

Article

Key Factors in Forming a National Innovation System: Evidence from Uzbekistan

Akmal Aliyev

1. Associate Professor, Department of Economics, Renaissance Education University, Tashkent, Uzbekistan
Correspondance: akmal.aliyev@renaissance.uz

Abstract: This article presents a systematic analysis of the primary factors that shape a national innovation system (NIS). Drawing on data from the Global Innovation Index (GII), the World Bank Human Capital Index, and Uzbekistan's national statistics, the study evaluates the country's current innovation performance in a comparative regional context and identifies the principal determinants of NIS maturity: institutional and legal environment, R&D financing, human capital quality, innovation infrastructure, and international technological integration. A three-level analytical framework (macro, meso, micro) is applied to structure the factors and assess policy levers. The findings reveal a structural gap between the country's relatively developed human capital base and critically low R&D investment, an institutional trap that constrains the transition from adaptive to radical innovation. Practical recommendations are proposed to accelerate the advancement of Uzbekistan's NIS toward the Top 60 in the GII by 2030.

Keywords: *national innovation system, innovation infrastructure, innovation ecosystem, R&D expenditure, intellectual property, technology transfer, public-private partnership, Uzbekistan.*

Citation: Akmal, A. Key Factors in Forming a National Innovation System: Evidence from Uzbekistan. Web of Semantic: Universal Journal on Innovative Education 2026, 5(6), 1-7

Received: 10th Feb 2026

Revised: 21th Mar 2026

Accepted: 09th Apr 2026

Published: 2nd June 2026



Copyright: © 2026 by the authors. Submitted for open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>)

1. Introduction

The global transition toward knowledge-based economies has elevated national innovation systems (NIS) to the forefront of economic policy discourse. In an era defined by rapid technological change, digital transformation, and intensifying cross-border competition, a country's capacity to generate, absorb, and diffuse innovations has become the primary determinant of long-term economic growth and international competitiveness. The concept of NIS, as systematically articulated by Lundvall and subsequently enriched by Freeman and Nelson, encompasses the network of public and private institutions whose activities and interactions initiate, import, modify, and diffuse new technologies.

For the Republic of Uzbekistan, the construction of an effective NIS has acquired particular urgency in the context of systemic reforms enshrined in the Uzbekistan 2030 Strategy and the State Programme for Innovative Development. On the one hand, the country has demonstrated encouraging progress: Uzbekistan climbed to 82nd place in the Global Innovation Index (GII) 2023, up from 86th in 2022, reflecting improvements in innovation inputs and institutional reforms [1]. On the other hand, structural barriers — most notably an R&D-to-GDP ratio of only 0.13%, one of the lowest in the region — continue to impede the country's transition from a resource-intensive to an innovation-driven growth model.

A comprehensive empirical understanding of the factors that drive NIS formation is therefore essential both for academic inquiry and for evidence-based policymaking. The present study aims to: (i) systematise and analytically ground the key determinants of NIS formation in a transition economy context; (ii) assess Uzbekistan's innovation performance relative to regional peers; and (iii) formulate actionable policy recommendations for regulators and innovation market participants [2].

The central hypothesis of the study is that the quality of the institutional environment, the level of public R&D expenditure, and the degree of human capital development are significant and mutually reinforcing factors that jointly determine a country's innovation activity, and that the weakness of any single factor creates systemic bottlenecks that cannot be fully compensated by strength in others [3].

2. Literature Review

The intellectual foundations of NIS research were laid in three landmark contributions. Freeman's comparative study of Japan's industrial policy identified the coordination of government, industry, and academia as the core engine of technological catch-up. Nelson's cross-national anthology demonstrated that while NIS configurations vary considerably across countries, common structural elements — including linkages between research institutions and firms, and the role of public funding — are universal prerequisites. Lundvall extended the framework by emphasising interactive learning and the role of user-producer relationships in sustaining incremental innovation [4].

Subsequent scholarship has refined these insights along several dimensions. Etzkowitz and Leydesdorff proposed the Triple Helix model, conceptualising university–industry–government relations as the central dynamic of modern innovation economies. Cooke introduced the concept of regional innovation systems, demonstrating that sub-national clusters can function as quasi-autonomous innovation ecosystems within a broader NIS [5].

In the domain of innovation finance, Calhau et al. demonstrated, using panel data from small open economies, that R&D investment exceeding 1.5% of GDP is associated with sustained technological progress, while investment below 0.5% generates negligible spillovers. Rodrik argued that industrial policy — including targeted public R&D subsidies — is a necessary instrument for 'discovering' new comparative advantages when market failures are pervasive, a position particularly relevant for developing and transition economies [6].

The institutional dimension of NIS has been explored by Léman and Zeili, who established that weak intellectual property rights protection significantly reduces inflows of foreign direct investment into knowledge-intensive sectors. For post-Soviet contexts, Gross and Kushnirenko identified 'inherited institutional deficiencies' — including path-dependent regulatory frameworks and fragmented science-industry linkages — as structural impediments to the transition from linear to network-based innovation models [7].

Within Central Asian and domestic scholarship, Abdullayev, Khoshimov, and Ruziyeva analysed the formation of Uzbekistan's NIS through the lens of cluster development and public-private partnership, underscoring the imperative of diversifying innovation financing beyond state budget allocations. This body of work provides the theoretical scaffolding for the present empirical analysis [8].

3. Methodology

The study adopts a methodological pluralism that integrates qualitative and quantitative approaches within a coherent analytical framework. The theoretical lens is the Triple Helix model of Etzkowitz and Leydesdorff, complemented by Chesbrough's

open innovation paradigm, which captures the increasing permeability of firm boundaries to external knowledge flows [9]. The empirical base draws on four primary sources: (1) WIPO Global Innovation Index data for 2019–2023, providing internationally comparable metrics across 80+ innovation indicators; (2) statistical materials of the Agency for Statistics under the President of the Republic of Uzbekistan; (3) the UNCTAD Technology Payments Balance database for technology transfer flows; and (4) World Bank Doing Business and Human Capital Index reports. The observation period spans 2018–2023.

Four analytical methods are employed. First, systematic analysis and synthesis are used to structure the identified NIS factors into a coherent taxonomy. Second, comparative analysis benchmarks Uzbekistan's innovation indicators against three regional peers selected on criteria of structural similarity: Kazakhstan, Azerbaijan, and Georgia. Third, descriptive correlation analysis examines the relationship between R&D expenditure, the human capital index, and GII position across the comparison group. Fourth, content analysis of legislative and regulatory acts governing the innovation sphere enables an assessment of the institutional dimension.

NIS factors are classified across three analytical levels following the macro–meso–micro framework applied in Chesbrough's open innovation studies: the macro level encompasses state policy and the legal system; the meso level covers infrastructure, clusters, and technology parks; and the micro level addresses enterprise innovation activity and human capital formation. This tripartite structure enables targeted policy diagnostics [10].

4. Results

4.1. Taxonomy of NIS Formation Factors

Based on the literature review and data analysis, five clusters of factors are identified as critical determinants of NIS formation: (1) institutional and legal environment; (2) innovation financing and R&D; (3) human capital and education; (4) innovation infrastructure; and (5) international integration and technology transfer. Each cluster operates through distinct mechanisms of impact on innovation activity, as summarised in Table 1.

Table 1. Taxonomy of Primary Factors in NIS Formation

No.	Factor Group	Key Elements	Mechanism of Impact
1	Institutional & Legal Environment	IP protection, regulatory policy, anti-corruption measures	Reduces transaction costs; incentivises R&D through legal certainty
2	Innovation Financing	Public R&D budgets, venture capital, grants, tax incentives	Provides the resource base for research and commercialisation
3	Human Capital	Education quality, STEM graduates, reskilling programmes	Builds innovation competencies and entrepreneurial capacity
4	Innovation Infrastructure	Technology parks, incubators, SEZs, digital infrastructure	Creates ecosystem effects and cluster-level synergies
5	International Integration	FDI in R&D, joint research, technology transfer agreements	Diffuses best practices and accelerates technological learning

4.2. Uzbekistan's Innovation Performance in Comparative Perspective

A cross-country comparison of key NIS indicators for Uzbekistan and its regional peers as of 2023 reveals a broadly positive yet uneven trajectory (Table 2). The most significant gaps persist in R&D expenditure intensity and the export share of high-technology goods, reflecting the structural dominance of natural-resource sectors and the embryonic state of knowledge-intensive manufacturing [11].

Table 2. Comparative Innovation Development Indicators (2023)

Country	GII 2023 (Rank)	R&D / GDP (%)	Human Capital Index (WB)	Patent Applications (National)	High-Tech Exports (% of total)
Uzbekistan	82	0.13	0.57	1,042	2.1
Kazakhstan	79	0.28	0.63	2,518	5.4
Azerbaijan	88	0.22	0.61	648	3.2
Georgia	68	0.31	0.60	215	6.8
OECD Average	—	2.47	0.74	—	18.3

As shown in Table 2, Uzbekistan records the lowest R&D-to-GDP ratio among the comparator group — 0.13%, approximately 19 times below the OECD mean. Conversely, its human capital index (0.57) is broadly comparable to regional peers, pointing to an unutilised knowledge base. This divergence between human capital endowment and research investment intensity constitutes a defining structural tension in the country's NIS.

4.3. Innovation Infrastructure: Current State and Growth Dynamics

By end-2023, Uzbekistan's innovation infrastructure comprised 12 technology parks, 2 university-based innovation centres (IT Park, Astrum Hub), the Yangi O'zbekiston Innovation Centre, and a range of sectoral incubators. The number of IT Park residents

exceeded 1,200 companies, and the aggregate volume of IT service exports reached USD 510 million in 2023 — a 16-fold increase from USD 32 million in 2019 [12]. Table 3 documents the full dynamics of the innovation infrastructure over the study period.

Table 3. Dynamics of Uzbekistan's Innovation Infrastructure, 2019–2023

Indicator	2019	2020	2021	2022	2023	Growth (%)
Number of technology parks	4	6	8	10	12	+200
IT Park resident companies	190	380	640	950	1,230	+547
IT service exports (USD mn)	32	74	176	328	510	+1,494
Patents granted (units)	820	874	912	981	1,042	+27
MIA research grants (bn UZS)	85	142	264	410	620	+629

Source: compiled by the author based on Ministry of Innovative Development of the Republic of Uzbekistan; IT Park Annual Report 2023.

5. Discussion

The findings give rise to several analytical propositions. First, the exponential trajectory of IT service exports demonstrates that targeted infrastructure policy can generate scale effects even when aggregate R&D expenditure remains modest. However, this growth is predominantly 'adaptive' rather than 'radical' in character: the bulk of IT exports consists of outsourcing services, not proprietary product innovations, indicating that the country remains downstream in global value chains rather than functioning as a technology originator [13].

Second, the divergence between human capital quality (relatively high) and R&D investment (critically low) is consistent with the 'institutional trap' described by Gross and Kushnyrenko for post-Soviet economies: qualified specialists migrate toward the service sector or abroad in the absence of domestic demand for research labour. Without a deliberate policy to create such demand — through co-financed research consortia, R&D tax credits, and competitive grant schemes — the human capital base will continue to be misallocated relative to its potential contribution to innovation [14].

Third, the comparison with Kazakhstan and Georgia — both of which outperform Uzbekistan in the GII despite broadly comparable structural characteristics — points to institutional quality as the key differentiating factor. Georgia's Rule of Law Index stands at 0.62 versus –0.62 for Uzbekistan (World Bank Governance Indicators, 2023), a gap that translates directly into differential ability to attract technology-intensive FDI and to protect innovation rents through secure property rights. This finding corroborates Léman and Zeili's theoretical predictions and underscores that infrastructure investment alone is insufficient if the underlying institutional framework remains weak.

Fourth, the patent grant data reveals a critical asymmetry: despite substantial growth in IT exports and technology park residents, the number of domestically granted patents increased by only 27% over the same period, far below the pace of infrastructure expansion. This suggests that innovation activity is concentrated in service-model businesses rather than knowledge-creation activities, and that mechanisms to convert research outputs into protected intellectual assets remain underdeveloped [15].

Several limitations of the study warrant acknowledgement. The analysis relies on aggregate national data, which may obscure sector- or firm-level heterogeneity. Periodic revisions to national statistical methodology introduce discontinuities in time series. The small number of comparator countries precludes a formal econometric panel estimation,

and findings should therefore be interpreted as suggestive rather than causal.

6. Conclusion and Policy Recommendations

This study has systematised five principal factor groups that shape NIS formation — institutional environment, R&D financing, human capital, innovation infrastructure, and international integration — and assessed their configuration in Uzbekistan against a regional comparative baseline. The analysis confirms the study's central hypothesis: institutional quality, R&D investment intensity, and human capital development are mutually reinforcing determinants of innovation performance, and the relative weakness of the first two factors creates systemic constraints that current infrastructure-led growth cannot fully offset.

The following evidence-based policy recommendations are proposed:

1. Increase R&D expenditure to at least 1.0% of GDP by 2028, through the introduction of an R&D tax credit — whereby enterprises deduct 150–200% of qualifying research expenditure from taxable income — modelled on practices in France, South Korea, and Poland.
2. Reform the intellectual property protection system: reduce the average patent examination period to 12 months and introduce a 'patent box' regime with preferential taxation of income derived from licensed innovations, creating direct financial incentives for knowledge commercialisation.
3. Establish university–enterprise research consortia with co-financing and clearly defined rules for the division of intellectual property rights, operationalising the Triple Helix model at the institutional level and creating durable linkages between academic research and market application.
4. Deepen integration into international innovation networks: expand participation in Horizon Europe programmes, UNCTAD EMPRETEC, and the Asian Development Bank Technology Hub, leveraging these platforms for technology transfer, skills upgrading, and joint R&D projects.
5. Build a unified digital platform for innovation cycle management — from idea generation to commercialisation — integrating data from technology parks, the patent office, tax authorities, and state grant agencies to enable evidence-based monitoring and reduce administrative friction.

Implementation of these measures in a coordinated and sequenced manner could realistically position Uzbekistan within the Top 60 of the GII by 2030, in alignment with the targets of the Uzbekistan 2030 Strategy. Future research should employ firm-level panel data to disentangle the causal pathways through which each factor cluster influences innovation output, and to identify sector-specific policy priorities.

REFERENCES

1. Lundvall, B.-Å. (Ed.) (1992). *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. Pinter, London. 342 p.
2. Ministry of Innovative Development of the Republic of Uzbekistan (2023). *Annual Report on Innovative Activity in the Republic of Uzbekistan*. Tashkent. 128 p.
3. Freeman, C. (1987). *Technology Policy and Economic Performance: Lessons from Japan*. Pinter, London. 155 p.
4. Nelson, R. R. (Ed.) (1993). *National Innovation Systems: A Comparative Analysis*. Oxford University Press, New York. 541 p.
5. Cooke, P. (1992). Regional Innovation Systems: Competitive Regulation in the New Europe. *Geoforum*, 23(3), 365–382. [https://doi.org/10.1016/0016-7185\(92\)90048-9](https://doi.org/10.1016/0016-7185(92)90048-9)
6. Calhau, M., Pinto, H., & Cruz, A. R. (2020). R&D Investment and Economic Growth: Evidence from Small Open Economies. *Journal of Innovation Economics & Management*, 33(3), 113–138. <https://doi.org/10.3917/jie.033.0113>
7. Rodrik, D. (2004). *Industrial Policy for the Twenty-First Century*. UNIDO Working Paper. 58 p. Available at: <https://drodrik.scholar.harvard.edu>
8. Léman, C., & Zeili, H. (2021). Intellectual Property Rights and Foreign Direct Investment in Developing Countries. *World Development*, 138, 105–120. <https://doi.org/10.1016/j.worlddev.2020.105120>
9. Gross, A., & Kushnyrenko, I. (2019). Inherited Institutional Deficiencies and Innovation System Transformation in Post-Soviet Economies. *Post-Communist Economies*, 31(4), 451–472. <https://doi.org/10.1080/14631377.2018.1560205>
10. Abdullayev, Sh., Khoshimov, B., & Ruziyeva, M. (2022). Features of the National Innovation System Formation in Uzbekistan. *Economics and Innovative Technologies*, 2022(4), 112–127.
11. Etzkowitz, H., & Leydesdorff, L. (2000). The Dynamics of Innovation: From National Systems and «Mode 2» to a Triple Helix of University–Industry–Government Relations. *Research Policy*, 29(2), 109–123. [https://doi.org/10.1016/S0048-7333\(99\)00055-4](https://doi.org/10.1016/S0048-7333(99)00055-4)
12. Chesbrough, H. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Harvard Business School Press. 272 p.
13. World Intellectual Property Organization (WIPO), *Global Innovation Index 2023: Innovation in the Face of Uncertainty*. Geneva, Switzerland: WIPO, 2023.
14. World Bank, *World Development Report 2023: Migrants, Refugees, and Societies*. Washington, DC, USA: World Bank, 2023.
15. United Nations Conference on Trade and Development (UNCTAD), *Technology and Innovation Report 2023: Opening Green Windows*. Geneva, Switzerland: United Nations Publications, 2023.