# The Impact of Integrating Science, Education and Production on Innovative Development: A Conceptual Framework and Evidence from Uzbekistan

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**Abstract**

This thesis asks how the integration of science, education and production shapes innovative development. It builds on national innovation system theory, the triple helix model and the concept of absorptive capacity, and treats integration as four links: education to science, science to production, production to science and education, and ecosystem coordination. Innovation outcomes, the argument goes, depend on the weakest link rather than on the supply of knowledge alone. Global Innovation Index profiles of Uzbekistan for 2025 and 2026 point to a gap. Graduates in science and engineering rank second (36.8% of graduates) and researchers per million rose from 542.1 to 639.5, yet the knowledge absorption score fell from 24.1 to 17.8 and the business-financed share of R&D from 42.4% to 38.5%, while university-industry collaboration improved only from 33.5 to 36.5. The priority therefore lies in strengthening the demand-side and intermediary links.

**Keywords**

science-education-production integration, innovative development, triple helix, absorptive capacity, university-industry collaboration, Uzbekistan.

**Annotatsiya.**

Tezisda ilm-fan, ta’lim va ishlab chiqarish integratsiyasi innovatsion rivojlanishga qanday ta’sir ko’rsatishi o’rganiladi. Tahlil milliy innovatsion tizimlar nazariyasi, uch

spiral (triple helix) modeli va o'zlashtirish qobiliyati tushunchasiga tayanadi; integratsiya to'rt bo'g'in - ta'limdan ilm-fanga, ilm-fandan ishlab chiqarishga, ishlab chiqarishdan ilm-fan va ta'limga hamda ekotizim muvofiqlashtiruvi - sifatida ko'riladi. Innovatsion natijalar faqat bilim taklifiga emas, eng zaif bo'g'inga bog'liq degan xulosa ilgari suriladi. O'zbekistonning Global innovatsion indeks 2025 va 2026 profillari tafovutni ko'rsatadi: fan va muhandislik bitiruvchilari bo'yicha mamlakat 2-o'rinda (bitiruvchilarning 36,8 foizi), million aholiga to'g'ri keladigan tadqiqotchilar 542,1 dan 639,5 gacha oshgan. Biroq bilimni o'zlashtirish bali 24,1 dan 17,8 gacha, tadqiqotlarning biznes tomonidan moliyalashtirilgan ulushi 42,4 foizdan 38,5 foizgacha kamaygan, universitet va sanoat hamkorligi esa 33,5 dan 36,5 gacha ozgina yaxshilangan. Shu bois ustuvorlik talab tomoni va vositachi bo'g'inlarni mustahkamlashga qaratilishi kerak.

**Kalit so'zlar:** ilm-fan, ta'lim va ishlab chiqarish integratsiyasi, innovatsion rivojlanish, uch spiral modeli, o'zlashtirish qobiliyati, universitet va sanoat hamkorligi, O'zbekiston.

**Аннотация.**

В тезисе рассматривается, как интеграция науки, образования и производства влияет на инновационное развитие. Анализ опирается на теорию национальных инновационных систем, модель тройной спирали и концепцию поглощающей способности; интеграция трактуется как четыре звена - от образования к науке, от науки к производству, от производства к науке и образованию, а также координация экосистемы. Утверждается, что инновационные результаты определяются самым слабым звеном, а не только предложением знаний. Профили Узбекистана в Глобальном инновационном индексе 2025 и 2026 годов указывают на разрыв: по доле выпускников в области науки и инженерии страна занимает 2-е место (36,8% выпускников), число исследователей на миллион жителей выросло

с 542,1 до 639,5. Однако показатель поглощения знаний снизился с 24,1 до 17,8, доля бизнеса в финансировании НИОКР - с 42,4% до 38,5%, а сотрудничество университетов и промышленности улучшилось лишь с 33,5 до 36,5. Поэтому приоритетом должно стать укрепление звеньев со стороны спроса и посреднических институтов.

**Ключевые слова:** интеграция науки, образования и производства, инновационное развитие, тройная спираль, поглощающая способность, сотрудничество университетов и промышленности, Узбекистан.

**Introduction**

Innovation is increasingly seen as the outcome of interaction among universities, research organizations and firms. Indicators of the supply of knowledge and skills in Uzbekistan have improved, but innovation outputs still rank below inputs, which suggests that the links between science, education and production may be a binding constraint. The thesis builds a framework that maps these links to measurable indicators and checks it against Uzbekistan's Global Innovation Index profiles.

**Literature Review**

The literature falls into four strands. The first concerns innovation systems: Lundvall describes innovation as an interactive learning process among firms, universities and institutions [1]. The second is the triple helix, in which Etzkowitz and Leydesdorff locate the source of innovation dynamics in the overlap of university, industry and government spheres [2]. The third is empirical: Jaffe found that academic research has positive spillover effects on corporate patenting [3], and Perkmann et al. review the forms of academic engagement and commercialization [4]. The fourth is absorptive capacity: firms benefit from external knowledge only if prior related knowledge lets them recognize, assimilate and apply it [5]. Together, they imply that

university knowledge raises innovation only when firms can absorb it and institutions connect both sides.

**Results and Discussion**

To test the framework, the four integration links are first mapped to Global Innovation Index indicators (Table 1). They are then examined with the Uzbekistan profiles of the 2025 and 2026 editions (Table 2).

| Integration link | Mechanism | Indicator used as evidence |
|---|---|---|
| **Education to science** | training of researchers and STEM graduates supplies skills | Graduates in science and engineering; researchers per million |
| **Science to production** | joint R&D and knowledge transfer move research results into firms | University-industry R&D collaboration |
| **Production to science and education** | firms finance and demand research and train staff | GERD financed by business |
| **Ecosystem coordination** | clusters and intermediaries connect the three sides | Cluster development; innovation linkages |

**Table 1. Conceptual link between science-education-production integration and innovative development (compiled by the author based on [1;2;3;4;5])**

Education supplies researchers and graduates, science passes knowledge on to firms, firms fund and demand research, and ecosystem institutions such as clusters coordinate the whole process. Only the first link measures knowledge supply; the rest measure integration proper [1;2].

| Indicator | GII 2025 | GII 2026 |
|---|---|---|

| | | |
|---|---|---|
| **University-industry R&D collaboration (survey score)** | 33.5 (75th) | 36.5 (71st) |
| **Innovation linkages (sub-pillar score)** | 23.0 (78th) | 23.1 (74th) |
| **Knowledge absorption (sub-pillar score)** | 24.1 (81st) | 17.8 (95th) |
| **GERD financed by business, % of GERD** | 42.4 (41st) | 38.5 (51st) |
| **State of cluster development (survey score)** | 60.1 (44th) | 58.2 (44th) |

**Table 2. Integration indicators of Uzbekistan in the Global Innovation Index, 2025 and 2026 editions (value or score, rank in brackets; source: WIPO) [6;7]**

Table 2 shows where the integration deficit lies. University-industry collaboration improved only modestly, from 33.5 to 36.5 (75th to 71st), as did innovation linkages, from 23.0 to 23.1 (78th to 74th). Knowledge absorption, by contrast, fell from 24.1 to 17.8 (81st to 95th), and so did the business-financed share of R&D, from 42.4% to 38.5% (41st to 51st); the 2025 edition flags the latter figure as dated [6;7]. Cluster development stayed at 44th place (60.1 and 58.2). Supply indicators moved faster: science and engineering graduates reached 36.8% of graduates (second place, up from 13th with 32.8%), tertiary enrolment 59.8% (from 56.2%) and researchers 639.5 per million (from 542.1) [6;7]. Knowledge supply is thus outrunning its absorption by firms, in line with the World Bank's finding that growth in 2017-2022 came entirely from capital deepening and that productivity in industry and services is about one third of the upper-middle-income average [8].

**Conclusion**

Innovative development is shaped by the integration of science, education and production, not by the supply of knowledge alone. For Uzbekistan the framework points to four priority directions: (1) raise business funding of research, and demand for it, through co-financed R&D programs; (2) build firms' absorptive capacity - skills, R&D units and technology adoption; (3) strengthen intermediaries such as clusters, technology transfer offices and technology parks to improve innovation linkages; and (4) track integration with annual indicators such as university-industry collaboration and knowledge absorption. Two editions fit this reading but cannot prove causality, so future research should use firm-level innovation survey data.

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