Explaining External Competitiveness and Trade Capacity in Developing Economies: A Panel Data Analysis

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Citation: Pulaj, I. Guga, K. & Serjanaj, L. (2026). Explaining External Competitiveness and Trade Capacity in Developing Economies: A Panel Data Analysis. *Theoretical and Practical Research in Economic Fields, 17*(2), 498-508.
https://doi.org/10.14505/tpref.v17.2(38).14

Article info: Received 1 February 2026; Received in revised form 14 March 2026; Accepted 23 April 2026;
Published 30 June 2026.

Abstract: Competitiveness and trade capacity are critical determinants of sustainable growth in developing economies, particularly in an increasingly globalized and knowledge-based economic environment. While trade openness expands access to international markets, long-term competitiveness depends on a country's ability to innovate, share knowledge, and adopt new technologies. This study empirically examines the relationship between innovation-related factors and external competitiveness, using high-technology exports as a proxy for trade capacity and competitive performance. The analysis is based on panel data from 33 developing countries over the period 2010–2021 and employs a fixed-effects regression model to assess the association between university–industry collaboration, research and development (R&D) intensity, human capital, and information and communication technology (ICT) adoption, and high-tech export performance. The findings indicate that innovation systems are closely associated with external competitiveness. University–industry collaboration shows the strongest and most robust positive association with competitiveness, followed by R&D intensity and ICT adoption. In contrast, human capital does not exhibit a statistically significant direct association, suggesting that its contribution to trade capacity may operate indirectly through innovation processes and absorptive capacity. Overall, the results highlight the importance of integrated innovation systems and institutional coordination in supporting technological export performance and facilitating participation in global trade networks. Policies supporting innovation, digitalization, and university–industry collaboration are closely associated with improvements in technological capabilities and broader socio-economic development.

Keywords: External competitiveness; university–industry collaboration; developing economies; human capital; innovation systems; research and development; trade capacity.

JEL Classification: O11; O32; O33; F14; C23.

Introduction

In the last few decades economies have changed their structures due to big changes in networking, interconnection and globalization. The integrated markets of goods and factors have made different countries more dependent on each other. Economies face more competition while globalization also brings the exchange of new ideas, physical and human capital. Under these conditions, economies are encouraged to specialize, improve resource efficiency, and enhance the quality and competitiveness of their products. The need to integrate, as an important factor of the socio-economic system's success, is a challenge and a risk. International openness makes competition tougher and highlights more the difference between countries with different levels of development. Compared to each other, developing economies have structural problems that make it harder for them to fully benefit from international openness (Stiglitz and Rodrik 2025). Moving towards a knowledge-based economy is more difficult in cases where

there are unskilled workers for research and development, infrastructure for innovation and research is lacking, public institutions are weak, and intersectoral and university-industry collaboration is lacking (World Bank. 2020. *World Development Report 2020: Trading for Development in the Age of Global Value Chains*, Lema *et al.* 2021). The limited rate of endogenous innovation and reliance on imported technologies diminish competitive capacity in global markets (Cirera and Maloney 2017). Empirical evidence also confirms that sustainable competitiveness in global markets requires local knowledge creation and innovation capacity, rather than mere participation in global value chains (Lee *et al.* 2017). In this context, several forms of university-industry collaboration, such as joint innovation projects, internship programs, the creation of university spin-offs, and technology transfer, may support the development of innovation capacity. These forms of collaboration can generate mutual benefits. Universities can apply research outcomes in real-world contexts, enhancing their societal and economic relevance, while firms gain access to new knowledge, technologies, and opportunities for workforce training. U–I cooperation may therefore contribute to increased innovation capacity and a stronger competitive position in global markets. It is essential to establish collaborative frameworks among universities, businesses, and the government like the Triple Helix model, to cultivate innovative and competitive skills (Zhou and Etzkowitz 2021; Carayannis *et al*. 2012). The ability of national innovation systems to create effective collaborative networks and to absorb, modify, and enhance new knowledge has become essential for the transformation of globalization processes into lasting economic and social benefits (Freeman 2008, Archibugi *et al.* 2020). This shows how important it is to have rules that make it easier for universities and businesses to work together. These rules are necessary for improving external competitiveness and making it easier for businesses to enter international trade. The goal of this paper is to critically examine how university-industry collaboration can help developing economies become more competitive and better at trading with other countries. In this line, research should be conducted to identify the main factors that influence how much and in what ways U-I helps developing economies become more competitive in trade. A decisive role in this framework is also played by the appropriate policies and tools in place to encourage businesses and universities to work together, build networks and conduct research and development. These steps have effects on the economy and trade. The study combines a literature review with a statistical analysis of indicators. After the introduction, the paper continues with a literature review in section 2, a description of the methodology and data in section 3, empirical analyses and results in section 4, conclusions and policy implications in section 5.

1. Literature Review

International competitiveness is the ability of a country, sector or firm to make goods and services that meet global market standards while keeping or growing its market share and making sure that the economy stays healthy in the long run (Porter 1990). International competitiveness emerges from the dynamic interplay among innovation, institutions, and global integration (Schwab and Zahidi 2020). Countries that engage in knowledge-sharing networks and systems of collaboration and exchange, especially in university-industry collaborations, help the economy improve exports and become more involved in global markets in the long term. In the knowledge-based economy, competitiveness is no longer based only on having lower costs or more natural resources but on innovation, developing technology, and having efficient institutions (OECD/Asian Productivity Organization. 2022. *Identifying the Main Drivers of Productivity Growth: A Literature Review*). Efficient use of resources and knowledge adds value to the final product and increases exports. Countries can use their comparative advantages, increase the size of their production, and join global value chains through trade (World Bank. 2020. *World Development Report 2020: Trading for Development in the Age of Global Value Chains)*. Integration into global markets helps small and developing economies boost their productivity, spread new technologies, and change how they work (UNCTAD. 2022. *Trade and Development Report 2022: Development Prospects in a Fractured World*). Furthermore, exposure to global competition promotes innovation, efficiency, and managerial enhancement, which are crucial factors for enhancing competitiveness (Aiginger and Vogel 2015). Economic, institutional, and technological factors all play a role in how well a country can compete on the world stage. More recent contributions also highlight the role of digital trade and innovation in supporting inclusive economic growth and competitiveness across countries (Yeerken and Feng 2024). First, basic factor conditions, like good infrastructure, a skilled workforce, and access to money, are what make an economy competitive (Porter 1998) The transition toward a knowledge-based economy and to help economic growth requires investment in education, innovation, and ICT infrastructure (Chen and Dahlman 2005). Recent empirical studies also confirm the growing importance of digitalization and knowledge-based capabilities for export competitiveness in developing economies (Handoyo *et al.* 2025; Doan and Luong 2025). Good governance and high-quality institutions, such as stable rules, protection of intellectual property, and public policies that help businesses, also make it easier for productivity to grow and for businesses to get ahead of their competitors (IMD. 2022. *IMD World Competitiveness Booklet 2022)*. Zhao *et al.*

(2018) (demonstrate that investments in human capital, especially in sales personnel, exert a substantial and favorable influence on export performance, particularly within technology-intensive and R&D-oriented enterprises. On the other hand, collaborative mechanisms such as university–industry (U–I) collaboration are essential for accelerating knowledge transfer and promoting innovation co-creation, thereby augmenting the competitive capacity of developing economies (Zhou and Etzkowitz 2021; Ankrah and Al-Tabbaa 2015).

International trade and competition are good for the economy and long-term growth. Countries can use their comparative advantages to make better products and increase production when trade is open. This helps the country be more productive (Sowrov 2024; Ijirshar 2022). Also, being involved in international markets helps the spread of technology and the gaining of new knowledge, which speeds up the modernization of production processes and structures (UNCTAD. 2022. *Trade and Development Report 2022: Development Prospects in a Fractured World)*. To be competitive, the economies should improve their technological and productive advantages in global markets. The highest levels of international competitiveness are linked to innovation, human capital, and institutional quality, which help attract foreign direct investment and boost value-added exports (Barbary and Tawfiq 2024; Kordalska and Olczyk 2016). Trade and competition help to diversify export products and markets, spread new technologies and management methods, encourage innovation and productivity growth, and improve human capital through training programs and knowledge transfer (OECD/Asian Productivity Organization. 2022. *Identifying the Main Drivers of Productivity Growth: A Literature Review*). Joining global value chains gives high-value sectors access to new markets and makes it easier for the country to sell goods abroad. This shows how important it is to link trade to competitiveness for long-term economic growth (Sowrov 2024; Ijirshar 2022).

1.1. Types of University–Industry Collaboration and Their Effects on Trade and Competitiveness

Different types of university-industry collaboration help countries compete in different but complementary ways. Joint research and development (R&D) projects allow companies to use scientific knowledge and cutting-edge technologies, which leads to new products and better technology that help exports (Perkmann *et al.* 2013; Bellucci *et al*. 2023). Collaborative R&D makes it easier for companies, especially small and medium-sized businesses (SMEs), to meet international standards and enter new markets by lowering the costs and risks of innovation. Technology transfer activities that help make academic knowledge available for business use include patent licensing, contract research, and consulting agreements. This results in the development of high-value products that have an increased likelihood of being marketed internationally (Rossi *et al.* 2022). The creation of academic spin-offs and start-ups associated with universities also helps to diversify export structures by bringing in new technologies and knowledge-based services (Guerrero and Urbano 2019; Martínez-Ardila *et al.* 2023). Mobility programs and training partnerships also help companies absorb new information by improving their employees' skills and making sure that academic programs meet the needs of the job market. Industries improve their competitive position if the workforce improves in quality. The latter also increases the chances for innovation. But human capital is improved not only through training and education but also through exchange and mobility, helping to absorb new work models. Studies have shown that countries with institutionalized U–I collaboration frameworks tend to have more advanced exports, faster integration into global value chains, and steady growth in technology-driven sectors (OECD/Asian Productivity Organization. 2022. *Identifying the Main Drivers of Productivity Growth: A Literature Review*; Schwab and Zahidi 2020). As a result, the different ways that universities and businesses can work together act as catalysts that link the knowledge base of universities with the skills that businesses need to succeed in the market. This gives businesses an edge in international trade and makes them more competitive. These kinds of partnerships help businesses compete better in international markets by giving them the chance to come up with new ideas, follow international standards, and connect with global knowledge networks [14]. For developing economies, there are ways to make industries in the global value chain better by moving from making things that don't add much value to doing things that need more knowledge.

2. Method

This study combines a literature review with an empirical panel data analysis to examine the relationship between innovation-related factors and external competitiveness in developing economies. The empirical component is based on a country-level panel dataset covering 33 developing economies over the period 2010–2021. The analysis focuses on the association between university–industry collaboration, research and development (R&D) intensity, human capital, and information and communication technology (ICT) adoption, and their relationship with high-technology export performance as an indicator of external competitiveness.

2.1 Data Description

The empirical analysis uses an unbalanced panel dataset of 33 developing economies observed annually from 2010 to 2021. All variables are organized in a country–year format. The dependent variable is high-technology exports, used as a proxy for external competitiveness and trade capacity in technology-intensive sectors. The explanatory variables include university–industry collaboration (UIC), research and development (R&D) expenditure as a percentage of GDP, human capital proxied by tertiary education participation, and ICT adoption rates. All data were obtained from internationally comparable sources, primarily the World Bank databases.

Table 1. Variables and Data Sources

Variable	Symbol	Source
High-Technology Exports (Dependent Variable)	Competitiveness	World Bank
University–Industry Collaboration Index	UIC	World Bank
Expenditure in research and development % GDP	Innovation	World Bank
Human Capital, proxied by tertiary education rates	HC	World Bank
Information and Communication Technology adoption rates	ICT	World Bank

Source: (Author's compilation)

To ensure comparability across variables measured in different units and scales, all variables were normalized prior to estimation. Specifically, a min–max normalization approach was applied, transforming each variable according to the following expression:

$$X_{it}^{*} = \frac{X_{it} - \min(X)}{\max(X) - \min(X)}$$

where X_{it} denotes the original value of variable X for country i in year t, and $\min(X)$ and $\max(X)$ represent the minimum and maximum values observed in the sample. This transformation rescales all variables to the $[0, 1]$ interval while preserving relative differences across observations.

High-technology exports are used as an operational indicator of external competitiveness because they reflect the ability of an economy to produce and commercialize technologically sophisticated goods in international markets. While this measure does not capture all dimensions of competitiveness, it provides a focused proxy for technology-based trade performance, which is particularly relevant in the context of innovation-driven growth.

The empirical specification focuses on domestic innovation-related factors influencing competitiveness, rather than directly including trade policy or external demand variables. This allows for a more targeted examination of internal drivers of technological export performance. Descriptive analysis shows that there are some differences across countries. UIC ranges from around 1.7 to 4.5, and the average competitiveness index ranges from 14 to 28. The correlation matrix in table 2 shows that UIC (r = 0.58) and Innovation (r = 0.60) are the two elements most closely related to Competitiveness. This suggests that collaborative innovation mechanisms are closely associated with differences in competitiveness across countries. ICT (r = 0.33) and Human Capital (r = 0.06) show weaker, positive, correlations.

Table 2. Coefficients (Pearson correlations)

Variable	Competitiveness	UIC	Innovation	HC	ICT
Competitiveness	1.000	0.581	0.602	0.061	0.330
UIC	0.581	1.000	0.439	0.071	0.300
Innovation	0.602	0.439	1.000	0.217	0.418
HC	0.061	0.071	0.217	1.000	0.403
ICT	0.330	0.300	0.418	0.403	1.000

Source: Author's compilation using Python (2025)

All coefficients are Pearson correlations derived from panel data (2010–2021, N = 396).

3. Research Results

The empirical analysis is conducted using a country fixed-effects panel model estimated through Ordinary Least Squares (OLS) with heteroskedasticity-robust standard errors (HC3). The fixed-effects approach controls for time-invariant country-specific characteristics, such as geography, historical institutional structures, or long-term development patterns, that may influence competitiveness but are not directly observable. As a result, the estimates capture within-country associations over time between changes in innovation-related variables and changes in high-technology export performance.

The model is specified as:

$$Competitiveness_{it} = \alpha_i + \beta_1 UIC_{it} + \beta_2 Innovation_{it} + \beta_3 HC_{it} + \beta_4 ICT_{it} + \varepsilon_{it}$$

where i indexes countries and t indexes years, α_i represents country-specific fixed effects, and ε_{it} is the idiosyncratic error term.

Because the analysis is observational and the specification does not fully address potential endogeneity or reverse causality, the estimated coefficients should be interpreted as conditional associations rather than causal effects.

Table 3. Fixed-Effects OLS Regression Results (Model without Trade)

Variable	Coefficient	Std. Error	z-Statistic	p-Value	Significance
Intercept	15.907	0.272	58.39	0.000	***
UIC (β_1)	0.240	0.062	3.85	0.000	***
Innovation (β_2)	0.199	0.080	2.49	0.013	**
Human Capital (β_3)	0.029	0.126	0.23	0.821	ns
ICT (β_4)	0.151	0.052	2.88	0.004	***

Source: Author's compilation using Python, (2025)

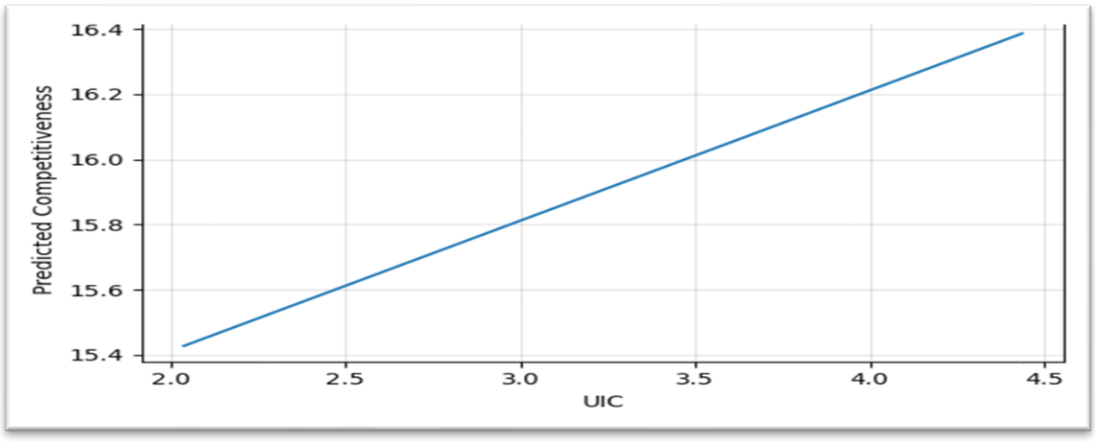
The estimation results are presented in Table 3. The model explains a substantial share of the within-sample variation in competitiveness ($R^2 = 0.984$). While this indicates a strong in-sample fit, it should be interpreted with caution given the use of fixed effects and normalized panel data. University–industry collaboration (UIC) is positively and statistically significantly associated with competitiveness ($\beta_1 = 0.240,\ p < 0.001$). This is the largest coefficient among the explanatory variables, suggesting that stronger collaborative linkages between academia and industry are closely related to higher levels of high-technology export performance within countries over time. R&D intensity also shows a positive and statistically significant association ($\beta_2 = 0.199, p = 0.013$), indicating that higher levels of investment in research and development are correlated with stronger technological export capacity. ICT adoption is likewise positively associated with competitiveness ($\beta_4 = 0.151,\ p = 0.004$), supporting the view that digital infrastructure plays an enabling role in innovation diffusion and participation in technology-intensive trade. By contrast, human capital does not exhibit a statistically significant coefficient in the baseline specification ($\beta_3 = 0.029, p = 0.821$). This result does not imply that human capital is unimportant; rather, it suggests that its contribution to competitiveness may operate indirectly through complementarities with innovation systems, absorptive capacity, or institutional mechanisms. Overall, the findings are consistent with the interpretation that innovation-related factors are closely associated with differences in technological export performance across countries, although these relationships should not be interpreted as causal.

These findings are broadly consistent with the existing literature, which emphasizes the role of collaborative innovation systems and technological infrastructure in shaping export performance and productivity growth [8], [2]. In particular, the results support the view that interaction between knowledge-producing institutions and firms is a key mechanism through which innovation is translated into market outcomes. The absence of a statistically significant coefficient for human capital may reflect structural factors such as delays in education systems or mismatches between acquired skills and labor market needs, suggesting that its contribution to competitiveness may operate indirectly rather than through a direct channel.

The marginal effects plots provide additional insight into the relationships identified in the regression model. Figure 1 illustrates the marginal association between university–industry collaboration and predicted competitiveness, showing a clear positive relationship. This pattern indicates that higher levels of UIC are associated with higher

predicted values of high-technology export performance, holding other variables constant. This finding is consistent with theoretical perspectives emphasizing that collaborative innovation systems facilitate knowledge diffusion and enhance absorptive capacity (Ankrah and Al-Tabbaa 2015; Granstrand and Holgersson 2020).

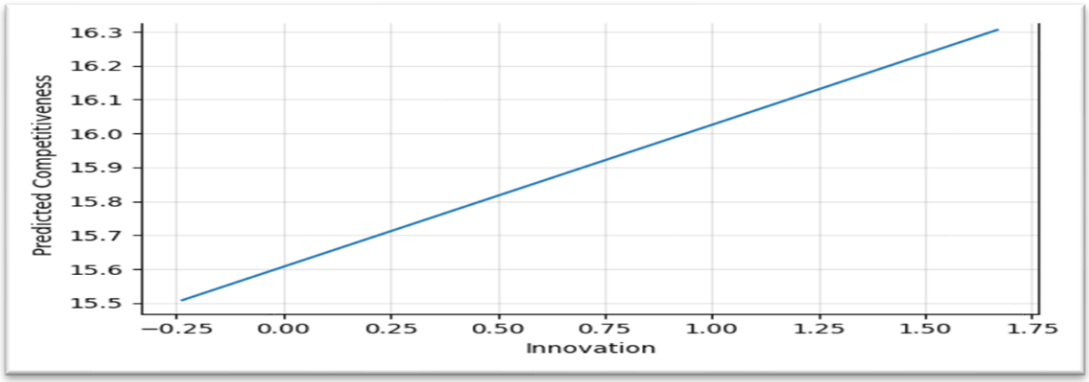
Figure 1. Marginal effect of UIC on competitiveness.



Source: Python-generated figure, author's calculations, (2025)

Figure 2 presents the marginal association between R&D intensity and competitiveness. The positive slope suggests that higher R&D expenditure is associated with stronger competitiveness, although the relationship appears to flatten at higher values, indicating potential diminishing marginal associations.

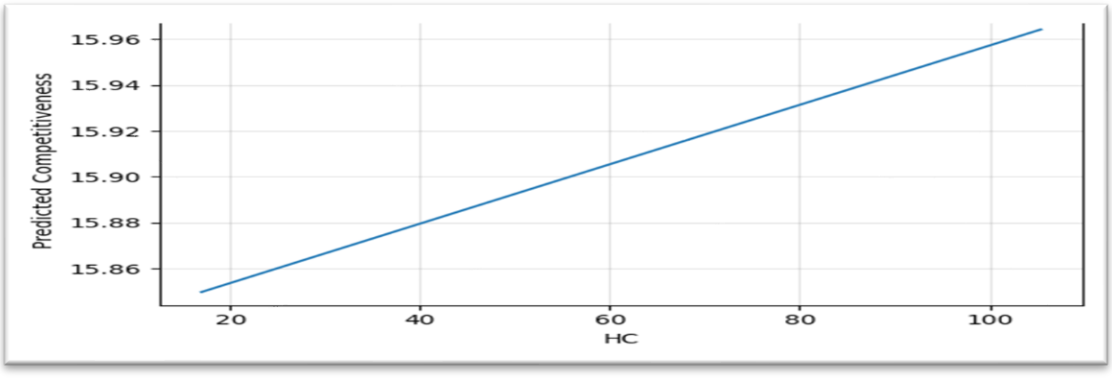
Figure 2. Marginal effect of R&D (Innovation) on competitiveness.



Source: (Python-generated figure, author's calculations, 2025)

Figure 3 shows the marginal relationship between human capital and competitiveness. The relatively flat pattern is consistent with the statistically insignificant coefficient observed in the regression results.

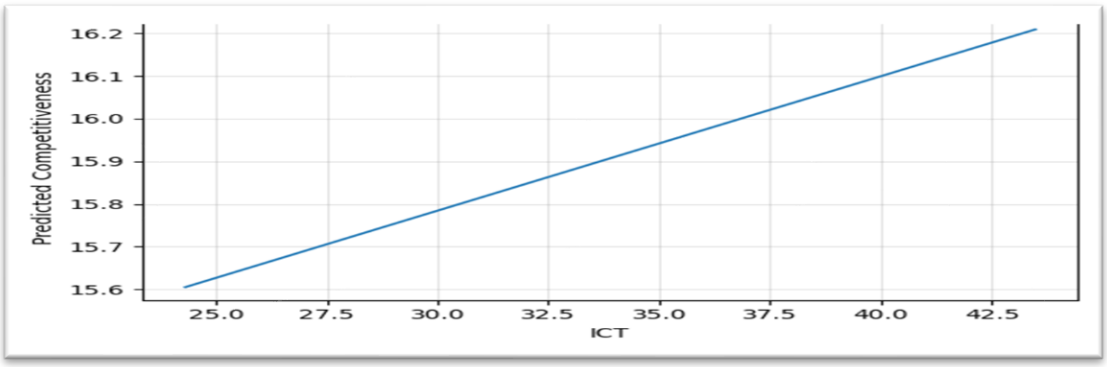
Figure 3. Marginal effect of Human Capital on competitiveness



Source: (Python-generated figure, author's calculations, 2025)

Figure 4 displays the marginal association between ICT adoption and competitiveness, indicating a positive relationship that is consistent with the estimated coefficient and the role of digital infrastructure in supporting innovation diffusion.

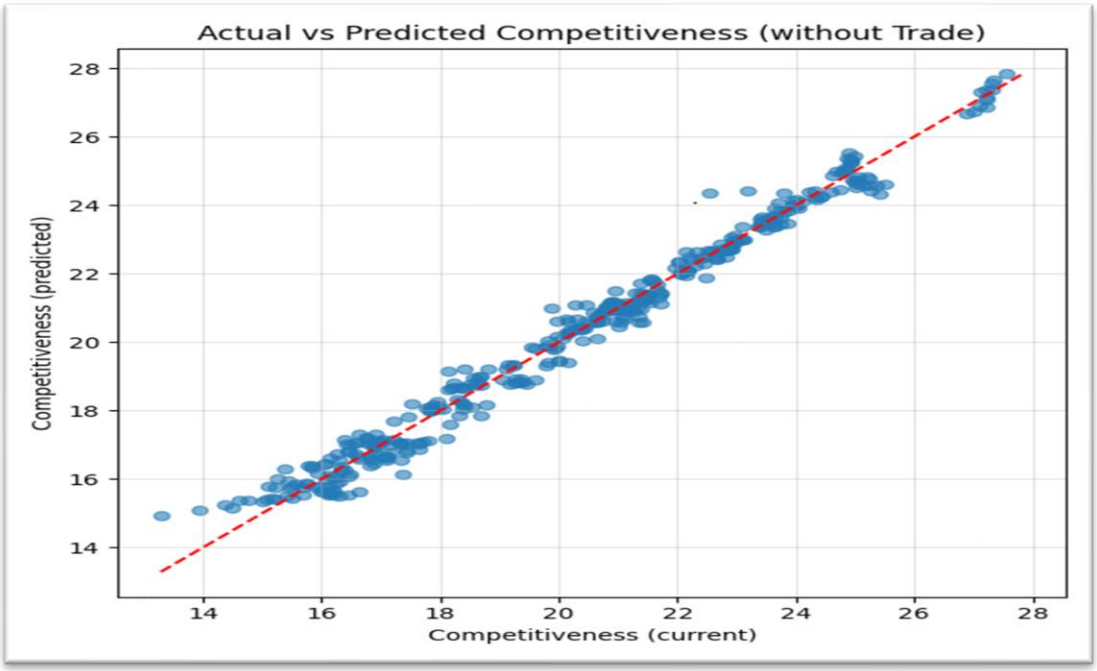
Figure 4. Marginal effect of ICT Human Capital on competitiveness



Source: (Python-generated figure, author's calculations, 2025)

Figure 5 compares the observed and predicted values of competitiveness (excluding trade-related variables). The close alignment of observations along the 45-degree line indicates a strong in-sample fit of the model, suggesting that the included variables capture a substantial share of the within-sample variation in high-technology export performance. However, this result should be interpreted with caution, as it does not imply causal validity or predictive performance beyond the sample.

Figure 5. Actual vs. predicted competitiveness (model without Trade).



Source: (Python-generated figure, author's calculations, 2025)

The empirical results suggest that policy frameworks supporting university–industry collaboration, R&D investment, and digital infrastructure are closely associated with stronger technological export performance. These findings are consistent with the view that coordinated innovation systems may play an important role in shaping external competitiveness in developing economies.

4. Discussions

The findings of this study contribute to the literature on external competitiveness by highlighting the role of innovation-system variables in shaping high-technology export performance in developing economies. In particular,

the results indicate that university–industry collaboration exhibits the strongest positive association with competitiveness, followed by R&D intensity and ICT adoption, while human capital does not show a statistically significant direct coefficient in the baseline specification.

These findings are consistent with the view that competitiveness in technology-intensive trade depends not only on factor endowments, but also on the institutional and organizational mechanisms through which knowledge is generated, shared, and applied. This interpretation is also supported by recent empirical evidence highlighting the complementary role of digitalization, human capital, and institutional quality in shaping export competitiveness (Handoyo et al. 2025; Yeerken and Deng 2024). University–industry collaboration may be especially relevant in this context because it connects research capabilities with firm-level production and commercialization processes. Similarly, R&D intensity and ICT adoption appear to be closely associated with stronger technological export performance, suggesting that innovation investment and digital infrastructure are important complementary conditions within national innovation systems.

The non-significant coefficient on human capital deserves particular attention. Rather than suggesting that education is irrelevant, this result may indicate that the contribution of human capital operates indirectly through absorptive capacity, innovation quality, institutional complementarities, and the ability of firms to adopt and adapt technology. In developing economies, educational expansion alone may not translate immediately into higher technological export performance if skills are weakly aligned with productive structures or if innovation and commercialization channels remain underdeveloped.

The results also suggest that innovation-related variables do not operate in isolation. Their association with competitiveness is likely to depend on broader structural and institutional conditions, including policy coordination, productive capacity, firm absorptive capability, and the quality of governance. In the absence of supportive frameworks, university–industry collaboration may remain limited in depth or effectiveness, while R&D investment may not be fully converted into marketable outputs. This helps explain why not all variables display the same level of statistical significance in the baseline model.

Taken together, the results are more supportive of a systemic innovation interpretation than of a purely resource-based explanation of competitiveness. The stronger association of UIC, together with the positive coefficients on R&D and ICT, suggests that trade capacity in developing economies is shaped not only by the presence of inputs, but these inputs are connected through institutions, networks, and mechanisms of knowledge transfer.

From a policy perspective, the findings suggest that strategies aimed at strengthening innovation ecosystems may be more relevant than isolated interventions. Measures that support university–industry linkages, technology transfer mechanisms, R&D investment, and digital infrastructure are likely to be associated with stronger technological export performance when they are embedded in coherent institutional frameworks. At the same time, the observational nature of the analysis means that these patterns should not be interpreted as proof of causal effects, but rather as evidence consistent with the importance of coordinated innovation capacity in developing economies.

Conclusions and Further Research

This study examined the relationship between university-industry collaboration, R&D intensity, human capital, and ICT adoption, and their association with high-technology export performance in a panel of 33 developing economies over the period 2010 - 2021. The empirical results indicate that university-industry collaboration shows the strongest positive association with external competitiveness, followed by R&D intensity and ICT development, while human capital does not exhibit a statistically significant direct coefficient in the baseline specification.

These findings contribute to literature by supporting a systemic view of competitiveness in developing economies, where interaction between innovation actors and institutional frameworks plays a central role. This perspective is consistent with recent research emphasizing the integrated and systemic nature of innovation-driven competitiveness in developing economies (Doan and Luong 2025; Yeerken and Deng 2024). In particular, the results suggest that collaboration between academia and industry, together with investment in research and digital infrastructure, is closely associated with stronger performance in technology-intensive trade sectors. This interpretation is consistent with recent theoretical contributions emphasizing the systemic nature of innovation networks and the collaborative generation of knowledge across institutional boundaries (Granstrand and Holgersson 2020; Ankrah and Al-Tabbaa 2015).

At the same time, the absence of a direct effect of human capital is consistent with the interpretation that education contributes to competitiveness primarily through indirect channels, such as absorptive capacity, innovation capability, and the effective functioning of innovation systems.

From a policy perspective, the findings suggest that strengthening innovation ecosystems may be more relevant than focusing on isolated inputs. Policies that encourage university-industry collaboration, support R&D activities, and expand digital infrastructure are likely to be associated with stronger technological export performance when embedded in coherent institutional frameworks. However, given the observational nature of the analysis, these relationships should not be interpreted as causal effects.

The study also has several limitations. The model focuses on a limited set of innovation-related variables and does not explicitly incorporate factors such as institutional quality, trade openness, or global value chain participation. In addition, the fixed-effects approach captures within-country variation but does not fully address potential endogeneity or dynamic relationships.

Future research could extend this framework by incorporating additional dimensions, including institutional quality, international trade dynamics, and the long-term effects of human capital. Further work could also explore dynamic panel models or alternative estimation strategies to better account for causality and time lags. Expanding the analysis to different country groups or sectoral levels may also provide deeper insights into the mechanisms linking innovation systems and external competitiveness.

Declarations

Credit Authorship Contribution Statement:

Ilira Pulaj: Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing.
Klaudja Guga: Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing.
Lorena Serjanaj: Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing.

Declaration of Competing Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-Assisted Technologies: The authors declare that they have not used AI and AI-assisted technologies in the writing process before submission, but only to improve the language and readability of their paper and with the appropriate disclosure

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