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Article

Digital Connectivity, Access Infrastructure, and the Global Expansion of Higher Education

María Monserrate Cedeño Barcia[1], Évelyn Fernanda Córdoba[2], Lizandro Agustín Cedeño Barcia[3], Francisco Omar Cedeño Loor[4], Pablo Ramon Flores Cedeño[5], Leonor Alexandra Rodriguez Alava[6]

[1] Universidad Técnica de Manabí, Ecuador.
Email: maria.cedeno@utm.edu.ec
[2] Latinova, Ecuador.
Email: evelyncordobap@gmail.com
[3] Universidad Técnica de Manabí, Ecuador.
Email: lizandro.cedeno@utm.edu.ec
[4] Universidad Técnica de Manabí, Ecuador.
Email: francisco.cedeno@utm.edu.ec
[5] Universidad Técnica de Manabí, Ecuador.
Email: pablo.flores@utm.edu.ec
[6] Universidad Técnica de Manabí, Ecuador.
Email: leonor.rodriguez@utm.edu.ec
Corresponding Author: Évelyn Fernanda Córdoba

Abstract: The global expansion of higher education over recent decades has coincided with an equally rapid expansion of digital connectivity, yet the literature has less frequently examined whether both processes are systematically associated at the country level. This study examines whether digital access infrastructure, measured through three complementary indicators (internet users, fixed broadband, and mobile telephony), predicts gross tertiary enrollment, and whether this association is homogeneous across income groups and levels of inequality. Using a cross-sectional panel of 163 countries drawing on World Bank data, robust regression models (HC3), a non-parametric between-income-group test, and two interaction models were estimated. Fixed broadband was the strongest predictor of tertiary enrollment ($\beta = 1.09$, $p < .001$), followed by the percentage of internet users ($\beta = 0.29$, $p = .011$) and mobile phone penetration ($\beta = 0.10$, $p < .001$), even after controlling for GDP per capita and government effectiveness. Contrary to the leapfrogging hypothesis, the return of mobile telephony on tertiary enrollment was not larger in low-income countries; it was significantly smaller than in high-income countries. Income inequality (Gini index) did not significantly moderate the relationship between connectivity and tertiary enrollment. These findings position fixed broadband infrastructure, rather than mobile connectivity, as the digital divide component most consistently associated with the global expansion of higher education.
Keywords: digital connectivity; digital divide; higher education; broadband; mobile telephony; inequality; cross-national analysis

1. Introduction

The expansion of higher education has been one of the most notable social processes of recent decades, with gross tertiary enrollment worldwide growing steadily across virtually every region of the planet. In parallel, digital connectivity, measured through internet access, fixed broadband, and mobile telephony, has undergone an equally rapid expansion, albeit one that remains deeply unequal across countries (ITU, 2025). The digital divide literature has documented that this inequality is not limited to material access to infrastructure, but extends to the skills needed to use it and to the outcomes that derive from it, including access to education (Van Deursen & Helsper, 2015; Ragnedda, 2017).

However, the specific association between connectivity infrastructure and the expansion of higher education at the country level has rarely been subjected to a systematic empirical test that distinguishes between the different components of that infrastructure. Most of the literature has treated digital connectivity as a homogeneous block, when in reality internet access, fixed broadband, and mobile telephony follow distinct diffusion trajectories and could have differentiated effects on access to higher education. The leapfrogging hypothesis, popularized from the observation that mobile telephony spread in many developing countries without a prior stage of fixed-line telephony, suggests that mobile connectivity could play a particularly relevant role in lower-income countries, where fixed broadband infrastructure is scarce (Donner, 2015).

There is, in addition, evidence that not all forms of connectivity produce the same economic and social effects. The work of Hjort and Poulsen (2019) on the arrival of high-speed internet through submarine cables in Africa showed substantial effects on employment and productivity, effects that were not replicated with the same magnitude from the expansion of mobile telephony alone. This evidence suggests that connection quality and stability, attributes more closely associated with fixed broadband than with mobile telephony, could be determinant for connectivity to translate into more demanding educational outcomes, such as higher education, which generally requires sustained access to learning platforms, academic databases, and online application processes.

There is, consequently, a specific empirical gap: it has not been established, with comparable data at a global scale, which of the three components of connectivity infrastructure (internet, fixed broadband, mobile telephony) is most robustly associated with tertiary enrollment once economic development and institutional quality are controlled for, nor whether this association is uniform across income groups or is moderated by within-country income inequality. The present study occupies that niche: using a cross-sectional panel of 163 countries, it examines the relationship between the three components of digital connectivity and tertiary education enrollment, assessing its robustness against structural controls, its heterogeneity by income group, and its interaction with income inequality.

The study pursues three specific objectives: (a) to determine which component of connectivity infrastructure predicts tertiary enrollment after controlling for economic development and government effectiveness; (b) to assess whether the return of mobile telephony on tertiary enrollment is larger in low-income countries, as the leapfrogging hypothesis would anticipate; and (c) to examine whether income inequality moderates the relationship between internet access and tertiary enrollment.

2. Theoretical Framework

2.1. The Three-Level Digital Divide and Higher Education

The three-level digital divide framework, namely access, skills, and outcomes, holds that digital inequality is not exhausted by the material availability of infrastructure, but progressively shifts toward usage competencies and, ultimately, toward the benefits effectively obtained (Van Deursen & Helsper, 2015; Ragnedda, 2017). Applied to higher education, this framework suggests that internet access is a necessary but not sufficient condition: tertiary enrollment, which requires sustained use of academic platforms, digitalized application processes, and access to online bibliographic resources, may depend more on connection quality and stability than on its mere nominal availability.

2.2. Diffusion of Innovations and Distinct Trajectories of Technology Adoption

Diffusion of innovations theory (Rogers, 2003) posits that technologies are adopted following distinct temporal and social curves according to their attributes: complexity, cost, compatibility with existing infrastructure, and observability of benefits. Mobile telephony and fixed broadband have indeed followed markedly different diffusion trajectories at the global scale: the former has expanded rapidly even in the absence of prior fixed networks, while the latter has required sustained investment in physical infrastructure of higher cost and complexity. This difference in trajectories is the theoretical basis for treating both connectivity components as distinct, rather than interchangeable, predictors of educational outcomes such as tertiary enrollment.

2.3. The Leapfrogging Hypothesis

The leapfrogging hypothesis holds that lower-income countries can skip intermediate infrastructure stages, adopting mobile technologies directly without having previously developed extensive fixed networks (Donner, 2015). Transferred to the educational domain, this hypothesis would anticipate that mobile telephony would play a proportionally more relevant role for access to higher education in lower-income countries, where it often constitutes the only available means of digital connection. This expectation, however, must be weighed against the possibility that higher education, given its data-intensive nature and its reliance on sustained use of digital platforms, depends on a connection quality that mobile telephony alone does not always guarantee, especially in contexts of low network speed and high relative cost of mobile data.

2.4. Connection Quality and High-Demand Educational Outcomes

Recent empirical evidence suggests that not all connectivity produces equivalent effects. Hjort and Poulsen (2019) documented that the arrival of high-speed internet through submarine cables in Africa had substantial effects on employment and productivity, effects that depended specifically on connection speed and stability, attributes associated with fixed broadband more than with mobile connectivity. This finding is relevant to higher education, an outcome that demands more sustained, stable, and data-intensive use than other forms of digital participation, and that could therefore depend disproportionately on fixed broadband infrastructure.

2.5. Internal Inequality and the Translation of Connectivity into Educational Outcomes

The digital divide literature has noted that income inequality within a country can condition whether access to connectivity translates into equitable outcomes, since the aggregate availability of infrastructure does not guarantee that groups with lower economic capacity actually access it or use it for educational purposes (Ragnedda, 2017). This consideration motivates the question of whether income inequality, measured through the Gini index, attenuates the educational return of digital connectivity at an aggregate scale, even though the available evidence on this specific mechanism remains limited.

2.6. Individual-Level Evidence on Broadband and Educational Outcomes

Although the present study operates at the country level, individual-level evidence supports the plausibility of a specific causal relationship between broadband and high-demand educational outcomes. Dettling et al. (2018) showed, using U.S. data, that the availability of high-speed internet in a residential ZIP code predicts better performance on standardized tests and application to a greater number of universities. Sanchis-Guarner et al. (2021) found a similar pattern in the United Kingdom, where increases in household broadband speed were associated with improvements in the academic performance of fourteen-year-old students. Skinner (2019) documented that access to higher-speed broadband predicts greater enrollment in online courses at U.S. open-admission institutions, while Cullinan et al. (2021) showed, for the case of Ireland, that university students residing in areas with poorer quality broadband coverage tend to come from more disadvantaged socioeconomic backgrounds. Taken together, this literature suggests a consistent mechanism across different geographic scales: connection quality, rather than its mere nominal availability, conditions the educational payoff of digital connectivity.

2.7. Tertiary Enrollment as an Indicator of Human Capital

Gross tertiary enrollment, the dependent variable of this study, is itself a classic indicator of human capital accumulation in the tradition of the economics of education (Schultz, 1961; Becker, 1964). By examining its technological determinants, this study is situated within a broader line of research that understands digital infrastructure not as an end in itself, but as an input for the formation of human capital at the national scale, in line with the argument put forward by Warschauer (2002), who argued early on that the digital divide should be reconceptualized in terms of the physical, digital, human, and social resources needed for effective use of technology, and not solely in terms of access to equipment or connections.

3. Method

3.1. Design and Data Sources

A quantitative, non-experimental, cross-sectional design was used, based on the World Development Indicators (WDI) of the World Bank, from which the three digital connectivity indicators, tertiary enrollment, GDP per capita, government effectiveness, and the Gini index were extracted. The integration of these sources into a single country-level panel allows the association between digital connectivity and higher education to be examined with virtually universal geographic coverage.

3.2. Variables

The dependent variable was the gross tertiary education enrollment rate. The main independent variables were three digital connectivity indicators: the percentage of internet users, the number of fixed broadband subscriptions per 100 inhabitants, and the number of mobile telephony subscriptions per 100 inhabitants. As control covariates, the natural logarithm of GDP per capita (PPP, constant 2021 international dollars) and the government effectiveness estimate were included. The country's income group (World Bank) was used as a grouping factor and as an interaction term, and the Gini index was included as a moderator in a specific model.

3.3. Analytic Sample

The main analytic sample, after listwise deletion of cases with missing values on any of the additive model's variables, consisted of 163 countries (low income n = 15; lower-middle income n = 39; upper-middle income n = 45; high income n = 64). For the inequality moderation model, the more limited availability of the Gini index reduced the sample to 132 countries, a figure that is transparently reported as a coverage limitation specific to that variable.

3.4. Analysis Plan

The analysis was carried out in four stages. First, descriptive statistics were generated for all variables by income group and by geographic region. Second, the non-parametric Kruskal-Wallis test was applied to contrast differences in tertiary enrollment across income groups, accompanied by the epsilon-squared effect size. Third, a linear regression model with heteroscedasticity-robust standard errors (HC3) was estimated, including the three connectivity indicators simultaneously along with the control covariates, followed by a model with the mobile telephony by income group interaction term, using the high-income category as the reference, to test the leapfrogging hypothesis. Fourth, an additional model was estimated with the interaction term between internet users and the Gini index, both centered on their mean, to assess the moderating role of inequality. All analyses were run in Python (pandas, statsmodels, scipy).

3.5. Assumption Checks and Multicollinearity Diagnostics

The Shapiro-Wilk test applied to the residuals of the additive model indicated a significant deviation from normality ($W = 0.942$, $p < .001$), and Levene's test for homogeneity of variances of tertiary enrollment across income groups was also significant ($F = 5.15$, $p = .002$). Both results justify the use of the non-parametric Kruskal-Wallis test for the descriptive between-group contrast and of heteroscedasticity-robust standard errors (HC3) in the regression models. Variance inflation factors (VIF) for the additive model were all below the conventional threshold of 10 (internet users = 3.81; fixed broadband = 3.24; mobile telephony = 1.21; log GDP per capita = 6.91; government effectiveness = 2.93), although the value for log GDP per capita indicates moderate collinearity with the other predictors, consistent with the strong bivariate association between economic development and digital infrastructure reported in the literature.

4. Results

4.1. Descriptive Analysis by Income Group and Region

Table 1 presents the descriptive statistics by income group. A monotonic gradient is observed across the four indicators as income level increases, although of very different magnitude depending on the indicator: while mobile telephony rises from 78.7 subscriptions per 100 inhabitants in low-income countries to 138.3 in high-income countries, a ratio of less than two to one, fixed broadband rises from just 0.8 to 33.9 subscriptions per 100 inhabitants, a ratio of more than forty to one. This pattern anticipates that fixed broadband, rather than mobile telephony, concentrates most of the global inequality in connectivity infrastructure.

Table 1. Descriptive statistics by income group (N = 163)

Income group	n	Tertiary enrollment % M (SD)	Internet % M (SD)	Fixed broadband M (SD)	Mobile M (SD)
Low income	15	10.7 (10.0)	24.6 (11.4)	0.8 (1.7)	78.7 (23.1)
Lower-middle income	39	24.5 (15.3)	61.4 (19.4)	5.3 (6.8)	101.3 (27.0)
Upper-middle income	45	53.0 (24.9)	78.9 (14.9)	18.3 (10.4)	135.2 (75.1)

High income	64	73.2 (28.4)	92.0 (6.4)	33.9 (11.1)	138.3 (37.1)

Figure 1. Gross tertiary enrollment by income group, with error bars of one standard deviation

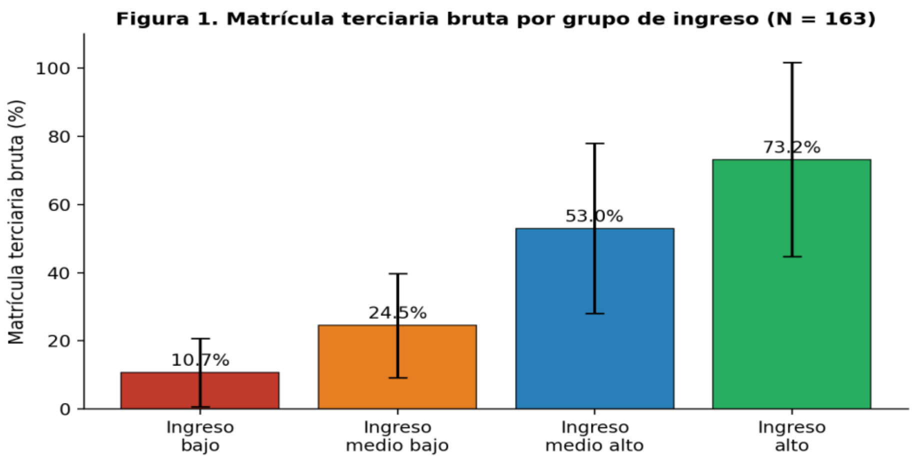


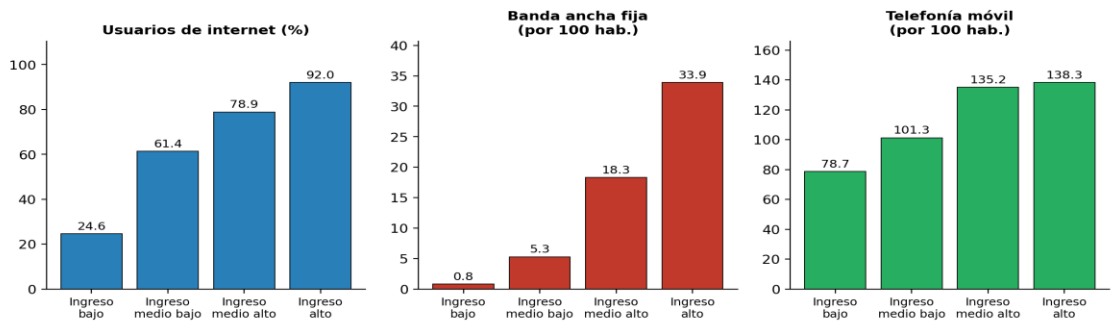
Table 2 disaggregates tertiary enrollment and the three connectivity indicators by geographic region. Europe and Central Asia presents the highest values in tertiary enrollment (M = 73.1%) and in fixed broadband (M = 33.0), while Sub-Saharan Africa presents the lowest values on both dimensions (M = 13.0% and M = 3.3, respectively). It is notable that the regional gap in mobile telephony is considerably smaller than the gap in fixed broadband: the region with the highest mobile penetration (East Asia and Pacific, M = 150.5) does not even triple the region with the lowest penetration (Sub-Saharan Africa, M = 102.7), whereas in broadband the ratio between the leading and lagging regions exceeds tenfold.

Table 2. Descriptive statistics by geographic region (N = 163)

Region	n	Tertiary enrollment % M	Internet % M	Fixed broadband M	Mobile M
Europe and Central Asia	50	73.1	89.0	33.0	126.7
East Asia and Pacific	25	58.4	78.8	17.6	150.5
Latin America and the Caribbean	27	51.5	79.6	20.1	120.0
Middle East and North Africa	19	48.3	81.6	15.2	124.7
North America	3	57.7	95.8	44.2	101.3
South Asia	6	27.0	66.8	8.7	111.3
Sub-Saharan Africa	33	13.0	42.3	3.3	102.7

Figure 2. Internet users, fixed broadband subscriptions, and mobile telephony subscriptions by income group, each on its own scale (N = 163). Note that the ratio between high income and low income is approximately 40-fold for broadband, versus less than twofold for mobile telephony.

Figura 2. Los tres componentes de la conectividad digital por grupo de ingreso



The Kruskal-Wallis test confirmed statistically significant differences in tertiary enrollment across the four income groups, $H(3) = 87.75$, $p < .001$, with a very large effect size ($\varepsilon^2 = .53$), substantially larger than that observed for institutional AI readiness in a previous analysis using this same database, suggesting that tertiary enrollment is even more strongly stratified by income level than institutional technological readiness.

4.2. Additive Model: The Three Components of Connectivity (H1)

The robust regression model (HC3) evaluated the simultaneous effect of the three connectivity indicators on tertiary enrollment, controlling for log GDP per capita and government effectiveness. The model explained a substantial proportion of the variance ($R^2 = .609$, adjusted $R^2 = .597$). All three connectivity indicators were significant: fixed broadband showed the strongest effect ($\beta = 1.09$, $SE = 0.205$, $z = 5.33$, $p < .001$), followed by the percentage of internet users ($\beta = 0.29$, $SE = 0.114$, $z = 2.53$, $p = .011$) and mobile telephony ($\beta = 0.10$, $SE = 0.026$, $z = 3.69$, $p < .001$). Log GDP per capita ($p = .462$) and government effectiveness ($p = .362$) did not reach statistical significance once the three connectivity indicators were included, suggesting that much of their bivariate association with tertiary enrollment operates indirectly, through digital infrastructure.

These results support Hypothesis 1, though with an important nuance: not all connectivity carries the same weight. Fixed broadband, despite having the lowest and most unequal coverage among the three indicators, as shown in Table 1, was the predictor with the highest coefficient, which is consistent with the idea that connection quality and stability matter more than mere nominal availability for a high-demand educational outcome such as tertiary enrollment (Hjort & Poulsen, 2019).

4.3. Heterogeneity by Income Group: Testing the Leapfrogging Hypothesis (H2)

The interaction model incorporated the mobile telephony by income group term, using the high-income category as the reference, while retaining the other connectivity indicators and control covariates ($R^2 = .623$). The slope of mobile telephony in the reference group was 0.198 ($p = .012$). The interaction was significant only for the contrast with the low-income group ($\beta = -0.28$, $SE = 0.115$, $z = -2.42$, $p = .015$), implying a marginal slope close to zero, and even slightly negative ($0.198 - 0.280 \approx -0.08$), for that group. The interactions with the lower-middle income ($\beta = -0.14$, $p = .209$) and upper-middle income ($\beta = -0.14$, $p = .388$) groups did not reach statistical significance.

This result directly contradicts the leapfrogging hypothesis as originally formulated: rather than a larger return of mobile telephony in lower-income countries, the data show the opposite pattern, a smaller return, statistically indistinguishable from zero, precisely in the low-income group. This finding is consistent with the idea that the mere availability of a mobile phone does not guarantee the type of sustained, stable, and high-volume data connection that enrollment in higher education appears to require, and suggests that mobile connectivity alone does not compensate for the absence of fixed broadband in lower-development contexts.

4.4. Income Inequality as a Moderator of Connectivity (H3)

The moderation model, estimated on a subsample of 132 countries with available Gini index data, incorporated the interaction term between the percentage of internet users and the Gini index, both centered on their mean, along with the other connectivity indicators and control covariates ($R^2 = .664$). The main effect of internet remained significant ($\beta = 0.30$, $p = .030$), but the interaction between internet and inequality did not reach statistical significance ($\beta = 0.017$, $SE = 0.011$, $z = 1.55$, $p = .120$). It is worth noting that the bivariate correlation between the percentage of internet users and the Gini index was negative and of moderate magnitude (rho = -.41), indicating that countries with greater internet penetration tend, on average, to present lower income inequality, although this descriptive association did not translate into a statistically significant moderating effect on tertiary enrollment.

These results do not support Hypothesis 3: income inequality, measured at the aggregate level through the Gini index, does not detectably moderate the relationship between digital connectivity and tertiary enrollment in this sample. This null finding is itself informative: it suggests that, at least at the macro scale of this analysis, the educational effect of digital connectivity operates in a relatively uniform manner across different levels of internal inequality, although this does not rule out that such moderation may exist at the individual or subnational level, a scale that these country-level data do not allow us to examine.

5. Discussion

5.1. Fixed Broadband, Not Connectivity in the Abstract, Drives Tertiary Enrollment

The most robust finding of this study is that, of the three components of digital connectivity examined, fixed broadband shows the strongest association with tertiary enrollment, despite being the indicator with the lowest and most unequal coverage across countries. This suggests that treating digital connectivity as a homogeneous block, as is often done in much of the digital divide literature applied to education, conceals substantive differences among its components. Higher education appears to depend disproportionately on connection quality and stability, attributes that mobile telephony, despite its near-universal coverage, does not always guarantee (Hjort & Poulsen, 2019). This pattern is consistent with individual-level evidence in high-income economies: Dettling et al. (2018) showed that the availability of high-speed internet in a residential ZIP code predicts better performance on standardized tests and a higher likelihood of applying to more universities in the United States, while Sanchis-Guarner et al. (2021) documented that increases in household broadband speed raise the academic performance of students in the United Kingdom. Along the same lines, Skinner (2019) found that access to higher-speed broadband predicts greater enrollment in online courses at U.S. open-admission institutions. The convergence between these individual-level findings and the aggregate country-level pattern reported here reinforces the plausibility that fixed broadband is the causally most relevant component, and not merely a spurious correlation of general economic development.

This reading is also consistent with the World Bank's (2016) call for "analog complements" in its World Development Report on digital dividends, which warned early on that the mere expansion of internet access does not guarantee development benefits unless accompanied by investment in skills, institutions, and regulation. The gap between broadband and mobile telephony documented in Figure 2 of this study can be read as a concrete manifestation of that warning: the near-universal availability of mobile telephony has not, by itself, been sufficient to close the gap in tertiary enrollment between countries.

5.2. Leapfrogging Is Not Confirmed for Higher Education

The second central finding importantly qualifies the leapfrogging hypothesis (Donner, 2015). While this hypothesis has found support in other domains, such as financial inclusion or access to basic information, the results of this study show that, for a high-demand educational outcome such as tertiary enrollment, mobile telephony does not compensate for the absence of fixed broadband in lower-income countries. The return of mobile connectivity on tertiary enrollment is, in fact, smaller and statistically indistinguishable from zero precisely in the group where the leapfrogging hypothesis would anticipate its greatest relevance. This suggests that leapfrogging may be an effective strategy for certain low-data-demand digital outcomes, but insufficient on its own to sustain more complex educational trajectories.

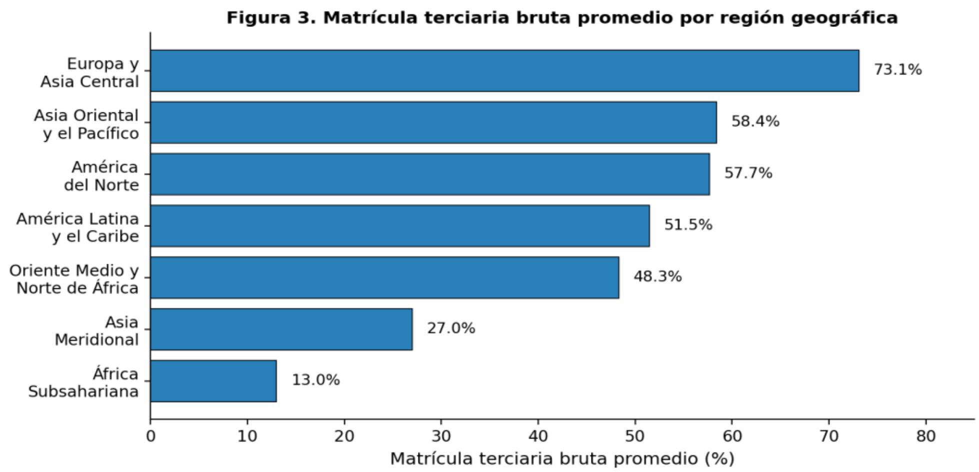
5.3. Internal Inequality: An Absent Moderator at the Aggregate Scale

The null finding regarding income inequality as a moderator deserves a careful reading. The absence of a significant moderating effect at the country level does not imply that inequality is irrelevant to unequal access to connectivity and higher education within a country; rather, it implies that such dynamics likely operate at a different, individual or subnational, scale of analysis, one that the country-level aggregate data used in this study do not allow us to capture. The negative correlation between internet penetration and inequality, although descriptive and not causal, is consistent with the idea that the expansion of connectivity has historically accompanied, rather than counteracted, the trajectories of inequality reduction in many countries.

5.4. Implications for Public Policy

Figure 3 illustrates the magnitude of the task ahead: the gap between Sub-Saharan Africa (13.0%) and Europe and Central Asia (73.1%) is more than fivefold, a regional disparity that, according to the findings of this study, is more likely to close by investing in fixed broadband than by expanding mobile coverage alone. These findings carry a direct public policy implication: strategies aimed at expanding access to higher education through digital connectivity should prioritize investment in fixed broadband over the sole expansion of mobile coverage, especially in lower-income countries, where the broadband gap is more than forty times greater between the low-income and high-income groups, compared with a gap of less than twofold in mobile telephony. School and university connectivity programs that rely exclusively on mobile networks may be overestimating their capacity to sustain higher education trajectories, which demand more intensive and sustained data use than other forms of digital participation.

Figure 3. Gross tertiary enrollment by geographic region, ordered from highest to lowest



6. Limitations

This study presents limitations that should condition the interpretation of its findings. First, the cross-sectional design precludes establishing causality; it is plausible that countries with higher tertiary enrollment in turn invest more in broadband infrastructure, in a bidirectional or even reverse causal relationship to the one proposed. Second, gross tertiary education enrollment does not distinguish between in-person and distance modalities, so it is not possible to determine whether the association with connectivity reflects an effect on access to higher education in general or specifically on its online modality. Third, the more limited availability of the Gini index reduced the moderation model's sample to 132 countries, which may have introduced a bias toward countries with higher-capacity national statistical systems. Fourth, the three connectivity indicators show moderate collinearity with each other and with log GDP per capita, as indicated by the VIF diagnostics, which warrants additional caution in interpreting the exact magnitude of each individual coefficient beyond its joint statistical significance. Finally, since the unit of analysis is the country, the findings should not be extrapolated to educational institutions, specific programs, or individuals, in order to avoid an ecological fallacy.

7. Conclusion and Implications

This study shows that digital connectivity predicts enrollment in higher education at a global scale, but that its three components are not interchangeable: fixed broadband, despite its lower and more unequal coverage, is the most robust predictor, ahead of mobile telephony and the overall percentage of internet users. Contrary to the leapfrogging hypothesis, mobile connectivity does not compensate for the absence of fixed broadband in lower-income countries, where its educational return is diluted. Income inequality, for its part, does not detectably moderate this relationship at the aggregate scale. For the formulation of public policy in higher education, these results suggest that educational connectivity strategies should prioritize investment in fixed broadband infrastructure, particularly in lower-income countries, where the gap in this specific indicator is substantially larger than in mobile telephony. Future research should distinguish between in-person and distance modalities of tertiary enrollment, incorporate measures of connection speed and quality beyond mere subscription counts, and explore, through longitudinal designs, whether the recent expansion of broadband in middle-income countries has begun to translate into greater tertiary enrollment in more recent years.

References

1. Becker, G. S. (1964). Human capital: A theoretical and empirical analysis, with special reference to education. University of Chicago Press.
2. Boeri, F. (2026). High-speed broadband and educational achievements. Journal of Regional Science, 66(2), 445–483. https://doi.org/10.1111/jors.70030
3. Briglauer, W., Krämer, J., & Palan, N. (2024). Socioeconomic benefits of high-speed broadband availability and service adoption: A survey. Telecommunications Policy, 48(7), Article 102808. https://doi.org/10.1016/j.telpol.2024.102808
4. Cullinan, J., Flannery, D., Harold, J., Lyons, S., & Palcic, D. (2021). The disconnected: COVID-19 and disparities in access to quality broadband for higher education students. International Journal of Educational Technology in Higher Education, 18, Article 26. https://doi.org/10.1186/s41239-021-00262-1
5. Dettling, L. J., Goodman, S., & Smith, J. (2018). Every little bit counts: The impact of high-speed internet on the transition to college. Review of Economics and Statistics, 100(2), 260–273. https://doi.org/10.1162/REST_a_00712
6. Donner, J. (2015). After access: Inclusion, development, and a more mobile Internet. MIT Press.
7. García-Umaña, A., Perez, E., Estela, L. (2026). Artificial Intelligence Literacy in Higher Education: Cross-CulturalValidation and Extended Structural Model of the AILS Scale. International Journal of Drug Delivery Technology, 16 (66), 127-132.
8. GSMA. (2024). The state of mobile internet connectivity 2024. GSMA.
9. Harahap, V., Kamp, L. M., & Ubacht, J. (2024). A decision support scheme for solving the mobile coverage gap in rural areas in developing countries: Demonstrated with a case in Indonesia. Technological Forecasting and Social Change, 207, Article 123600. https://doi.org/10.1016/j.techfore.2024.123600
10. Hjort, J., & Poulsen, J. (2019). The arrival of fast internet and employment in Africa. American Economic Review, 109(3), 1032–1079. https://doi.org/10.1257/aer.20161385
11. International Telecommunication Union. (2025). Global connectivity report 2025. https://www.itu.int/itu-d/reports/statistics/2025/11/17/gcr-2025-chapter-2/
12. Mack, E. A., Helderop, E., Ma, K., Grubesic, T. H., Mann, J., Loveridge, S., & Maciejewski, R. (2021). A broadband integrated time series (BITS) for longitudinal analyses of the digital divide. PLOS ONE, 16(5), Article e0250732. https://doi.org/10.1371/journal.pone.0250732
13. Ponnusamy, S., & Trinh, T.-A. (2025). The impact of mobile internet on student cognitive performance during COVID: Evidence from Pakistan. Economics of Education Review, 106, Article 102732.
14. Ragnedda, M. (2017). The third digital divide: A Weberian approach to digital inequalities. Routledge. https://doi.org/10.4324/9781315606002
15. Rogers, E. M. (2003). Diffusion of innovations (5th ed.). Free Press.
16. Sanchis-Guarner, R., Montalbán, J., & Weinhardt, F. (2021). Home broadband and human capital formation (CESifo Working Paper No. 8846). CESifo.
17. Schultz, T. W. (1961). Investment in human capital. American Economic Review, 51(1), 1–17.
18. Skinner, B. T. (2019). Making the connection: Broadband access and online course enrollment at public open admissions institutions. Research in Higher Education, 60(7), 960–999. https://doi.org/10.1007/s11162-018-9539-6
19. Van Deursen, A. J. A. M., & Helsper, E. J. (2015). The third-level digital divide: Who benefits most from being online? En L. Robinson, S. R. Cotton, J. Schulz, T. M. Hale, & A. Williams (Eds.), Communication and information technologies annual (pp. 29–52). Emerald Group Publishing. https://doi.org/10.1108/S2050-206020150000010002
20. Warschauer, M. (2002). Reconceptualizing the digital divide. First Monday, 7(7). https://doi.org/10.5210/fm.v7i7.967
21. World Bank. (2016). World development report 2016: Digital dividends. World Bank. https://doi.org/10.1596/978-1-4648-0671-1
22. World Bank. (2025). World Development Indicators. https://databank.worldbank.org/source/world-development-indicators
23. Yaacoub, E., & Alouini, M.-S. (2020). A key 6G challenge and opportunity: Connecting the base of the pyramid, a survey on rural connectivity. Proceedings of the IEEE, 108(4), 533–582. https://doi.org/10.1109/JPROC.2020.2976703