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METHODS AND MODELS FOR ASSESSING THE SOCIO-ECONOMIC EFFICIENCY OF REGIONAL INNOVATION INFRASTRUCTURE

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Abstract: The development of regional innovation infrastructure is a key component in enhancing the competitiveness of national economies and ensuring sustainable growth. This article explores the methodological foundations and models used to assess the socio-economic efficiency of innovation infrastructure at the regional level. Drawing upon international practices and the context of Uzbekistan, the article proposes an integrated approach for evaluating efficiency based on quantitative and qualitative indicators.

Key words: Regional innovation infrastructure, socio-economic efficiency, innovation assessment models, Global Innovation Index, European Innovation Scoreboard, innovation policy, regional development, composite indicators.

In the context of accelerating globalization and technological transformation, innovation has become a key driver of sustainable economic growth, regional competitiveness, and social development. The effectiveness of a country's or region's innovation ecosystem increasingly depends not only on the availability of advanced technologies or research capacity but also on the functionality and efficiency of its regional innovation infrastructure (RII). This infrastructure, comprising technology parks, innovation centers, incubators, research institutions, and support services, plays a central role in generating, transferring, and commercializing knowledge.

Assessing the socio-economic efficiency of RII is essential for evidence-based policymaking and strategic development planning. It provides policymakers, investors, and stakeholders with insights into how effectively innovation inputs—such as funding, human capital, and institutional support—are transformed into tangible socio-economic outcomes, including employment generation, productivity growth, regional diversification, and improved quality of life.

Despite the recognized importance of innovation infrastructure, methods for evaluating its efficiency—especially at the regional level—remain underdeveloped in many countries, including Uzbekistan. Traditional assessment tools often emphasize input-output relationships but fail to capture the complex socio-economic dynamics associated with innovation ecosystems. In recent years, international organizations such as the Organisation for Economic Co-operation and Development (OECD), the World Intellectual Property Organization (WIPO), and the European Union have developed composite indices and models—such as the Global Innovation Index (GII) and the European Innovation Scoreboard (EIS)—to enable more comprehensive evaluations.

This article aims to explore and synthesize the main methods and models used internationally to assess the efficiency of regional innovation infrastructure from a socio-

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economic perspective. It also critically examines their applicability in emerging economies, with a particular focus on Uzbekistan. The study seeks to provide recommendations for improving assessment methodologies in line with regional development goals and innovation policy priorities.

By drawing on best practices and comparative analysis, the article contributes to the growing discourse on measuring innovation-driven development at the regional level and provides a conceptual and methodological foundation for future empirical studies.

The concept of innovation infrastructure refers to the institutional, technological, financial, and human resource systems that support the generation, diffusion, and commercialization of innovations within a defined region or country. It is an essential component of the broader national innovation system (NIS), providing the physical and organizational foundation for innovative activities. Innovation infrastructure encompasses a wide range of elements including:

- Physical infrastructure (e.g., technology parks, laboratories, research facilities),
- Institutional infrastructure (e.g., universities, R&D institutions, innovation agencies),
- Financial infrastructure (e.g., venture capital funds, innovation grants),
- Support infrastructure (e.g., incubators, accelerators, consulting services).

According to Carlsson[1], innovation systems are composed of networks of institutions and firms that interact to produce and diffuse innovation. Within this system, the regional level has become increasingly important due to the spatial concentration of knowledge flows and the role of local context in shaping innovation outcomes (Asheim & Gertler[2]).

The OECD[3] emphasizes that regional innovation infrastructure plays a key role in ensuring that national innovation strategies are effectively implemented at the local level, especially through the alignment of research and innovation capacities with regional development objectives.

The literature identifies several core components of regional innovation infrastructure (Cooke[4], Tödtling & Trippl[5]):

- Knowledge generation institutions: universities, public research organizations, and private R&D centers.

[1] Carlsson, B., Jacobsson, S., Holmén, M., & Rickne, A. (2002). Innovation systems: analytical and methodological issues. Research Policy, 31(2), 233–245.
[2] Asheim, B. T., & Gertler, M. S. (2005). The Geography of Innovation: Regional Innovation Systems. In J. Fagerberg, D. C. Mowery, & R. R. Nelson (Eds.), The Oxford Handbook of Innovation. Oxford University Press.
[3] OECD. (2011). Regions and Innovation Policy. OECD Publishing.
[4] Cooke, P., Uranga, M. G., & Etxebarria, G. (2004). Regional innovation systems: Institutional and organisational dimensions. Research Policy, 34(8), 1173–1190.
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- Knowledge application institutions: firms, especially SMEs, that absorb and commercialize innovations.
- Bridging institutions: technology transfer offices, innovation intermediaries, incubators, and cluster initiatives.
- Policy and governance structures: regional innovation councils, development agencies, and funding bodies.

These components interact in complex and dynamic ways to create an environment conducive to innovation. The strength and coherence of these linkages are critical to the performance of innovation systems.

The Triple Helix Model (Etzkowitz & Leydesdorff[6]) provides a widely used theoretical framework to understand the collaboration among universities, industry, and government in driving innovation. This model underlines the importance of synergy among the three spheres and the emergence of hybrid institutions (e.g., university spin-offs, public-private partnerships) in enhancing innovation capacity.Building upon this, the Quadruple and Quintuple Helix models (Carayannis & Campbell[7]) incorporate civil society and the natural environment, emphasizing the socio-ecological context of innovation and the role of user-driven innovation, particularly in regional settings.

The spatial dimension of innovation has gained attention in regional development theory. Scholars such as Storper[8] and Malecki[9] have shown that innovation tends to be geographically concentrated due to proximity advantages, localized knowledge spillovers, and the role of place-based institutions.

The effectiveness of regional innovation infrastructure is also crucial for reducing territorial disparities and promoting smart specialization, a concept developed by the European Commission (Foray[10]) to encourage regions to focus on their unique strengths and opportunities through innovation. In the context of developing and transition economies, including Uzbekistan, the development of innovation infrastructure faces several constraints:

- Limited R&D investment and weak research base,
- Fragmented institutional coordination,
- Low levels of industry-academia collaboration,
- Insufficient access to finance for innovation.

As noted by Radosevic[11] and more recently by the World Bank, building effective regional innovation systems in such contexts requires not only infrastructure investment but

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also capacity building, governance reforms, and better integration of local innovation actors into global networks. Assessing the socio-economic efficiency of regional innovation infrastructure is a complex task that requires evaluating multiple dimensions of economic and social outcomes. The goal is to understand how well the innovation infrastructure contributes to regional development, economic growth, social equity, and sustainability. The socio-economic efficiency of an innovation system can be assessed using a variety of quantitative and qualitative criteria, often based on the balance between inputs (resources, investment) and outputs (innovation outcomes, economic impact).

Criteria for socio-economic efficiency assessment of regional innovation infrastructure. Table-1

Economic Impact	• GDP Growth and Employment Creation • Productivity and Competitiveness • Return on Investment (ROI)
Innovation Output	• Patent Activity and Technology Transfer • Start-ups and Spin-offs • Research and Development Outputs:
Social Impact and Inclusion	• Human Capital Development • Social Equity • Quality of Life and Sustainability
Sustainability and Environmental Impact	• Green Innovation and Eco-Technologies: • Carbon Footprint and Resource Efficiency
Institutional and Governance Effectiveness	• Policy Alignment and Coordination • Governance Quality
International Competitiveness	• Global Positioning and Foreign Direct Investment

The assessment of the socio-economic efficiency of regional innovation infrastructure, as illustrated in Table 1, is conducted using a variety of criteria that take into account both inputs (such as resources and investments) and outputs (including economic growth, equity, and sustainability). The critical areas of focus encompass:

Economic Impact: Innovation infrastructure drives GDP growth, employment, and productivity. Fagerberg[12] link innovation to productivity gains, while Rodríguez-Pose (2013) ties R&D hubs to job creation and economic diversification. Porter (1998) emphasizes innovation's role in competitiveness, and Chesbrough[13] highlights ROI through spillover effects. Innovation

[12] Fagerberg, J., Mowery, D. C., & Nelson, R. R. (2013). The Oxford handbook of innovation. Oxford University Press.

[13] Chesbrough, H. W. (2003). Open innovation: The new imperative for creating and profiting from technology. Harvard Business School Press.

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Output: Patents (Griliches[14]), start-ups (Audretsch & Keilbach[15]), and R&D collaborations (Cohen & Levinthal[16]) reflect output. Technology transfer (Mowery & Nelson[17]) and absorptive capacity determine commercialization success.

Social Impact & Inclusion: Human capital development (Autor[18]) and equitable benefit distribution (Storper[19]) are critical. Innovation systems enhance quality of life via sustainability-focused solutions (Fukuyama[20]). Sustainability & Environmental Impact: Green innovation (Mazzucato[21]) and resource efficiency (Porter & van der Linde[22]) position regions as sustainability leaders. Institutional & Governance Effectiveness: Policy coordination (Tödtling & Trippl[23]) and transparent governance (Harrison & Weiss[24]) ensure alignment with regional goals.

International Competitiveness: Global indices (e.g., GII, EIS) and FDI inflows (Kaufmann & Tödtling[25]) reflect a region's innovation leadership.

Collectively, these criteria underscore the need for a holistic approach to assess how innovation infrastructure fosters balanced socio-economic development. Assessing the socio-economic efficiency of regional innovation infrastructure requires a multidimensional and context-sensitive approach. While global models such as the Global Innovation Index and European Innovation Scoreboard offer valuable frameworks, they must be adapted to the specific institutional, economic, and social realities of emerging economies like Uzbekistan. A holistic evaluation should integrate not only input-output analysis but also factors such as governance quality, sustainability, inclusion, and digital readiness. By adopting an integrated and dynamic assessment model, Uzbekistan can more effectively align innovation infrastructure with regional development goals, enhance competitiveness, and foster inclusive, innovation-driven growth.

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