Proceedings of ICEMGD 2025 Symposium: Resilient Business Strategies in Global Markets
DOI: 10.54254/2754-1169/2025.CAU26156

Export Intensity and Tertiary Education: A Cross-National Analysis with Economic Complexity Index as a Moderator

Qianrong Hu

Durham University, Durham, United Kingdom
ramla.hu.qianrong@gmail.com

Abstract. This study examines the bidirectional relationship between export intensity and tertiary education enrollment across 109 countries from 1998 to 2023, with a focus on the moderating role of economic complexity. Using fixed-effects panel models, interaction terms, and system GMM estimation, the analysis reveals an asymmetric pattern: while both directions are statistically significant, the influence of education on exports is more robust and contingent on structural sophistication. The Economic Complexity Index (ECI) significantly strengthens the education-to-export link but has limited moderating effect in the reverse direction. The study highlights the importance of aligning human capital development with structural transformation to support inclusive, export-led growth. Context-specific strategies are recommended for countries at different levels of economic complexity. The robustness of findings is confirmed through alternative specifications and transformations. Overall, the study offers new insights into how trade and education co-evolve and underscores the role of productive capabilities in shaping development pathways amid shifting global dynamics.

Keywords: Export Intensity, Tertiary Education, Economic Complexity, Fixed Effects, System GMM

1. Introduction

1.1. Background and literature review

The relationship between international trade and human capital formation is central to comparative development economics. Export-led growth remains a core strategy for many low- and middle-income countries seeking industrialization and structural transformation. Tertiary education is widely seen as essential for productivity, innovation and long-term competitiveness. Understanding how these two forces interact is critical for informing development policies, especially as globalization slows and geopolitical tensions rise. In such a context, aligning human capital formation with evolving export opportunities becomes vital for inclusive development. However, the connection between export orientation and tertiary education enrollment is neither straightforward nor uniform. Countries like South Korea and Ireland achieved parallel gains via different paths, while resource-based economies such as Equatorial Guinea or Angola show that export growth does not always lead to human capital development due to structural differences.

Several studies underscore this cross-country heterogeneity. For, instance, evidence shows that the trade's impact on education depends on development stage: in OECD countries, trade promotes education, while in non-OECD countries, gains are often diverted to demographic expansion [1]. In

DOI: 10.54254/2754-1169/2025.CAU26156

addition, regional context also shapes the mechanisms through which tertiary education contributes to high-tech exports, with stronger effects in Asia Pacific and weaker ones in Europe [2].

Other studies frame these dynamics through the lens of economic complexity, suggesting that the sophistication and skill intensity of export structures—not merely a country's development level—shape education outcomes. Specifically, growth in skill-intensive exports promotes schooling, while less skill-intensive expansion depresses attainment [3]. Complementing findings clearly indicate that structural transformation via skill-intensive exports enhances the impact of education aid on tertiary enrollment [4]. Correspondingly, as a proxy for low-skill sectors, rising resources exports in Chile are linked to lower tertiary attainment [5].

Beyond structural variation, causality direction matters. While education may enhance exports, findings are mixed. On one hand, tertiary education promotes the growth of high technology exporting firms in Latin America [6], while advanced degrees positively effects industrial exports in Iran [7]. On the other hand, China's education expansion appears to reduce domestic value added in exports due to greater reliance on processing trade [8].

Despite growing literature, two gaps remain. First, most studies treat the relationship between trade and education as unidirectional, overlooking feedback loops. Second, cross-national research on how education affects exports remains limited and often neglects structural factors like economic complexity.

1.2. Research objectives

Considering data integrity and availability, this study investigates the bidirectional relationship between export intensity and tertiary enrollment across 109 countries from 1998 to 2023. It examines both directions and introduces the Economic Complexity Index (ECI) as a moderator to assess how structural differences in productive capabilities shape the strength and direction of this linkage. Through descriptive visualizations and regression analysis, the research contributes to a more nuanced understanding of how trade and education co-evolve under varying structural conditions.

2. Theoretical framework and mechanisms

2.1. Conceptual model

To guide hypothesis development, this study draws on three theoretical perspectives: the compensation hypothesis, endogenous growth theory, and new economic geography:

The compensation hypothesis posits that global trade exposure increases economic volatility and inequality, prompting governments to expand public spending, including on education. In this view, export-led growth may promote tertiary enrollment as states invest in human capital to stabilize society and enhance competitiveness. Endogenous growth theory, by contrast, highlights internal drivers such as education, knowledge accumulation, and innovation as foundations of sustained growth. Tertiary education supports technological upgrading and high-value production, thereby reinforcing export complexity and competitiveness. New economic geography underscores the role of industrial clustering, labor pooling, and knowledge spillovers in shaping development, with complex economies offering structural conditions that support the export-education linkages.

2.2. Mechanisms and hypotheses

As the theoretical perspectives suggest, the relationship between education and export is bidirectional and shaped by structural context. Export orientation is likely to enhance education by increasing fiscal capacity for public investment [9], generating demand for skilled labor [10], and exposing domestic industries to international standards and technologies [11]. Conversely, tertiary education may boost

DOI: 10.54254/2754-1169/2025.CAU26156

exports by providing skills for innovation and high-value production [12], expanding the middle class and raising demand for advanced products that drive industrial upgrading [13], and strengthening institutional quality for effective export-oriented policies [14].

The strength of these linkages depends on economic complexity. In diversified economies, robust infrastructure, industrial clusters, and knowledge networks reinforce education-export feedback loops. In contrast, countries with low complexity may face institutional or absorptive constraints.

Based on this framework, the following hypotheses are proposed:

H1: Export intensity is positively associated with tertiary education enrollment.

H2: Tertiary education enrollment is also positively associated with export intensity.

H3: Economic complexity amplifies H1 and H2 when structural diversification is high.

3. Empirical analysis

3.1. Methodology

3.1.1. Data and variables

This study uses three main variables. Export intensity, measured as export (% of GDP), captures the extent of a country's orientation toward international trade and serves as either the dependent or independent variable depending on model specification. Tertiary enrollment is measured by the gross enrollment ratio in higher education (GER)—total enrollment divided by the population of the official five-year age group following secondary education, multiplied by 100. Economic complexity is the moderating variable, represented by Economic Complexity Index (ECI), which reflects the diversity and technological sophistication of a country's export structure.

Four control variables are included: GDP per capita (constant USD), government expenditure on education (% of GDP), urbanization rate, FDI net inflows (% of GDP). Data sources include the World Bank, UNESCO Institute for Statistics, OECD, Eurostat, the UN Population Division, IMF and the Harvard Center for International Development.

3.1.2. Modeling strategy

To examine the bidirectional relationship between export intensity and tertiary education enrollment, two baseline models are estimated using two-way fixed effects panel regressions with country and year fixed effects:

$$GER_{it} = \beta_0 + \beta_1 \cdot Export_{it} + \gamma \cdot Controls_{it} + \alpha_i + \lambda_t + \epsilon_{it} \tag{1}$$

$$Export_{it} = \beta_0 + \beta_1 \cdot GER_{it} + \gamma \cdot Controls_{it} + \alpha_i + \lambda_t + \epsilon_{it} \tag{2}$$

In these models, β_1 captures the marginal effect of the independent variable on the dependent variable. α_i and λ_t denote country and time fixed effects, accounting for time-invariant heterogeneity across countries and common trends across years. The subscripts i and t represent countries and years respectively. ϵ_{it} is the idiosyncratic error term.

To test for moderation by economic complexity, interaction terms between ECI and the primary explanatory variable are introduced:

DOI: 10.54254/2754-1169/2025.CAU26156

$$GER_{it} = \beta_0 + \beta_1 \cdot Export_{it} + \beta_2 \cdot ECI_{it} + \beta_3 \cdot (Export_{it} \cdot ECI_{it}) + \gamma \cdot Controls_{it} + \alpha_i + \lambda_t + \epsilon_{it} \quad (3)$$

$$Export_{it} = \beta_0 + \beta_1 \cdot GER_{it} + \beta_2 \cdot ECI_{it} + \beta_3 \cdot (GER_{it} \cdot ECI_{it}) + \gamma \cdot Controls_{it} + \alpha_i + \lambda_t + \epsilon_{it} \quad (4)$$

The interaction coefficient β_3 indicates how the marginal effect of export intensity or education on the dependent variable varies depending on a country's level of economic complexity. A significantly positive β_3 would suggest that the positive impact of main predictors is amplified in countries with higher ECI values.

3.1.3. Empirical strategy

Given concerns about endogeneity, system GMM is employed. Lagged values of the dependent variable and key explanatory variables serve as instruments to mitigate bias from reverse causality and omitted variable problems. The one-step system GMM estimator is applied with individual effects, using first differencing to eliminate time-invariant country-specific heterogeneity. As a robustness check, the model is re-estimated using logarithmic transformations of the two most right skewed variables—export (% of GDP) and GDP per capita—to test the stability of results.

3.2. Results

3.2.1. Descriptive patterns and regional trends

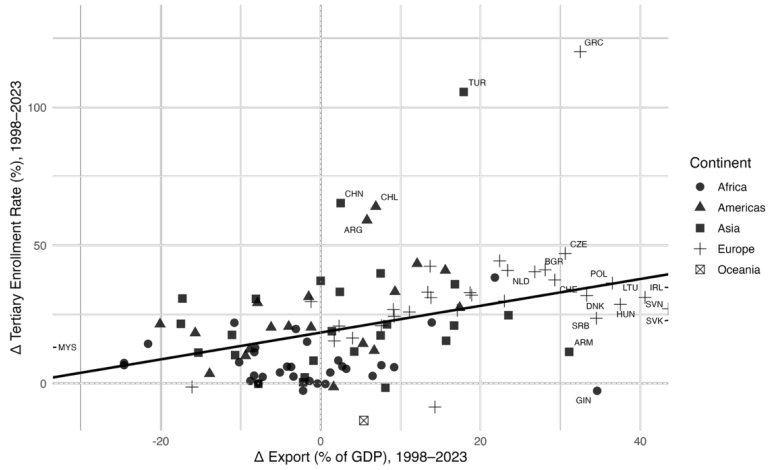

Figure 1. Change in Export % of GDP and Tertiary Enrollment (1998–2023, by Country)

To inform the empirical models, this section examines descriptive trends in key variables from 1998 to 2023. Export (% of GDP) ranges from 6.8 to 135 (mean 39.8); tertiary enrollment from 1.2% to 166.7% (mean 46.2). Substantial skewness across variables suggests heteroskedasticity, supporting the use of clustered robust standard errors. Extending this overview, Figure 1 reveals that although most countries experienced rising tertiary enrollment over the 26-year period, changes in export intensity varied widely, pointing to potential structural factors shaping the export-education nexus.

Disaggregating the trends by region, Europe recorded the strongest growth in both export intensity (39.1% to 56.0%) and tertiary enrollment (46.2% to 72.0%). Asia followed with moderate gains, while Africa started slower but made steady progress. The Americas showed uneven trends, with exports rising (20.5% to 32.6%), but enrollment slightly declining (31.3% to 28.1%). These contrasts align with ECI patterns: Europe remained highly complex, Asia improved gradually, and the Americas declined. This

DOI: 10.54254/2754-1169/2025.CAU26156

suggests that structurally advanced economies may benefit from reinforcing cycles between complex exports and human capital investment. Supporting this, Pearson correlations show ECI is moderately associated with both export intensity (r=0.38) and tertiary enrollment (r=0.70), while the direct link between export and enrollment is weaker (r=0.27).

3.2.2. Regression findings

Building on the descriptive findings, four two-way fixed effects panel regressions examine the bidirectional relationship between export intensity and tertiary enrollment, with and without the moderating role of economic complexity (ECI).

In the baseline model, a 1% increase in export intensity is associated with a 0.195 percentage-point rise in tertiary enrollment ($p<0.05$), suggesting export-oriented economies tend to support higher education. Adding ECI as a moderator slightly strengthens the main effect (0.208, $p<0.01$), but the interaction term is insignificant, indicating that the effect does not vary by complexity.

In the reverse direction, a 1 percentage-point increase in tertiary enrollment predicts a 0.156-point rise in export intensity ($p<0.01$), pointing to human capital's role in enhancing trade. However, after including the interaction with ECI, the direct effect of tertiary enrollment becomes insignificant, while the interaction term is positive and significant (0.173, $p<0.01$). This suggests that education boosts exports more in countries with complex economies. Notably, ECI itself shows a significant negative main effect (-6.86, $p<0.05$), implying possible non-linear or suppressor dynamics.

Taken collectively, these results indicate a more robust pathway from education to trade, particularly under conditions of high economic complexity, while the effect of trade on education appears more direct and less conditioned by structural sophistication.

3.2.3. Robustness checks

Robustness was assessed through two complementary approaches. First, system GMM addresses endogeneity, showing that a 1% increase in export intensity predicts a 0.020-point decrease in tertiary enrollment ($p<0.05$), while a 1-point rise in education predicts a 0.065-point increase in export ($p<0.001$). Instrument validity is supported by the Sargan test ($p=1$) and auto correlation diagnostics. Second, semi-log models apply logarithmic transformations to export intensity and GDP per capita to reduce skewness. Results are consistent: the education-to-export effect remains positive and significant, and the interaction between tertiary enrollment and ECI continues to be significant (0.003, $p<0.01$), reaffirming ECI's moderating role.

These checks confirm that the main conclusions hold across estimation methods and functional forms, reinforcing the reliability and generalizability of the observed patterns in the export-education relationship.

3.3. Discussion

The findings underscore the catalytic role of ECI in fostering a virtuous cycle between human capital and trade. In high-ECI countries, skilled labor and complex industries generate cumulative returns through innovation and market access, supporting dual investment in education and industrial upgrading. Strengthening ties between universities, research institutions and advanced export sectors can enhance the impact of tertiary education and boost global competitiveness. For low-ECI economies, education reform alone may be insufficient without aligning it with broader industrial strategies. Policymakers should integrate education policies with industrial planning, technology adoption and support for entrepreneurship in export-oriented activities to drive export-led growth.

DOI: 10.54254/2754-1169/2025.CAU26156

Nonetheless, some limitations warrant caution. The models omit cultural, institutional, or geopolitical factors, as well as informal trade and education quality, potentially overlooking some key aspects of the export-education nexus.

4. Conclusion

This study provides systematic empirical evidence for a bidirectional but asymmetric relationship between export intensity and tertiary education enrollment, shaped by a country's economic complexity. While fixed-effects models suggest significant effects in both directions, system GMM and interaction models indicate that the influence of education on export is more robust and conditioned on structural sophistication. Specifically, tertiary enrollment boosts export intensity more strongly in structurally sophisticated economies, whereas the influence of exports on education is more uniform and less contingent on economic complexity.

These findings basically align with endogenous growth theory and new economic geography, which emphasize the importance of human capital and structural sophistication in driving development outcomes; however, the compensation hypothesis receives only limited empirical validation in this study. Based on the empirical results, the three hypotheses can now be reassessed: H1 is partially supported: export intensity is positively associated with tertiary enrollment, but the effect is relatively uniform across different levels of economic complexity. H2 receives stronger support: tertiary education positively predicts export performance, especially in economies with more diversified and complex structures. H3 is also validated, as economic complexity significantly moderates the education to export link.

The results also point to actionable implications for policymakers. Rather than one-size-fits-all solutions, aligning education and trade strategies with countries' structural capabilities emerges as a critical foundation for sustainable, inclusive growth. Future research could delve into subnational variations in the export-education nexus or examine how sectoral dynamics—such as those in green technologies or digital services—shape and mediate these relationships.

References

[1] Galor, O., & Mountford, A. (2008). Trading population for productivity: Theory and evidence. Review of Economic Studies, 75(4), 1143–1179.
[2] Nguyen, H. T. T., Pham, M. H. N., Nguyen, T. T., & Duong, K. D. (2024). The impact of government expenditure and tertiary education on high-technology exports: Evidence from Asia-Pacific and European nations. Applied Economics Journal, 31(2), 77–97.
[3] Blanchard, E. J., & Olney, W. W. (2017). Globalization and human capital investment: Export composition drives educational attainment. Journal of International Economics, 106, 165–183.
[4] Suzuki, M. (2023). Aiding higher education with export expansion in the developing world. World Trade Review, 22(5), 608–628.
[5] Álvarez, R., & Vergara, D. (2016). Natural resources and education: Evidence from Chile (Working Paper No. 433). University of Chile, Department of Economics.
[6] Peña-Vinces, J., & Audretsch, D. B. (2021). Tertiary education and science as drivers of high-technology exporting firms' growth in developing countries. The Journal of Technology Transfer, 46(6), 1734–1757.
[7] Mehrbani, V. (2018). Educational levels and export performance of Iranian industries. Theoretical Economics Letters, 8, 1460–1474.
[8] Du, Y., Yan, J., Cao, F., Li, Y., & Zhou, M. (2023). Higher education expansion and domestic value added in exports: Theory and evidence from China. Journal of Asian Economics, 87, 101621.
[9] Rodrik, D. (1998). Why do more open economies have bigger governments? Journal of Political Economy, 106(5), 997–1032.
[10] Michaels, G. (2008). The effect of trade on the demand for skill: Evidence from the Interstate Highway System. The Review of Economics and Statistics, 90(4), 683–701.
[11] Mahmood, T., Din, M. U., & Ghani, E. (2009). An analysis of technology adoption by export-oriented manufacturers in Pakistan. The Pakistan Development Review, 48(4), 939–948.

DOI: 10.54254/2754-1169/2025.CAU26156

[12] Zapata, A. N., Arrazola, M., & de Hevia, J. (2024). Determinants of high-tech exports: New evidence from OECD countries. Journal of the Knowledge Economy, 15(1), 1103-1117.
[13] Hardy, B. L., & Marcotte, D. E. (2015). Education and the dynamics of middle-class status. Brookings Institution.
[14] Tzivanakis, N. (2019). The educational path to institutional quality: A panel analysis of developing economies. SSRN. https: //doi.org/10.2139/ssrn.4973048