An Applied IT KPI Framework for Technology Transfer and Commercialization Measurement: Baseline Results from Uzbekistan

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Abstract: Innovation is the lifeblood of twenty-first-century economies, but the measurement of technology transfer and commercialization (TT&C) remains uneven across countries and institutions, particularly in emerging economies. This paper introduces the Technology Transfer and Commercialization Index (TTCI)-a fair, transparent KPI framework for state bodies and enterprises in Uzbekistan-together with the methodology, survey instrument, and baseline results developed by the author. Drawing on international best practices from the Global Innovation Index, European Innovation Scoreboard, and AUTM statistics, the TTCI translates innovation performance into four measurable pillars: innovation financing, commercial outcomes, human capital, and infrastructure efficiency. The framework employs a scoring formula (SubScore = Fact/Target × 100) with traffic-light classification for management action. A digital implementation blueprint integrates cloud/edge architectures, IoT/IIoT sensor networks, digital twins, and machine learning for real-time monitoring, automated validation, and predictive analytics. Empirical evidence from the first quarterly survey of 29 state organizations reveals nascent innovation development (mean 30.64, median 22.20, range 0-75), with most organizations scoring below 71 points and none achieving Green status (>91), underscoring urgent need for targeted digital interventions. The applied IT enhancements transform static quarterly reporting into a continuous measurement system that senses, learns, and adapts in real-time, supporting Uzbekistan's Development Strategy 2030 and positioning the country for improved Global Innovation Index rankings.

1 INTRODUCTION

Around the world, technology transfer and commercialization (TT&C) channels-licensing, collaborative R&D, spin offs, and informal mobility-translate public research into marketable products, services, and processes [1]. Robust TT&C systems enhance inclusive growth (new firms, skilled jobs) and sustainability (diffusion of clean technologies, process efficiency) [2]. Global institutions and practice guides emphasize dedicated technology transfer offices (TTOs), incentives, and data driven management to raise TT&C throughput and socio-economic impact [3].

The transfer of new knowledge and techniques from universities, public research institutes and multinational laboratories into the productive fabric of society - technology transfer - shortens the route from discovery to application, raises productivity, narrows digital divides and generates positive spillovers into the broader economy [1], [2]. The commercialization of those discoveries through entrepreneurship, spin-offs, license agreements and collaborative ventures converts ideas into goods and services that raise living standards and empower previously excluded communities [4], [5]. The United Nations' Sustainable Development Goals call for clean energy solutions (SDG 7), resilient infrastructure and industry (SDG 9), universal quality education (SDG 4), decent work (SDG 8) and reduced inequalities (SDG 10): all depend upon purposeful technology transfer and the diffusion of innovation [5]. Uzbekistan's leadership has signaled a strong commitment to innovation: the National Development Strategy 2030 embeds innovation as a central pillar of its national vision, the Presidential Decree PF-165 (6 July 2022) codifies a detailed Innovation Development Strategy for 2022-26, and accompanying Cabinet resolutions prescribe quarterly reporting on innovation

performance [6], [7]. This paper constructs a Technology Transfer and Commercialization Index (TTCI) that aligns with national strategic priorities.

1.1 Research Background and Motivation

The gap this paper addresses: Uzbekistan needs a measurement system tailored to its development stage, statistical capabilities, and strategic priorities-one that's practical enough for quarterly use but rigorous enough to guide policy [5].

Effective technology transfer and commercialization (TT&C) rest on solid IP management and institutional capacity. International guidance from WIPO on TISCs/TTOs and incentives, alongside the CLDP Technology Transfer Handbook, sets practical standards for governance, definitions, and researcher rewards [8]. In Uzbekistan's 4IR context, local scholars underline the urgency of digital upgrading in industry and skills-Makhmudova maps national strategic initiatives, while Kambarov et al. highlight manufacturing gaps and an education focused "learning factory" approach [9]-[11].

Empirically, decades of the Association of University Technology Managers (AUTM) data document the TT pipeline-from disclosures and patents to startups and products-with 2023 marking record research expenditures and 714 products, reinforcing the case for outcome oriented KPIs [7]. For fair benchmarking, the GII and EIS provide audited, transparent indicator families; ASTP adds harmonised TT metrics-useful templates for normalisation by research intensity and sector profile [12]-[14].

At the policy level, OECD work classifies international technology transfer levers (absorptive capacity, IP, FDI, incentives) and warns against distortions; World Bank handbooks emphasise process KPIs across disclosure, valuation, licensing, and spin off support [2], [8]. Local green industry studies by Shodmonov & Mustafakulov show how IoT/AI can raise energy efficiency-evidence to embed sustainability into TT&C metrics-while Azizova connects innovation inputs to competitiveness outcomes [10], [11].

1.2 Novel Contributions

This research makes several original methodological contributions to innovation measurement science:

- First, while existing indices (GII, EIS) provide international comparisons [12]-[14], the TTCI is the first framework specifically designed for emerging economies' statistical capacities and development stages, with context-calibrated performance thresholds rather than one-size-fits-all benchmarks.
- Second, the integration of real-time digital technologies (IoT sensors, machine learning, digital twins) into national innovation measurement represents a paradigm shift from static annual/quarterly surveys to continuous, adaptive monitoring systems [10], [11], [13]. To our knowledge, no national innovation index has operationalized this level of technological integration [3].
- Third, the dual-KPI approach measuring both organizational performance and individual Chief Innovation Officer effectiveness creates accountability at multiple levels, addressing a gap in existing frameworks that focus solely on institutional metrics [3], [4], [8].
- Fourth, the traffic-light classification system (Red/Yellow/Green) translates complex multi-indicator performance into immediately actionable management signals, simplifying evidence-based decision-making for policymakers [5], [8].

2 METHODS

The TTCI follows the basic architecture laid out in the Appendix, Table A.1: a prescribed set of Main Indicators divided into conceptual groups and measured against pre-specified targets.

TTCI aggregates four pillars, balancing *inputs* and *enablers* with *outcomes*:

1) Innovation Financing - own-funded R&D; foreign grants; state R&D; FDI for technology acquisition; contract R&D; software/IT spend.
2) Commercial Outcomes - licensing revenue; patents & utility models; spin-offs; products launched; high-tech exports; IP income.
3) Human Capital - researchers; staff with advanced degrees; women with higher education in TT roles; internships; publications.
4) Innovation Infrastructure & Efficiency -energy efficiency; online assets/domains; R&D centres; tech parks/TT centres.

For each indicator i, a sub-score is computed as $SubScore_i = Fact_i / Target_i \times 100$. Maximum score for each indicator is 100. The arithmetic mean over N sub-scores yields the overall score: Overall Score = $(1/N) \sum SubScore_i$. A complementary KPI

for the Chief Innovation Officer (CIO) may be defined as a weighted sum: KPI_CIO = ∑ (w_i × Fact_i) / (Norm_i × Target_i), where weights sum to unity, Norm is a minimum threshold and Target is the ambition. Threshold values classify organisations into Green if score > 91, Yellow if between 71-91, and Red if < 71. These thresholds create clear management signals. The 71-point boundary between Red and Yellow represents a 71% target achievement rate-below this, organizations are falling significantly short. The 91-point threshold for Green ensures only consistently strong performers reach top status.

The national TT survey form (see Appendix, Table A.2), data schema, system architecture (see Fig. 1) and quarterly rating dashboards (prototype link[1]) were designed and implemented by the author. Pilot results from sector tables (e.g., geology, oil & gas, chemicals, etc.) illustrate dispersion across indicators (certifications, energy efficiency, product launches), enabling targeted interventions. The reproducibility package provides the scoring workbook, ETL pipeline, data schema, and indicator codebook-is available at docs.google.com[2].

Data sources include State Statistics Committee records, ministries/sector CIOs, institutional TT offices; customs/trade (high-tech exports/imports); IP office (patents/utility models, trademarks/designs); HR systems; ISO registries; energy audits [7], [14].

The indicators and methodology in this framework are designed to align with the data collection standards and definitions outlined in the WIPO Global Innovation Index 2025[3] [13].

Quality challenges. Time lags, uneven coverage, definitional heterogeneity, limited disaggregation-as documented in EIS audits and OECD reviews. The author's methodology includes a data governance charter, harmonised definitions, machine-validated submissions, and cross-source reconciliation to improve integrity and comparability [8].

Selected TTCI Indicators extracts and translates key sub-indicators from TTCI index template (see Appendix, Table A.3). An extension includes an explicit applied IT layer: sensor networks and IoT to monitor machine-level data; cloud and edge computing for storage and analytics; digital twins and AI/ML for prediction and simulation; dashboards for visualization; and blockchain for managing grants and agreements [10], [11], [13]. This IT design converts static reporting into a continuous measurement cycle that senses, learns and adapts.

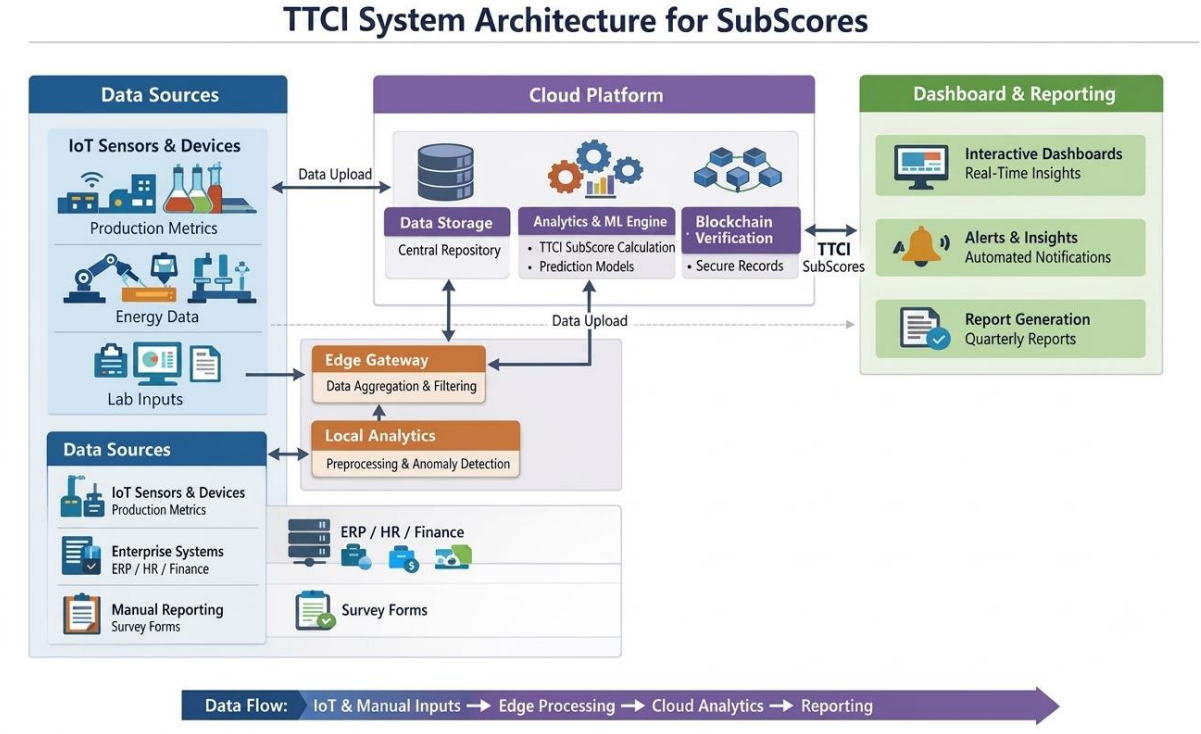

Figure 1: System architecture diagram.

[1] https://claude.ai/public/artifacts/fef3648f-0ef1-452f-aaaf-6d8ab9cdf5eb

[2] https://docs.google.com/document/d/1o-AC2yx9jUaX5r3AS-aa9hLf1hfgMpV4/edit?pli=1

[3] https://www.wipo.int/web-publications/global-innovation-index-2025/en/appendix-iii-sources-and-definitions.html

3 RESEARCH RESULTS

3.1 Innovation Development Assessment Results

The first quarterly survey yields Innovation Development scores for 29 actors. The summary appears in Table 1 and Figure 2; the full list is reproduced in the Appendix.

Table 1: Descriptive statistics of innovation KPI scores.

Statistic	Value
Count	29
Mean	30.64
Median	22.20
Standard deviation	21.97
Minimum	0.00
Maximum	75.00
25th percentile (Q1)	17.10
75th percentile (Q3)	45.60

Note: Table 1 reports descriptive statistics for Innovation KPI scores across 29 public sector organizations.

Low overall performance. With an average of 31 and median of 22, most organizations achieved less than one-third of their targets. No organization reached Green status (above 91), and only one achieved Yellow (71-91).

This reveals Uzbekistan's innovation ecosystem is in early development stages.

Wide variation. The range from 0 to 75 points, and the high standard deviation (22 points), shows extreme differences. Some organizations have made real progress; others have barely started. This variation suggests both success stories to learn from and struggling organizations needing support.

Concentration at the bottom. With 75% of organizations scoring below 46 points, the challenge is widespread, not isolated to a few laggards.

3.2 The Path Forward with Technology

Manual quarterly reporting is time-consuming and error prone. Modern technology offers solutions [9], [11]:

- Automated data capture. Sensors and connected systems (Internet of Things) can automatically record production metrics, energy use, and equipment performance.
- Cloud storage. A centralized data platform harmonizes different reporting formats.
- Machine learning. Algorithms can predict future trends and identify anomalies requiring investigation.
- Digital dashboards. Real-time visualization helps managers spot problems quickly.
- Blockchain verification. Transparent, tamper-proof records of grants and agreements build trust.

These technologies transform the TTCI from a static quarterly snapshot into a living system that continuously monitors, learns, and adapts [3], [9].

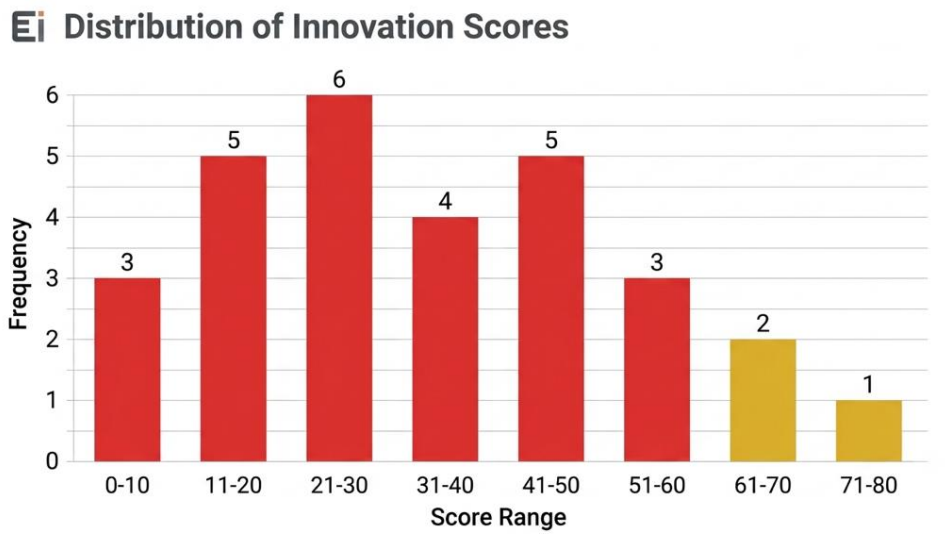

Figure 2: Distribution of innovation scores.

The empirical results confirm that Uzbekistan's innovation ecosystem remains at the early stages of digital maturity. The relatively low mean and median values signal large performance gaps: indicator values (Fact) fall far short of their prescribed Target in most cases [7], [12]. The high variance implies that pockets of excellence coexist with widespread underperformance [7], [10]. The integration of applied IT addresses challenges such as manual reporting errors, data gaps and heterogeneity [3], [9].

Aligning the TTCI with international benchmarks (Global Innovation Index, OECD indicators) creates normative anchors [5], [12]. Clarifying definitions and protocols requires a centralized body (e.g. a Centre for the Fourth Industrial Revolution) to oversee standards and training [6], [8]. Uzbekistan must invest in human capital, sensor infrastructure, legal expertise and absorptive capacity to actualize the recommendations, in line with Strategy 2030 and presidential pronouncements [2], [6], [12].

4 CONCLUSIONS

Innovation measurement provides an essential foundation for improving technology transfer and commercialization performance [3], [5], [12]. This study developed the Technology Transfer and Commercialization Index (TTCI) as a context-adapted framework aligned with Uzbekistan's innovation priorities and supported by established international measurement practices. The first-round assessment of 29 organizations revealed significant differences in innovation maturity, with a mean score of 30.64, no organizations reaching the Green performance category, and only one organization achieving the Yellow category. These findings indicate that Uzbekistan's innovation ecosystem remains at an early stage of development and requires further strengthening of human capital, digital infrastructure, data governance, and institutional capacity [7], [10], [11]. The proposed integration of information technologies can transform TTCI from a periodic reporting instrument into a more adaptive monitoring framework capable of supporting evidence-based decision-making [3], [9].

The results provide important policy implications for strengthening the national technology transfer and commercialization ecosystem. The concentration of organizations in lower performance categories suggests that the identified challenges are systemic rather than limited to individual institutions. Therefore, improvement strategies should combine broad capacity-building measures, including specialized technology transfer training, digital infrastructure development, standardized data management procedures, and stronger institutional support for technology transfer offices [2], [4], [14]. In parallel, targeted interventions should address specific weaknesses identified through TTCI assessment. By incorporating international practices from innovation measurement frameworks such as GII, EIS, and AUTM [7], [12]-[14], TTCI provides a transparent mechanism for monitoring progress, designing incentives, and improving coordination among government institutions, research organizations, and industry stakeholders.

5 LIMITATIONS

The initial assessment was conducted using a sample of 29 organizations and does not yet include private companies, universities, and other important innovation actors. In addition, variations in data availability and reporting quality affected the completeness of some indicators. Future research will focus on expanding the survey coverage, implementing the proposed digital monitoring architecture, refining indicator weights through empirical validation, and developing predictive models linking TTCI performance with economic and innovation outcomes [3], [5], [8]. The proposed framework may also serve as a transferable approach for other emerging economies seeking to improve the management and evaluation of technology transfer and commercialization ecosystems [2].

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APPENDIX

Table A.1: Sector ranking indicators.

No.	Main Indicators	Score
	I. Innovation financing	
1.	Volume of R&D expenditure funded by the organization's own funds	100
2.	Foreign grants allocated for research and development	100
3.	Volume of R&D funded by the State Budget	100
4.	Volume of Foreign Direct Investment (FDI)	100
5.	Funds utilized within projects financed by the Fund for Support of Innovation	100
6.	Value of commercial contracts signed with research institutes for R&D	100
7.	Volume of High-Tech Imports (Technology Transfer)	100
8.	Expenditure on Software	100
9.	Funds allocated to Higher Education Institutions for training highly qualified specialists	100
	II. Innovation Outcomes (Results)	
10	Number of innovatively active business entities (share of total industrial orgs)	100
11	Number of new innovative (spin-off) enterprises specializing in the production of high-volume scientific products	100
12	Export of high-tech products to foreign markets	100
13	Number of commercialized scientific developments in domestic and foreign markets	100
14	Number of new products created as a result of R&D research	100
15	Revenue from sales of newly created products, technologies (services)	100
16	Number of environmental certificates according to ISO 14001	100
17	Number of scientific patents obtained, including the number of joint patents	100
18	"Utility models" by origin	100
19	Number of rationalization proposals introduced	100
20	Labor efficiency in industry organizations	100
21	Number of "ISO 9001 quality management system" certificates	100
22	Volume of production of high and medium-tech products	100
23	Revenues from intellectual property	100
24	Created experimental - test samples	100
	III. Human capital development	
25	Number of specialists with academic degrees	100
26	Number of new jobs created as a result of innovative entrepreneurship	100
27	Number of female employees with higher education	100
28	Number of enterprises that organized advanced training and retraining courses, trainings and seminars	100
29	Number of specialists sent abroad for internships	100
30	Number of scientific and technical articles by employees	100
	IV. Development of scientific and innovative infrastructure	
31	Number of innovation infrastructure entities (technology parks, technology transfer centers, innovation clusters, venture funds, innovation centers, business incubators and accelerators)	100
32	Energy efficiency (ratio of the value of manufactured products to energy costs)	100
33	Number of top-level domains (.biz, .info, .org, .net and .com)	100
34	Established research and development (R&D) centers	100
	Average value (rating)	100

Note:

1) Key indicators - indicators by which the innovative activity of economic sectors is assessed.
2) Target - a planned indicator that economic sectors must achieve.
3) Fact - the actual results of work.
4) Score - an indicator of the result of the actual results of work in relation to target indicators.

Score = Fact/Target*100

Average value (rating) - the arithmetic average of the indicators.

According to the results of the rating assessment of the indicators, the level of effectiveness of the introduction and development of innovative technologies in economic sectors is determined by the rating score:

A) An organization with a score above 91 points is considered “green”;

B) An organization with a score from 71 to 91 points is considered “yellow”;

C) An organization with a score below 71 points is considered “red”.

Table A.2: Calculation of the efficiency coefficient of Chief Innovation Officers.

№	Key indicators	Weight	Norm	Target	Fact *(example)*	KPI index
1.	Financing Innovation	0.30	80%	100%	90%	34%
2.	Effectiveness from Innovation	0.30	80%	100%	80%	30%
3.	Development of Human Capital	0.20	80%	100%	90%	23%
4.	Development of Scientific and Innovative Infrastructure	0.10	80%	100%	10%	1%
5.	Other Tasks	0.10	80%	100%	80%	10%
Efficiency coefficient:						98%

Note:

1) Key performance indicators are the criteria by which employees' performance is evaluated.
2) Weight - in the range from 0 to 1, and their sum is equal to 1. It indicates the priority of each key performance indicator, taking into account the goals of the organization.
3) Norm - is the planned level that the employee must perform.
4) Target - is an indicator that the employee wants to achieve and serves to improve results.
5) Fact - is the actual results of work (based on the results of the rating).
6) KPI index - is an indicator of the result relative to the norm.

KPI index = (Weight * Fact) / (Norm * Target)

Efficiency coefficient = Total (KPI index)

Table A.3: Target indicators.

No.	Indicators	Measurement unit	Current indicator (2021)*	Target indicator (2022)	Indicators by year**			
					2023	2024	2025	2026
I. Innovation financing								
1.	The volume of research and development expenditures financed by industry organizations at their own expense	Million soums						
2.	……..							
II. Innovation Outcomes (Results)								
10.	Number of innovatively active business entities (in the total number of industrial production organizations)	unit						
11.	……							
III. Human Capital Development								
25.	Number of specialists with academic degrees	unit						
30.	……							
IV. Infrastructure development								
31.	Number of innovative infrastructure entities	unit						
34.	……	unit						

** Calculated based on data from the State Statistics Committee of the Republic of Uzbekistan.*

***Ensure compliance with the normative documents of the President of the Republic of Uzbekistan No. PF-165 and No. PQ-307 dated July 6, 2022. In particular, the main goal is to achieve our country's entry into the top 56 advanced countries in the world in the Global Innovation Index by 2026.*

**** Ensure compliance with the normative document of the Cabinet of Ministers of the Republic of Uzbekistan No. 83 dated February 21, 2022.*

***** The indicators and methodology in this framework are designed to align with the data collection standards and definitions outlined in the WIPO Global Innovation Index 2025 Appendix III*[3].

[3] https://www.wipo.int/web-publications/global-innovation-index-2025/en/appendix-iii-sources-and-definitions.html