Humanities and Social Sciences **2025**
Research Journal 32, No. 1 (2025), pp 143-152 **January-March**

Received: March 2024
Accepted: March 2025
DOI: 10.7862/rz.2025.hss.11

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INNOVATION ECOSYSTEM MODELS: DEFINING THE ROLE OF THE UNIVERSITY IN THE INDUSTRY 5.0 PERSPECTIVE

The purpose of this research is to outline the role of universities in the existing models of innovation ecosystems. Based on a literature review, theoretical approaches are compared with the practical case study of Kyiv Academic University through focus groups and in-depth interviews with the ecosystem representatives and stakeholders. This research identifies that the key functions of the universities within the innovation ecosystems include being an academic and technology anchor, entrepreneurial university, institutional entrepreneur, knowledge-exchange leader, trust-builder, and political actor. This paper contributes to the theoretical foundations of the ecosystem functioning by arguing for the necessity to combine a linear approach for the structured innovation development progression, a helix model – for stakeholder engagement and a network model – and for dynamic interconnectivity. The conducted case study analyses confirm Academ.City ecosystem alignment with the best practices of the European regional innovation ecosystems and can be used as a benchmark for other universities in emerging economies.

Keywords: university, innovation ecosystem model, entrepreneurial university, dynamic capabilities.

1. INTRODUCTION

In recent years, increased attention from researchers and policymakers has been paid to the development and commercialization of innovations in Europe as a driver of its competitiveness. However, despite its high innovative potential, the EU is failing to advance its technology growth compared to China and the US. The decline of the EU's share of the global tech revenue from 22% to 18% from 2013 to 2023 resulted in only 4 of the world's top 50 tech companies being European (Draghi, 2024). Closing this innovation gap in advanced technology is defined as one of the three main areas of action to ensure the future sustainable growth of the EU. Moreover, the Industry 5.0 approach, prioritized

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by the European Commission as a paradigm of technology development (Industry 5.0 – Publications Office of the EU, 2021), implies that social sustainability should be balanced with the environmental and economic impact, leading to greater social inclusion and justice. This vision places human-centric actions and policies at the center of any innovation. It drives the need for life-long learning opportunities and talent training, thus fostering the role of education providers within the innovation process. Current research aims to summarise different models of innovation ecosystems and identify the role higher education institutions (HEIs) play in them. Based on the experience of the Kyiv Academic University – a public university building an innovation ecosystem with the HEI as its core, the study aims to explore how universities (academia) rethink their role in innovation development and commercialization, considering the Industry 5.0 perspective. Authors also define their interrelations with other ecosystem players and challenges faced by industry and society while collaborating with research and education institutions The study investigated the role of the universities within innovation ecosystems, comparing theoretical approaches with practical findings from the case study of the Kyiv Academic University (KAU). Focus groups and in-depth interviews conducted with the representatives of the place-based innovation ecosystem around KAU and the energy-innovation ecosystem in Ukraine were used to identify challenges and perspectives of innovation ecosystems formed around or having solid collaborations with research and education institutions.

2. LITERATURE REVIEW

2.1. Innovation Ecosystems and Industry 5.0

The innovation ecosystem concept is elaborated based on Moore's business ecosystem concept (1993). Valkokari and colleagues (2012) distinguished it from the business and knowledge ecosystem based on the role it plays in knowledge generation and its usage for value creation. Dodgson and co-authors (2014) define an innovation ecosystem as "a network of interconnected organizations, organized around a focal firm or a platform, incorporating both production and use side participants, and focusing on developing new value through innovation". The objective of the innovation ecosystem is to not only explore new knowledge but also exploit it for the purpose of creating and co-creating value (Taxt et al., 2022). Paassi and colleagues (2023) emphasize the importance of the dynamic perspective of the innovation ecosystem, concluding that the innovation ecosystem's internal dynamics and its positive outcome on the ecosystem's operation are defined by three elements: ecosystem actors, ecosystem properties, and the environment and outcome. Based on the above, we will further refer to the innovation ecosystem following the definition of Granstrand and Holgersson (2020): "An innovation ecosystem is the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors".

Innovation ecosystem actors include education and research institutions, startups and enterprises, financial entities, government structures, facilitating organizations (incubators, accelerators, innovation hubs, etc.) (Davalli et al., 2023) as well as customers (Paassi et al., 2023) and civil society (Taxt, 2022). This expansion of the ecosystem actors to include simultaneously the supply and demand sides of the innovation process, as well as policymakers and civil society, put them in the centre of the innovation, as expected by the Industry 5.0 approach. The latter goes beyond pure technology development. Industry 5.0

advocates for the worker and society's well-being and the win-win human-machine collaboration that will ensure "future-proof, resilient, sustainable and human-cantered" technological advancements (Breque, De Nul, & Petridis, 2021, p. 6). At the same time, Industry 5.0 priorities will also require changes within the innovation ecosystem structures and dynamics, including a broader request for human-centricity, nature-based and sustainable design, strengthening of the ecosystem learning capacity, and appeal for open social innovation support activities (CoP 5.0, 2024).

2.2. Innovation Ecosystem Models

Based on the literature review, we analyzed the evolution and identified the current vision of the innovation ecosystem models, including

- Linear Models
- Helix Models,
- Network Models.

Linear Models focus on a straightforward flow from research to development to commercialization (e.g., IDIA, 2017). The Linear Models emphasize the sequential progression of innovation stages, with a focus on the "product" development lifecycle. It is often mapped along measurable frameworks such as the Technology Readiness Level (TRL) (US Department of Defence, 2011) or Business Readiness Level (BRL) (Vik et al., 2021), enabling stakeholders to identify gaps or inconsistencies in innovation stages. However, the Linear Model's inherent limitation lies in its focus on sequential development, often overlooking the dynamic interactions among stakeholders that drive co-creation and adaptive innovation.

Helix Models emphasize the composition of the ecosystem actors, extending the number of collaboration groups, starting with the Triple Helix Model (involving collaboration between academia, industry, and government) to the Quintuple Helix Innovation System Model (adding civil society and environment as ecosystem actors). These models emphasize the dynamic interplay between stakeholders, ensuring that the needs and interests of all participants are integrated. Disaggregating the innovation ecosystem structure using Helix models allows for a better understanding of how stakeholder interactions drive innovation. It also ensures that gaps in stakeholder engagement are identified and addressed, fostering co-creation and shared value.

Network Models highlight interconnections and partnerships among diverse stakeholders (e.g., Valkokari, Paasi, Rantala, 2012; Gomes et al., 2018; Adner, 2006; Adner, Kapoor, 2016). These models are particularly adept at highlighting how relationships and collaborations drive ecosystem dynamics. Unlike the Linear Model, which focuses on a progression line, and Helix Models, which concentrate on stakeholder roles, the Network Models map the structural relationships that underpin innovation. Network Models are particularly effective at revealing how distributed innovation activities are orchestrated across the ecosystem, enabling a more fluid and adaptive approach to innovation management.

2.3. Innovation Ecosystem Performance Indicators

Innovation ecosystems are meant to generate multiple-dimension impact for their stakeholders. The industry 5.0 paradigm also implies that the innovation ecosystem follows the requirements for the triple-bottom-line performance, which is expected from all its individual actors. Therefore, it is necessary to measure and monitor the performance of the innovation ecosystem by its output indicators.

Most of the innovation ecosystem research and indexes primarily focus on the knowledge output and economic impact (Chatti, Drabo, Gagnon, 2024). Within knowledge output, researchers demand that other than publication, measures and outputs must be recognized for the ecosystem performance, especially in the context of Industry 5.0 (Ozols, Sarkane, Avotis, 2024). Davalli and colleagues (2023) mention the importance of data interoperability, global alignment of the ecosystem needs and principles with international standards and practices (e.g., EU Green and Digital Transition, (EC, 2019), and open standards and open source for the ecosystems' success and therefore these parameters should be monitored and measured. Taxt and colleagues (2022) emphasize the wider social role of the innovation ecosystem through participation in policymaking, culture, and architecture, in creating global opportunities for the local communities, and by introducing green and sustainable innovations (specifically through universities as its actors). Ozols and co-authors also emphasize promoting and utilizing digital technologies (ICT, AI, IoT, cyber-physical systems) to deliver customized solutions for social innovation.

The above considerations allow us to summarise the basic performance indicators for innovation ecosystems across several groups of output indicators:

1. Knowledge output:
   a. Patent and publication rates.
   b. Open innovation, e.g., use of open data platforms for innovation and transparency.
   c. Knowledge transfer – adopting university-led research into the industry or public service.
2. Economic Impact
   a. Job creation in high-tech and deep tech sectors.
   b. The GDP contribution of the innovation-driven industries of the ecosystem.
   c. Establishment and business performance of the new business entities (spin-offs and startups).
3. Social and Environmental Impact
   a. Adoption of clean technologies, green energy, and circular economy and human-centred practices.
   b. Efforts to ensure equitable benefits of innovation across different stakeholders, including underrepresented groups, including through policymaking.
   c. Quality of life improvements.
   d. Volume and impact of the citizen-led grassroots innovation projects.

3. METHODOLOGY

A literature review was conducted to outline the possible roles of the universities with the innovation ecosystems. A case study method was further used to investigate how existing theoretical models and corresponding roles of universities and research institutions are applicable in the contemporary context of an emerging economy and an ecosystem, focused on the Industry 5.0 technologies. We used Kyiv Academic University and the place-based innovation ecosystem, that is being created around it to analyze the practical functioning of such an ecosystem and identify existing challenges of the effective and efficient integration of universities into the innovation process. Apart from analyzing the existing structure of the ecosystem, 20 interviews were conducted with the ecosystem stakeholders coming from all four groups of the quadruple helix and related to the energy

innovation market. Four focus groups were held with representatives from academia (2 focus groups), business, and civil society.

4. RESULTS

In the latest report on European competitiveness, special attention was paid to the role of research and higher education in the innovation process. M. Draghi (2024) underlined the underused potential of the EU's innovation due to the lack of cooperation between higher education and research institutions and other partners to exploit economies of scale. Moreover, low incentives for cooperation with businesses and for entrepreneurial activities are mentioned as obstacles to proper technology deployment and competitive growth of EU countries. Despite that, the global economy provides best practices for innovation processes, where universities form innovation ecosystems around their research and manage to attract other actors for the general success of the ecosystem.

Several key roles were identified, attributed to the university as an actor of the innovation ecosystem (Ozols, Sarkane, Avotis, 2024; Taxt et al., 2022; HEInnovate, 2023; Heaton, Siegel, Teece, 2019):

- Universities as anchor tenants, deciding on the key technology development directions, new research programs.
- Entrepreneurial universities, supporting entrepreneurship, innovation, and commercialization activities, fostering the generation of new ventures.
- Universities as institutional entrepreneurs.
- Universities, taking on the knowledge-exchange function as opposed to purely technology-transfer function, providing research infrastructure for collaborative research with the private sector.
- Universities as trust-builders across the innovation ecosystem, ensuring an enhanced level of communication and collaboration across ecosystem participants while orchestrating these relationships.
- Universities as political actors, advocating policy changes and fostering social justice.

Across most of these functions, universities can facilitate the implementation of the Industry 5.0 principles to be applied by all the stakeholders and the ecosystem as a whole. Davalli and colleagues (2023) outline that the ability of the ecosystem to foster dialogue and collaboration among stakeholders is needed to synchronize the societal challenges with the policy strategies and tailor the appropriate innovative solutions to be acceptable and sustainable in the long term. Universities can be responsible for this process through their role of trust-builders and political actors, making sure that technology is adopted and deployed for the benefit of the local communities, society, and planet with a human-centered (Breque, De Nul, Petridis, 2021) and eco-centered (Forbes Coaches Council, 2024) perspective at the core of the innovation development.

However, based on the coevolution view of the innovation ecosystem models, researchers argue that the university's role should change with the increase in the ecosystem's maturity level. Moreover, the dynamic capabilities to sense the environment, seize opportunities, and maintain competitiveness are key to the university's effective and efficient contribution to developing the innovation ecosystem.

Kyiv Academic University is coordinating the project of creating Science Park "Academ.City", which aims to foster innovation and entrepreneurship within the research institutes of the National Academy of Sciences of Ukraine (NASU). The project started as

a quadruple-helix model, formed around the infrastructure and operational capacity of KAU and 12 research institutes of the NASU. The ecosystem integrates four groups of stakeholders: academia, industry, government, and civil society. Some of the representatives of the ecosystem across the quadruple-helix groups are listed in Table 1.

Table 1. A selective list of Academ.City Innovation Ecosystem Partners

Quadruple-Helix Group			
Academia	**Business**	**Government**	**Civil Society**
Adlershof Science Park *University of Helsinki* *Reutlingen University* *Kyiv-Mohyla Academy* *The Arctic University of Norway* *Technical University of Varna* *Algebra University Colleague* *University of Wurzburg* *Noosphere*	*Ukrainian Cluster Alliance* *G-Fore* *Rezos Brands* *ISE Accelerator* *Yuria Pharm* *Impact Hub* *Fasttrack* *Goodguys* *Vertical*	*Ministry of Education of Ukraine* *Ukrainian Startup Fund* *Kyiv City Military Administration* *Kyiv Region Military Administration* *Ukrainian National Office for Intellectual Property and Innovation (IP Office)*	*NGO Innovation* *NGO "Club of Economists"*

Source: own elaboration.

Dealing mainly with deep tech innovations, the Academ.City innovation ecosystem is prioritizing the principles of Industry 5.0, namely social and environmental sustainability and social justice. Therefore, operations and relationships inside the ecosystem imply following the open science and innovation approach (Chesbrough, 2024), establishing extensive dialogue across ecosystem participants and wider society through internal and external digital communication tools, and building trustworthy and horizontal management structures that promote collaboration and transparency.

Academ.City ecosystem follows the effectuation approach in its development and builds its expansion strategy through the "crazy-quilt" principle (Sarasvathy, 2024). Partnerships with new ecosystem participants are created with self-selecting stakeholders, those who demonstrate pre-commitments and are willing to invest their own human and financial resources to co-create new projects and values within the whole innovation ecosystem of the Academ.City. As a result, it is gradually evolving to the Network model, where diverse stakeholders are encouraged to build interconnected partnerships within temporary projects or around certain ecosystem structures (e.g., digital innovation hub, TISC, etc.).

KAU, being the coordinator of the ecosystem, plays the leading role in identifying its vision and strategy, as well as the road map for its further development. Results obtained from the focus group and the in-depth interviews conducted within the KAU ecosystem participants proved that stakeholders recognize the existence and value of the university's roles within the ecosystem according to the theoretical and practical approaches described earlier in the text (see Table 2).

Table 2. Stakeholders' confirmation of the university's role within the innovation ecosystem

University role	Stakeholders' opinion
Deciding on key technologies	"We need to enforce living labs."
Entrepreneurial universities	"We do 1-day workshops, pitching events, hackathons, and startup nights" to involve students in entrepreneurial activities."
Institutional entrepreneur	"Universities need to define their value proposition and communicate it strategically and efficiently."
Knowledge-exchange function	"…will consider undertaking joint trials, projects, experiments or research … and publish their outcomes for the benefit of the innovation ecosystem."
Trust-builders' function	"Invite students and startups for free pizza parties" to establish rapport and build an atmosphere of trust and co-creation
Universities as political actors	"Tech alone is not enough for innovation. We need societal adaptation."

Source: own elaboration.

5. DISCUSSION

The paper described three main innovation ecosystem models - linear, helix, and network models - outlining the differences in their creation approaches. Innovation ecosystem models differ in their foundational focus and approach but are inherently interrelated. Linear and Helix models differ in terms of their focus on either the ecosystem's "product" or "customer," and it is necessary to disaggregate any ecosystem structure using the principles of both models. It is necessary to ensure that the interests of all helix stakeholders are met. Therefore, the quadruple helix or any advanced helix model should be utilized. On the other hand, it is essential to identify the possible gaps in the innovation stage development that are not addressed by the activities and services of the innovation ecosystem. Thus, the linear model helps plot ecosystem operations on the TRL and BRL progression line to trace inconsistencies. In turn, Network Models map the relationships and interdependencies that sustain the ecosystem, enabling strategic partnerships and adaptive innovation. By combining these models, an innovation ecosystem can simultaneously ensure structured progression (Linear Models), multi-stakeholder engagement (Helix Models), and dynamic interconnectivity (Network Models). This integrated approach helps identify gaps, optimize stakeholder alignment, and leverage partnerships for sustainable and impactful innovation.

The analyzed case study allowed supporting theoretical foundations of the innovation ecosystem development and assessment approach by the practical evidence from the Academ.City innovation ecosystem in Ukraine.

Following Schaeffer and colleagues' (2024) research findings on the role of public universities in emerging countries, KAU, as a research-intensive university supported by the research institutes of the NASU, can build a strong innovation ecosystem and positively impact its further growth.

The open-innovation approach of the Academ.City aligns with the best practices of other European regional and place-based ecosystems (Davalli et al., 2023) and the

confirmed importance of open innovation flow and its appropriate orchestration (Paasi et al., 2023).

6. CONCLUSIONS

The aim of the study was to identify the theoretical foundations of the role of the higher education and research institutions in innovation development and the composition of the innovation ecosystems. Investigated models allowed to identify six main functions of the university within such ecosystems, namely technology anchor, entrepreneurial incubator and supporter, institutional entrepreneur, knowledge-exchange facilitator, trust-builder, and political actor. KAU and Academ.City ecosystem case study confirmed that these activities are both anticipated and valued by the participants and stakeholders. Further research will dive deeper into the ways of evaluating the efficiency of the activities conducted by universities as the actors and stakeholders of the innovation ecosystems to define the guidelines and the most suitable metrics to evaluate the quality of the innovation-related activities, maximize triple-bottom-line impact, and avoid innovation theatre.

Acknowledgements

This paper was supported by the European Commission under the projects SEEDplus: Strengthening Entrepreneurial Ecosystem Development (project #101100494) and WEnnovate: Co-creating More Connected Ecosystems to Transition European Innovation (project #101134909).

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