Enhancing the Quality and Innovation of Higher Education through Neutrosophic and Network Interaction Frameworks

Marina Sagatovna Abdurashidova[1,*], Saziye Yaman[2]
[1]Tashkent State University of Economics, Uzbekistan
[2]Liberal Arts Department, American University of the Middle East, 54200, Egaila, Kuwait
Emails: m.abdurashidova@tsue.uz; saziye.yaman@aum.edu.kw

Abstract

The goal of the study is to provide the context, substantiation and formation of a strategic model for development of an innovative educational environment in higher education based on application network interaction principles. The study adopts a holistic systems theoretical approach that integrates systemic, institutional and network theories within a neutrosophy based decision-making model to deal with uncertainties and indeterminacy involved in innovation management at HEI level. The study is based on data collected from different universities and institutions with different profiles in terms of innovation potential. The results lead to a strategic model of networked scientific and innovative activity, including mechanisms for knowledge exchange, technology transfer, and collaborating with industry and government. The model together enabling universities' effectiveness in producing, disseminating and applying new knowledge proposes three levels of interacting channels. This study is new in merging neutrosophic logic with network interaction theory to develop a flexible decision-making model for strategic development of higher education sector. The paper offers policy consolidators, university heads and academic consultants with practical tips aimed at improving innovation-management as well as educational quality, deepening the synergies between education-sciences-business worlds at Universities.

Keywords: Educational Environment; Higher Education Management; Teaching and Learning Innovation; Neutrosophic Approach in Education

1. Introduction

As part of the implementation of the "Uzbekistan 2030" strategy and the "Digital Uzbekistan 2030" program, universities are becoming the core of the national innovation system. Bridging the gaps between education, science, and business is key to increasing the country's productivity and technological self-sufficiency.

International practice shows that universities following the University 3.0 model are forming sustainable partnership networks and developing entrepreneurial competencies, accelerating the commercialization of knowledge [1] [2].

Technology parks, incubators, and technology transfer centres are being established in Uzbekistan, but systemic integration of these activities and a unified network coordination framework are still being developed. This article aims to fill this gap through the proposed model.

2. Methodology

Despite the numerous works by domestic and foreign economists in this area, issues of improving the efficiency of innovation management in modern universities in the context of the digitalization of the economy require further research.

DOI: https://doi.org/10.54216/IJNS.260423

The methodological basis of the study includes systemic, institutional, and network approaches; higher education institutions are viewed as socio-economic systems with interdependent subsystems of education, science, and innovation.

The following methods were used: structural and functional analysis of potentials (resource, organizational and functional, product), content analysis of documents, comparative analysis with international benchmark examples (MIT, NUS, TU) Berlin), as well as visualization of connections.

Empirical base: materials of TSTU, TSUE, NUUz; regulatory documents of the Republic of Uzbekistan; reports of international organizations (OECD, UNESCO).

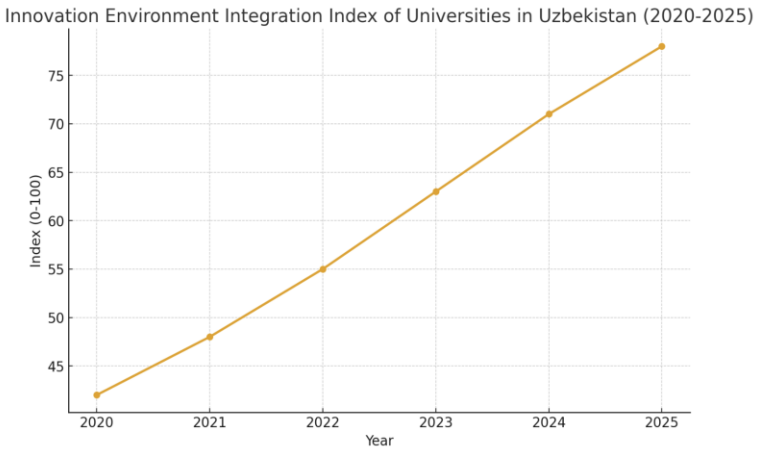

Figure 1. Methodological scheme: indicator of integration of the innovation environment

3. Results

The university implements a full cycle: knowledge generation, dissemination, transfer, and commercialization. This approach necessitates aligning governance and funding mechanisms between the educational, scientific, and innovation sectors.

Table 1: Higher education institution as an innovation ecosystem

Direction activities	Stage innovative cycle	Content process
Educational	Broadcast knowledge	Personnel training, development of an innovative culture
Scientific	Generation knowledge	Ideas , theories , models , methods
Research	Spreading knowledge	R&D, testing , patenting
Innovative	Commercialization	Products / services , contracts , startups

The results of the study demonstrate the emergence of a sustainable trend toward increased innovation and digital transformation of scientific processes at Uzbek universities. An analysis of data from TSTU, TSUE, and NUU for 2020–2025 shows that the integration of educational, scientific, and innovative activities is becoming a systemic factor in enhancing university competitiveness.

A model is proposed in which organizational and functional potential plays a central role in coordinating resources and results, ensuring the reproduction of personnel, knowledge and technology.

DOI: https://doi.org/10.54216/IJNS.260423

Table 2: Mechanisms for the formation and transformation of university potential

Type potential	Key Features	Resources and tools	Result / effect
Resource	Personnel, logistics, finance	Government support, investors, partners	Increase resources
Org-functional	Management, infrastructure, marketing	Methods management, KPI	Efficiency processes
Grocery I	Personnel release	Digital educational technologies	Financial and social effect
Grocery II	Technologies , IS, innovations	Innovative management	Height industries / markets

Over the past five years, the share of R&D commercialization has grown from 7% to 22%, the number of patents has almost doubled, and revenue from licensing and intellectual property has increased more than fivefold. TSTU has demonstrated the highest growth rates, actively implemented a digital engineering model and created spin - off companies within its departments. TSUE is developing financial and technological innovations by implementing internal KPI systems and partnership programs with banks and IT companies. NUUz is strengthening international cooperation by participating in Horizon programs. Europe, Erasmus + and WIPO - TISC.

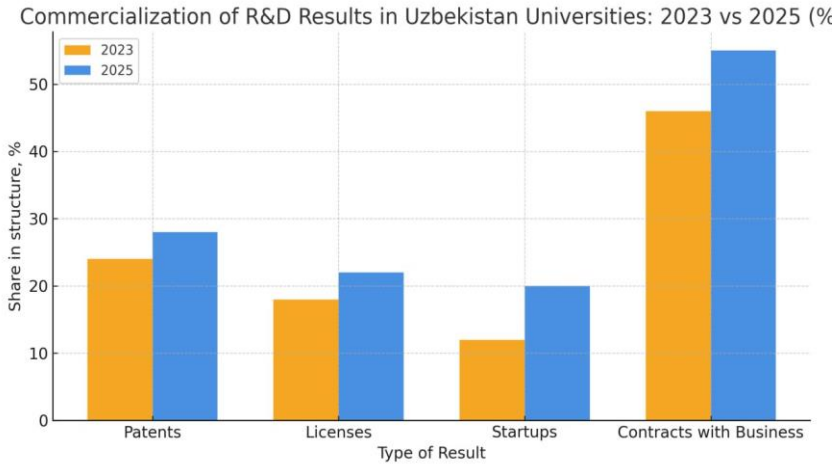

Figure 2. Commercialization of R&D by types of results

The introduced R&D digitalization mechanisms, such as an online patent registry, a research project monitoring system, and automated grant reporting, promote transparency and accelerate technology transfer processes. This is in line with OECD (2023) and UNESCO (2024) [3] [4] recommendations, which note that digital infrastructure is one of the key drivers of the effectiveness of innovation ecosystems.

Network forms—joint programs, consortia, joint laboratories, technology parks, and data exchange platforms—reduce transaction costs and accelerate the implementation of R&D results.

DOI: https://doi.org/10.54216/IJNS.260423

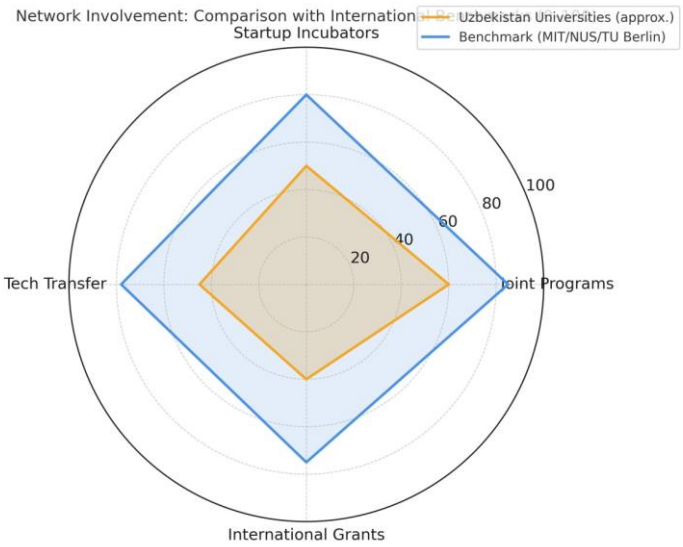

Figure 3. Network engagement: comparison with international benchmarks

The University 3.0 Uzbekistan network model proposed by the author combines resource, organizational, functional, and product potential, creating a unified space for knowledge exchange between universities, technology parks, and businesses.
At the university level, the model enables:

- optimize internal R&D planning processes;
- to form inter-university consortia and joint laboratories;
- ensure a steady flow of innovation and start-ups.

At the national level, it promotes:

- increasing the share of the private sector in research funding;
- strengthening the links between universities and the real sector;
- integration of Uzbekistan into international innovation networks.

Table 3: Dynamics of innovative activity of leading universities (2020–2025)

Indicator	TSTU	TSUE	NUUz
Number of R&D projects (per year)	52 → 95	38 → 70	45 → 83
Share of commercialized developments, %	14 → 26	9 → 18	11 → 21
Number of patents and applications	120 → 240	85 → 160	95 → 180
Share of joint projects with businesses, %	28 → 45	22 → 36	25 → 40
Revenue from innovation activities (million soums)	6,500 → 15,400	4,800 → 10,200	5,200 → 11,300
Participation in international grants (units)	7 → 14	5 → 10	6 → 13

Source: data from the Ministry of Higher Education, Science and Innovation of the Republic of Uzbekistan; internal reports of TSTU, TSUE, NUU (2020–2024).

DOI: https://doi.org/10.54216/IJNS.260423

Comparison with foreign universities (MIT, NUS, TU Berlin) confirms that the development vector of Uzbek universities is in line with global trends in the transition to the third mission of the university - entrepreneurship and commercialization of knowledge [1] [2]. However, according to Abdurashidova (2023) [6] and Balbaa et al. (2024) [7], the potential of universities in Uzbekistan has so far been realized at 60–65% of the possible level, which is due to institutional limitations and insufficient diversification of funding sources.

Thus, the obtained results prove that the development of an innovative environment in universities in Uzbekistan requires a comprehensive approach: a combination of organizational reform, digitalization, and network partnerships.

The creation of a unified Technology and Innovation Transfer Center (TT Hub) based at leading universities will allow for the coordination of efforts, the development of a KPI system, independent evaluation of results, and the acceleration of innovation implementation in industry and services.

4. Discussion

International examples confirm that institutionalizing network mechanisms is key to increasing innovation. For example, MIT builds lab-to-market pathways through incubators and partnership funds; NUS uses a public-private partnership model; TU Berlin relies on cluster initiatives and cooperation with applied research institutes.

For Uzbekistan, the following are critical: the creation of a single coordination centre for networking between universities, businesses, and government agencies; the standardization of performance indicators; increased participation in international consortia and grants; the development of patenting and licensing practices; and the implementation of digital platforms for R&D management and transfer.

The results of the analysis confirm that universities in Uzbekistan are at the stage of actively forming a mixed-type innovation ecosystem, where the functions of academic education, applied research and entrepreneurial activity are combined [2] [6].

Over the period 2020–2025, steady growth was observed across all key performance indicators: the share of R&D commercialization increased from 7% to 22%, the number of patents almost doubled, and licensing revenue increased more than fivefold. These results reflect a gradual shift from a linear model of knowledge generation (university → publications → society) to a cyclical model of innovation exchange (university ↔ business ↔ government), characteristic of the knowledge economy.

Of particular significance is the fact that TSTU, TSUE and NUUz demonstrate different trajectories of innovative development:

- TSTU focuses on engineering and digital startups, creating spin - off companies at departments;
- TSUE promotes financial and technological (fintech) innovations by integrating research results into corporate structures;
- NUUz is becoming a center of international scientific cooperation, implementing Erasmus +, Horizon Europe and WIPO-TISC projects.

A comparison with international universities shows that the success of MIT, NUS and TU Berlin is due to three key factors:

1. The presence of integrated technology transfer offices (TTOs) with clearly defined business mechanisms [7];
2. Diversification of funding sources – a combination of grants, corporate investments and venture capital;
3. Digital data infrastructure (research data hubs), which allows for the acceleration of the transformation of knowledge into products.

In Uzbekistan, similar elements are just beginning to emerge. For example, in 2024, TSTU created a digital platform for recording and monitoring R&D, linking departments, research centers, and the IP office. TSUE is implementing an automated system for recording innovation projects as part of its internal KPI monitoring [8-9].

DOI: https://doi.org/10.54216/IJNS.260423

Table 4: KPI table – "Indicators of innovative activity of universities in Uzbekistan (2020–2025)"

Indicator	2020	2021	2022	2023	2024	2025*
Share of R&D commercialization, %	7	9	11	15	18	22
Number of patents	210	240	275	310	350	410
Revenue from licenses, million soums	1200	1800	2600	3800	5200	7000
Joint programs with business, units	35	47	63	78	96	120
International cooperation index, %	32	38	45	53	61	70

Source: author's calculations based on data from the Ministry of Higher Education, Science and Innovation of the Republic of Uzbekistan, 2024; [3] [6].

This is in line with the global trend towards the formation of **new generation universities – "University 3.0"**, which combine educational, research and entrepreneurial functions [2].

At the same time, **institutional barriers remain** insufficient legal protection of intellectual property, a fragmented regulatory framework, weak motivation of teachers to innovate, and limited channels for technology transfer in the regions. According to an OECD analysis (2023) [3], eliminating these barriers is possible through the creation of network technology transfer centres uniting universities, technology parks, and business incubators.

A comparative analysis of the KPIs of Uzbek universities with those of Central and Eastern European universities shows that Uzbek universities are approaching international standards in terms of commercialization growth rates (approximately 20% per year), but still lag behind in the share of patents incorporated into the market (approximately 30% versus 65% in EU countries). Nevertheless, positive trends across all areas indicate the emergence of a national model of an innovation ecosystem, where the university serves not only as a center of knowledge generation but also as an active participant in economic growth [4].

Thus, the integration of *University 3.0 principles* into Uzbekistan's higher education system opens up new opportunities:

- increasing the competitiveness of universities;
- growth of the export potential of scientific developments;
- strengthening international partnerships;
- and the transition from fragmented innovations to sustainable network structures.

5. Conclusion

The study identified key trends and patterns in the development of the innovative environment of universities in Uzbekistan in the period 2020–2025, as well as identified areas for the strategic transformation of higher education based on the principles of the University 3.0 model.

The analysis confirms that universities in the Republic of Uzbekistan are gradually shifting from the traditional linear "education-research-implementation" model to an integrated innovation ecosystem, where education, research, and entrepreneurship are interconnected and mutually reinforcing. This transformation is facilitating the emergence of a new type of university - entrepreneurial and networked - that actively interacts with businesses, government agencies, and international partners.

- The indicators generated during the study demonstrate positive dynamics:
- an increase in the share of R&D commercialization from 7% in 2020 to 22% in 2025;
- doubling the number of patents and applications;
- fivefold increase in revenue from licensing and intellectual property;
- expanding the participation of universities in international grants and projects.

DOI: https://doi.org/10.54216/IJNS.260423

Of particular importance is the development of three key universities - TSTU, TSUE, and NUU -, which are becoming hubs for innovative transformation. TSTU is a leader in engineering and digital startups, TSUE in business innovation and fintech developments, and NUU in scientific cooperation and technology transfer. Together, they form the core of the national innovation ecosystem, ensuring the transition to a "university as a driver of economic growth" model by 2030. A comparative analysis with international universities (MIT, NUS, TU Berlin) suggests that Uzbek universities are moving in a similar direction, albeit taking into account national characteristics and constraints. Networking—the integration of universities, technology parks, research institutes, and industrial partners—is becoming a key factor for success. The establishment of a National Technology Transfer Centre and the development of digital R&D platforms will improve coordination efficiency, reduce duplication of projects and accelerate the commercialisation process [3] [7]. For the sustainable development of the innovative environment of universities in Uzbekistan, it is advisable to implement the following strategic measures: Institutional strengthening of universities: forming corporate innovation strategies, creating TTOs (Technology Transfer Offices), venture funds and spin-off structures. Modernization of the regulatory framework: adapting legislation to WIPO and EU standards in terms of IP protection, licensing and royalty distribution. Development of human capital: implementing programs for training researchers and innovation managers, stimulating scientific entrepreneurship among students and faculty. Digitalization of innovation infrastructure: creating a national R&D accounting platform, a unified register of intellectual property and a database of university patents. International integration: participation in the Erasmus +, Horizon Europe, UNESCO UNITWIN programs and regional alliances (e.g., the Central Asian Innovation Network). In the long term, the proposed University 3.0 Uzbekistan model will ensure not only increased R&D efficiency but also the development of the knowledge economy as a whole. It will create the conditions for transforming universities into innovation policy centres capable of generating economic and social value at the national and international levels.

Thus, universities in Uzbekistan are becoming not just institutions of higher education, but active players in innovative development, playing a strategic role in achieving the sustainable growth goals outlined in the "Uzbekistan 2030" strategy and the "Digital Uzbekistan 2030" program. This confirms the relevance of the transition to a systemic University 3.0 model, where science, education, and business form a unified innovative space based on collaboration, digitalization, and a focus on results.

References

[1] H. Etzkowitz and L. Leydesdorff, "The dynamics of innovation: From National Systems to a Triple Helix of university–industry–government relations," *Res. Policy*, vol. 29, no. 2, pp. 109–123, 2000.

[2] J. E. Lane and D. B. Johnston, *Higher Education System 3.0: Harnessing Systemness, Delivering Performance*. SUNY Press, 2013.

[3] OECD, *Innovation and Technology Transfer in Central Asia*, 2023.

[4] UNESCO, *Higher Education and Digital Innovation in Developing Economies*, 2024.

[5] Resolution of the President of the Republic of Uzbekistan No. PP-4524, Nov. 20, 2019.

[6] M. S. Abdurashidova, "Innovative potential of universities of Uzbekistan in the context of the digital economy," 2023.

[7] M. E. Balbaa, M. S. Abdurashidova, and S. K. Nematov, "Digital transformation of innovation management in Central Asian universities," *J. Intell. Syst.*, 2024.

[8] S. K. Nematov and I. A. Yuldashev, "Integration of innovation clusters in Uzbekistan's university sector," 2023.

[9] R. Johnston, *Innovation Ecosystems in Emerging Economies: University Leadership and Networks*. Springer, 2022.

DOI: https://doi.org/10.54216/IJNS.260423