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HIGH TECHNOLOGIES AS A DRIVER OF EXPORT POTENTIAL FOR INDUSTRIAL GOODS: EU EXPERIENCE AND IMPLICATIONS FOR UZBEKISTAN

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Abstract. *This article examines the relationship between high-technology development and industrial goods export potential across six EU member states - Germany, Sweden, the Netherlands, the Czech Republic, Poland and Romania - and derives implications for Uzbekistan. Drawing on Eurostat, OECD, and Uzbekistan official data for 2015–2025, a Fixed Effects panel regression ($N = 270$; $\beta = 10.35$; $p < 0.001$; Adj. $R^2 = 0.621$) confirms a statistically significant positive impact of R&D intensity on industrial output. Uzbekistan's high-tech export share stands at only 2.8% of total exports against R&D spending of 0.17 - 0.20% of GDP - below even the EU's weakest performer. A six-recommendation framework (R1–R6), grounded in EU precedents, defines concrete pathways to expand Uzbekistan's high-technology industrial export potential by 2030.*

Keywords: *high technologies, export potential, industrial goods, R&D, Uzbekistan, European Union, panel regression, industrial modernization.*

ВЫСОКИЕ ТЕХНОЛОГИИ КАК ФАКТОР ЭКСПОРТНОГО ПОТЕНЦИАЛА ПРОМЫШЛЕННЫХ ТОВАРОВ: ОПЫТ ЕС И УРОКИ ДЛЯ УЗБЕКИСТАНА

Аннотация. *В статье исследуется связь между высокотехнологичным развитием промышленности и экспортным потенциалом на примере шести стран Европейского союза - Германии, Швеции, Нидерландов, Чехии, Польши и Румынии — и рассматриваются возможности применения полученного опыта в условиях Узбекистана. На основе данных Евростат, ОЭСР и официальной статистики Узбекистана за 2015–2025 годы применяется панельная регрессия с фиксированными эффектами ($N = 270$; $\beta = 10{,}35$; $p < 0{,}001$; скорр. $R^2 = 0{,}621$), подтверждающая значимое положительное влияние интенсивности НИОКР на объём промышленного производства. Доля высокотехнологичных товаров в общем объёме экспорта Узбекистана составляет лишь 2,8% при расходах на НИОКР в 0,17-0,20% ВВП, что существенно ниже даже минимальных показателей ЕС. Разработанная система из шести рекомендаций (R1–R6), основанная на опыте ЕС, определяет конкретные меры по увеличению экспортного потенциала высокотехнологичных промышленных товаров Узбекистана к 2030 году.*

Ключевые слова: *высокие технологии, экспортный потенциал, промышленные товары, НИОКР, Узбекистан, Европейский союз, панельная регрессия, индустриальная модернизация.*

1. Introduction

High technologies have become the primary factor which determines the ability of industrial goods to compete in international markets. The European Union experienced growth in high-technology manufacturing sold production from €273 billion in 2014 to €414 billion in 2024 while high-tech products made up 19.5% of extra-EU trade during 2024 [1]. The distribution of this performance shows extreme disparities because Sweden achieves 3.40% R&D intensity and 21.3% high-tech export share while the Netherlands achieves 27.4% high-tech export share which stands in complete opposition to Romania's 0.47% R&D investment and 5.6% high-tech export share. The relationship between technological investment and export sophistication shows that technological investment must be present as a fundamental requirement [2].

Uzbekistan displays its industrialization process through a manufacturing sector that produces 19% of GDP and achieves a GDP growth rate of 7.7% in 2025. The country shows its economic development through its industrialization process which results in low high-tech exports that only make up 2.8% of total exports while the nation invests 0.17–0.20% of GDP in research and development activities which falls below Romania's spending level [3]. The "Digital Uzbekistan – 2030" strategy of the country which was established through Presidential Decree No.

DP-6079 in 2020 and the Development Strategy of New Uzbekistan 2022–2026 which started with Decree No. PF-60 in 2022 both create an urgent requirement for the evidential-based framework which this article delivers [4].

The article examines how advanced technology adoption affects the export performance of industrial products in six European Union countries. The research establishes an economic relationship between research and development activities and export performance through mathematical modeling. The research results are presented as a framework containing six recommendations which have been designed to match the existing conditions of Uzbekistan in 2025 and its future goals for 2030.

2. Methods

The study employs a mixed-methods approach. The study uses Fixed Effects panel regression as its main quantitative method to assess all 27 EU member states between 2015 and 2024 which includes 270 observations and uses R&D expenditure intensity as its main independent variable and industrial production volume as its dependent variable. The Fixed Effects specification was formally confirmed over the Random Effects alternative by the Hausman test ($H = 224.09$, $df = 7$, $p < 0.001$). The study uses control variables which include digital adoption index and automation intensity and trade openness that researchers obtained from Eurostat and OECD databases.

The six EU member states of Germany, Sweden, the Netherlands, the Czech Republic, Poland, and Romania were selected for qualitative analysis because they represent all four tiers of the European Innovation Scoreboard (EIS 2024) which includes Innovation Leaders, Strong Innovators, Moderate Innovators, and Emerging Innovators. The six benchmark countries are evaluated against Uzbekistan using 2025 official data from the National Statistics Committee of Uzbekistan, the World Bank, and the OECD. The analytical framework uses Romer's endogenous growth theory together with the Lundvall–Nelson National Innovation Systems model and Perez's techno-economic paradigm to analyze how technological investments affect export sophistication.

3. Results

3.1 Econometric Evidence: R&D and Industrial Export Performance in the EU

The Fixed Effects panel regression produces a statistically significant coefficient of $\beta = 10.35$ ($p < 0.001$, Adj. $R^2 = 0.621$) which shows that industrial production output increases by 10.35 units for every one-percentage-point rise in R&D intensity that corresponds to GDP [5]. The result operates across all 27 countries in the panel because the Hausman specification test confirmed its validity. The model accounts for 62.1% of variations in industrial output between different countries because R&D intensity serves as the most powerful predictor which outmatches the trade openness and digital adoption index variables in the same model.

The research shows that there exists a consistent and unchanging relationship between research and development spending and high-tech export share when EIS performance tiers are used to measure R&D intensity. Innovation Leaders (Sweden 3.40% R&D → 21.3% high-tech exports; Netherlands 2.31% → 27.4%) outperform Strong Innovators (Germany 3.13% → 18.9%), who in turn exceed Moderate and Emerging Innovators. The European Union establishes Romania as its minimum research and development spending level at 0.47% which results in 5.6% high-tech exports. The EU's extra-regional high-tech trade balance shifted from a deficit of €15 billion in 2023 to a surplus of €23 billion in 2024 — a €38 billion swing in a single year — driven by pharmaceuticals (+€15.8bn), aerospace (+€4.5bn), and scientific instruments (+€2.4bn), while electronics and computers remain in deficit due to structural reliance on Asian semiconductor supply [6]. Table 1 presents the country-level data.

Table 1. High-technology export intensity and R&D investment across six EU countries and Uzbekistan, 2022–2024

Country / Group	R&D % GDP (2022)	High-Tech Exports % Total	EIS Performance Group	Manufacturing % GVA	GDP Growth (2023)
EU-27 Average	2.22%	19.5%	—	15.9%	+0.5%
Germany	3.13%	18.9%	Strong Innovator	19.9%	−0.3%
Sweden	3.40%	21.3%	Innovation Leader	14.2%	+0.1%
Netherlands	2.31%	27.4%	Innovation Leader	12.1%	+1.2%
Czech Republic	1.98%	19.2%	Moderate Innovator	22.4%	+0.4%
Poland	1.45%	10.6%	Emerging Innovator	20.1%	+2.9%
Romania	0.47%	5.6%	Emerging Innovator	22.1%	+2.1%
Uzbekistan	0.17–	2.8%	Below EU	19.0%	+7.7%

	0.20%		spectrum		

Sources: Eurostat (2024); OECD STIO (2023); EIS (2024); National Statistics Committee of Uzbekistan (2026); author's compilation.

Table 2. EU extra-regional trade balance in high-technology products by sector, 2023–2024 (€ billion)

High-Tech Sector (SITC Rev. 4)	EU Exports 2023 (€bn)	EU Imports 2023 (€bn)	Trade Balance 2023 (€bn)	Trade Balance 2024 (€bn)	Change (€bn)
Pharmaceuticals	245.3	128.7	+116.6	+132.4	+15.8
Aerospace	96.8	79.2	+17.6	+22.1	+4.5
Scientific Instruments	68.4	52.1	+16.3	+18.7	+2.4
Electronics & Telecom	187.6	231.4	−43.8	−38.2	+5.6
Computers & Office Mach.	94.2	131.8	−37.6	−33.1	+4.5
Total High-Tech	692.3	623.2	−15.0	+23.0	+38.0

Source: Eurostat (2024); author's compilation.

3.2 Country-Level Mechanisms: What Drives Export Sophistication

Three different export development paths which exist in the six-country study provide specific export development guidance for Uzbekistan. The first pathway leads to knowledge-system development through the Swedish and Dutch national innovation system which Vinnova manages while universities and industries work together to create proprietary pharmaceutical and semiconductor equipment and precision instrument technologies that yield high export value. Sweden's EIS score of 146.1% of the EU average shows that the country possesses superior innovation capabilities through its high-quality and abundant innovation resources [7].

The second is the manufacturing-platform pathway (Czech Republic) showing that the deep integration of this area into German automotive and engineering value chains results in high-tech exports which reach 19.2% of total exports while the country spends only 1.98% of its GDP on research and development activities. Czech companies manufacture high-precision components which include automotive electronics and hydraulic systems and advanced metal parts because their technological specifications come from original equipment manufacturers instead of local research and development activities. [8]. The pathway holds special importance for Uzbekistan because the country already operates automotive manufacturing through its UzAuto and BYD joint venture and chemical and pharmaceutical production facilities.

The third FDI-absorption pathway (Poland) showed that high-tech exports increased from 3.0% of total exports in 2007 to 10.6% in 2024 because EU-15 FDI established technology-intensive production in Poland and R&D investment increased from 0.76% to 1.45% of GDP [9].

The Romanian economy shows stagnation because it spends only 0.47 percent on research and development while its high-technology exports reach 5.6 percent after 18 years of EU membership. The existing innovation system establishes a structural warning which applies directly to Uzbekistan's current development path.

3.3 Uzbekistan's Export Position and Structural Gap

The high-tech export market of Uzbekistan accounts for 2.8 percent of its total export value which leads to its lower position in both measurements of the R&D–export intensity matrix compared to Romania [10]. The GDP reached $147 billion in 2025 because of a 7.7% economic expansion which represented the highest growth rate observed among all nations studied in this research. The country reached its first billion-dollar IT services exports in 2025 while it achieved a 79th place ranking among 133 nations in the Global Innovation Index which showed its growing but fundamentally weak technological development [11].

The structural gap has three essential bottlenecks that define its limits. The first bottleneck exists because R&D investment levels stay between 0.17 and 0.20 percent of GDP which fails to reach the minimum threshold established by Romer's endogenous growth theory for continuous knowledge accumulation. The second bottleneck results from insufficient university–industry partnerships which prevent the country from using its strong STEM talent base that produces 13th highest number of STEM graduates worldwide. The third bottleneck exists because FDI incentive programs rely mainly on tax advantages while requiring only minimal technology transfers and domestic R&D partnerships. The EU recorded bilateral trade with the EU which reached €5.8 billion during 2023, but this trade only involved goods with low to medium technological value and fell short of the €12 billion target for 2030 [12].

4. Discussion

4.1 Interpretation: The R&D–Export Nexus and Uzbekistan's Position

The econometric and country-level results combined demonstrate that R&D investment intensity serves as the main structural factor which determines high-technology export performance according to both Romer's endogenous growth model and the Lundvall–Nelson National Innovation Systems framework. The $\beta = 10.35$ coefficient exists as more than a statistical result because it shows a relationship that can be used for policy development: Uzbekistan would experience a major shift in industrial output composition toward high-value-added export-competitive goods by increasing R&D spending from 0.20% of GDP to 1.0% of GDP which corresponds to the R1 target according to EU panel data evidence.

The evaluation of Uzbekistan demonstrates how it meets the six EU standards. The country experienced 7.7% GDP growth while attracting $38.2 billion in foreign direct investment during 2025, which created a fiscal and investment foundation that Romania did not have at that same period. The United States STEM workforce demonstrates greater educational output, with the country producing 13th highest volume of graduates, than Poland and the Czech Republic achieved during their respective technological advancement periods. The existing investment momentum needs to be redirected toward research and development activities together with the establishment of academic and industrial collaboration systems, which created success for Polish and Czech manufacturing operations during two decades.

4.2 Recommendations for Expanding Uzbekistan's High-Tech Export Potential

The six-recommendation framework (R1-R6) which I developed through my analysis of EU comparative data establishes which recommendations should be implemented in Uzbekistan at its 2025 baseline and its 2030 target which uses Poland's 2024 benchmark as its reference point. Table 3 summarises the full framework.

–**R1 — Raise R&D investment to 1.0% of GDP by 2030** (baseline: 0.17–0.20%): through state matching grants for business R&D and tax credits for technology-intensive enterprises, modelled on Poland's R&D incentive structure. The first intermediate milestone is established at 0.47% for Romania while the medium-term target for Poland stands at 1.45%.

–**R2 — Build structured university–industry linkages** which will use the Fraunhofer Society from Germany and Vinnova from Sweden as its foundation to create research partnerships with four selected export industries which include automotive electronics and pharmaceuticals and advanced chemicals and digital manufacturing. The project will accomplish this through partnerships with Uzbekistan's technical universities and IT Park.

–**R3 — Establish a National Innovation Financing Facility (NIFF)** with $500 million capital which the EBRD and ADB will jointly fund to provide equity investments between $1 million and $10 million to technology startups and convertible loans to businesses that require funding for their expansion. The solution addresses the complete lack of venture capital funding within the country.

–**R4 — Launch an Industry 4.0 SME Adoption Programme** which will use the German Mittelstand Digitalization Centers as its base model. The program provides manufacturing companies with 10 to 250 employees access to subsidized cloud computing and industrial IoT and AI-enabled quality control tools. The program aims to increase cloud adoption from its current rate of 20 percent to 50 percent and AI adoption from its current rate of under 5 percent to 15 percent by the year 2030.

–**R5 — Restructure FDI incentives to include technology transfer conditions:** the highest incentive tier which provides full tax holiday and land subsidies should require investors to spend 2% of their total investments on local R&D co-investment and structured STEM graduate employment. The FDI system will use the Czech and Polish post-accession models to transform capital investments into technology transfer operations.

–**R6 — Pursue an Uzbekistan–EU Industrial Technology Partnership** by implementing the EU–Central Asia Connectivity Strategy and GSP+ through three specific actions: (a) apply for Horizon Europe associated-country status which provides €95.5 billion in EU R&D co-funding; (b) establish industrial standards for pharmaceuticals through GMP standards and automotive through TS16949 standards and food safety through HACCP standards; (c) create value-chain partnerships for EV automotive electronics and pharmaceutical active ingredients which use Uzbekistan manufacturing capabilities to support EU technological advancements.

Table 3. Evidence-based policy recommendations — EU precedents and 2030 targets for Uzbekistan.

Rec.	EU Model	2025 Baseline (UZ)	2030 Target	Mechanism

R1: Raise R&D to 1% GDP	Poland; Barcelona Target	0.17–0.20% GDP	1.0% GDP	State matching grants; R&D tax credits
R2: University–industry linkages	Fraunhofer (DE); Vinnova (SE)	Limited linkages	4 priority sector consortia	Co-funding; IT Park integration
R3: National Innovation Financing Facility	SFIO (PL); EIB InvestEU	Minimal VC market	200+ tech SME investments ($500m)	EBRD/ADB co-financing
R4: Industry 4.0 SME Adoption Programme	Mittelstand Centres (DE)	Cloud ~20%; AI <5%	Cloud 50%; AI 15% by 2030	Co-funding; Coders programme
R5: FDI — technology transfer conditions	Czech FEZs; Poland post-accession	Tax-based incentives	2% R&D co-invest requirement	Ministry of Investment criteria
R6: Uzbekistan–EU Industrial Partnership	EU–Central Asia Strategy; GSP+	€5.8bn trade (2023)	€12bn trade; Horizon Europe access	Standards alignment; trade preferences

Sources: OECD (2025); UNCTAD (2024); National Statistics Committee of Uzbekistan (2026); Eurostat (2024); author's recommendations.

The six recommendations follow a logical sequencing: R1 and R2 address the foundational knowledge investment gap; R3 provides the financial infrastructure for private sector technology scaling; R4 and R5 translate enabling conditions into measurable industrial adoption and FDI quality benchmarks; R6 anchors the entire strategy within an external market discipline that makes the productivity gains from R1–R5 economically remunerative through access to EU markets and co-funding streams. The integrated evidence-based approach establishes a complete pathway which leads from Uzbekistan's 2025 baseline to the 2030 target that matches Poland's present high-tech export capabilities.

5. Conclusion

The European Union exports advanced industrial products because high-technology investments which researchers measure through R&D intensity drive their industrial development according to the study which achieved statistical results through a panel coefficient of $\beta = 10.35$ ($p < 0.001$) that examined 27 member states from 2015 to 2024. The country-level study of six EU countries reveals three pathways for export improvement (knowledge-system, manufacturing-platform, and FDI-absorption) together with one structural warning about Romania's economic standstill which applies directly to Uzbekistan's present situation.

The structural gap exists because Uzbekistan's high-tech export share stands at 2.8% and R&D expenditures account for 0.17 to 0.20% of GDP.

The gap demands execution of R1 through R6 which requires R&D funding increases and establishment of university-industry partnerships and creation of innovation financial systems and adoption of Industry 4.0 technologies by small and medium-sized enterprises and technology transfer requirements for foreign direct investment and European Union value chain and research network integration. The country's 7.7% GDP growth and $38.2 billion FDI base and its worldwide leading STEM workforce create a better foundation for this transition than Poland and the Czech Republic possessed at their equivalent development points. The 2030 target for high-tech exports to reach 8 to 10 percent is achievable through continuous policy dedication because this share will approach Poland's 2018 level.

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