include:

- case Studies: The method of studying successful EE examples helps identify key success factors and lessons for other ecosystems;

- surveys of Key Actors: This allows for an understanding of their roles, motivations, and participation in the ecosystem, revealing the dynamics of interactions;

- content Analysis: The study of data presented in reports, results of strategy implementations by large companies and holdings, and evaluation of the effectiveness of government programs help determine key measures that support the development of EEs.

2.2 Quantitative Methods may include:

- social Network Analysis: This method allows for measuring and visualizing connections between various ecosystem participants. It helps identify key participants (leaders), those on the periphery, support modules, and other system elements. This analysis aids in assessing the density of connections, identifying cluster elements, and outlining the overall network architecture;

- statistical Analysis and Econometrics: Using regression models, this method evaluates the correlation between various factors (e.g., access to venture capital and startup success);

- benchmarking: Aimed at comparing different ecosystems, or one's case with a benchmark system, this helps identify factors that contribute to entrepreneurship growth and sustainability, as well as obstacles to it;

- entrepreneurial Ecosystem Development Indices: These indices allow for the evaluation of ecosystem development based on various criteria (access to financing, institutional support, level of innovation, etc.);

2.3 Data Collection Tools: In this case, traditional tools are used, such as secondary data analysis (official reports, statistics, analytical reviews, etc.) and surveys of entrepreneurs and representatives of key ecosystem actors.

3 Research Stages are shown in Figure 3

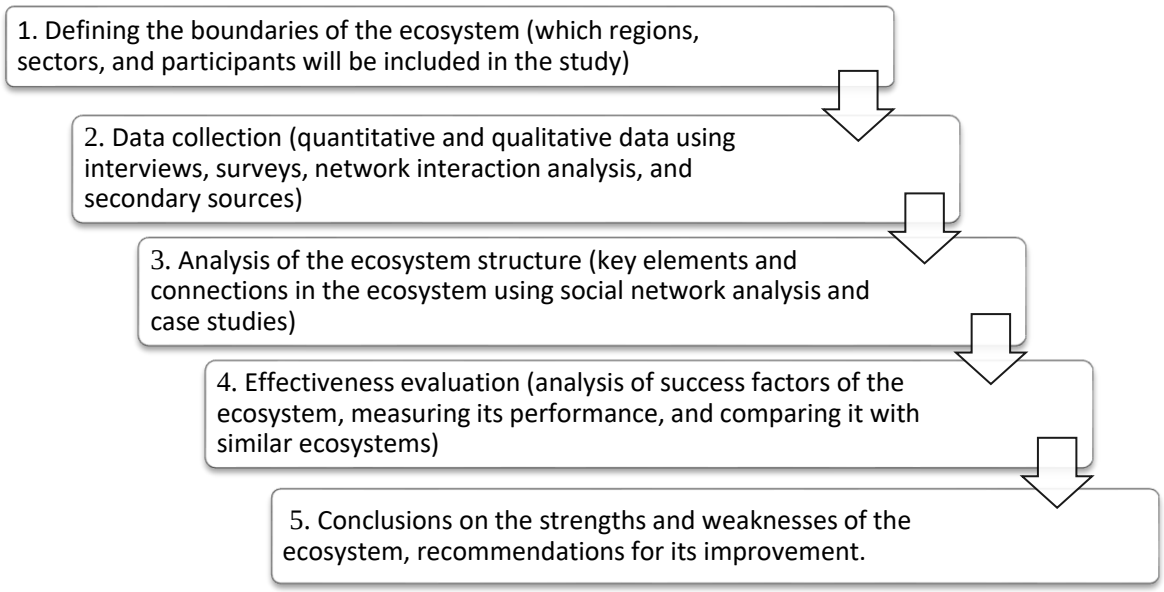

Figure 3: *Stages of Research on Entrepreneurial Ecosystems*

Thus, the proposed theoretical and methodological approach to the study of entrepreneurial ecosystems (EEs) meets the criteria of systematicity and multilevel analysis, combining theoretical and empirical methods for a joint analysis of the dynamics, structure, and factors that influence the functioning and development of ecosystems.

An essential condition for the scientific study of EEs is the systematization of characteristics that define their essence. The classification of EEs by their key features, as proposed by us, is presented in Table 1.

Table 1: *Classification of Entrepreneurial Ecosystems by Key Features*

Classification features	Subtypes	Description
1. Territorial Affiliation	Global Ecosystems:	Interactions and processes at the level of international business and global economies.
	National Ecosystems:	Characteristics of entrepreneurship within a single country.
	Regional Ecosystems:	Local business ecosystems in specific regions (cities, regions, rural areas).
2. Sectoral Focus	Technological Ecosystems:	Related to innovative and high-tech industries (IT, biotechnology, fintech, etc.).
	Agro-industrial Ecosystems:	Ecosystems in agriculture and agro-industry.
	Traditional Industries:	Include entrepreneurship in traditional economic sectors (trade, manufacturing, services).
3. Maturity Level	Nascent Ecosystems:	Ecosystems in the early stages, where infrastructure and connections between participants are still developing.
	Developing Ecosystems:	Ecosystems with basic infrastructure, actively growing through the adoption of technologies.
	Mature Ecosystems:	Stable ecosystems with well-established connections and a solid infrastructure.
4. Target Audience	Small and Medium-sized Enterprises (SMEs):	Ecosystems that support the development of small and medium-sized businesses.
	Large Companies:	Ecosystems interacting with large corporations and international players.
	Startups and Incubators:	Ecosystems aimed at supporting startups and business incubators.
5. Institutional Structure	University-based Ecosystems:	Include educational and research institutions as key elements.
	Corporate Ecosystems:	Ecosystems where large corporations play a leading role.
	Public-Private Partnerships:	Ecosystems developing with strong government support.
6. Technological Focus	Digital Ecosystems:	Structures based on digital technologies (blockchain, AI, Big Data, etc.).

	Analog Ecosystems:	Ecosystems with traditional business methods not related to digitalization.
7. Economic Model	Innovation-driven Ecosystems:	Focused on developing new products and services through innovation.
	Sustainability-oriented Ecosystems:	Include principles of ecological and sustainable growth.
	Investor-oriented Ecosystems:	Ecosystems focused on venture funding and investments.
8. Type of Interactions	Horizontal Ecosystems:	Interaction between participants of equal status.
	Vertical Ecosystems:	Interaction between participants at different levels, including startups and large companies.
9. Ecosystem Resources	Infrastructure-based Ecosystems:	Ecosystems where key roles are played by business incubators, coworking spaces, and technology parks.
	Financial Ecosystems:	Ecosystems focused on financial support (venture funds, grants, etc.).
	Cultural and Social Ecosystems:	Ecosystems that influence entrepreneurship through cultural and social factors.

In conclusion, the theoretical and methodological basis for the study of entrepreneurial ecosystems involves the integration of several theoretical approaches and the use of a wide range of methods and tools. To comprehensively study the ecosystem, a combination of qualitative and quantitative methods is necessary, such as social network analysis, case studies, interviews, and statistical analysis. This approach enables a deeper understanding of the structure and dynamics of the ecosystem and the development of measures to support and enhance it.

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