DOI: 10.52131/pjhss.2024.v12i4.2476

Pakistan Journal of Humanities and Social Sciences

Volume 12, Number 04, 2024, Pages 3474-3484
Journal Homepage:
https://journals.internationalrasd.org/index.php/pjhss

Bridging the Digital Divide or Widening the Gap? Internet Penetration and Economic Growth in 85 Developing Countries

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ARTICLE INFO

Article History:
Received: November 02, 2024
Revised: December 27, 2024
Accepted: December 28, 2024
Available Online: December 30, 2024

Keywords:
Internet Penetration
Economic Growth
Digital Divide
CS-ARDL
Developing Countries

Funding:
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

This study investigates the complex relationship between internet penetration and economic growth in 85 developing countries from 2001 to 2023. Utilizing annual data from the World Bank's World Development Indicators and employing the Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) methodology, the analysis uncovers that, contrary to widespread optimism, internet penetration is significantly and negatively associated with economic growth in both the short and long run. The results challenge the prevailing assumption that digital expansion alone fosters development, highlighting the importance of complementary investments in human capital, institutional quality, and macroeconomic stability. Robust positive effects of capital formation and trade openness underscore the need for an integrated development approach. The findings suggest that policymakers must go beyond digital infrastructure and address broader economic and social enablers to realize the full potential of digital transformation in developing economies.

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1. Introduction

Economic growth is the cornerstone of national development, underpinning improvements in living standards, poverty reduction, and overall social welfare (Barro, 1996; Robinson & Acemoglu, 2012). Over the past several decades, technological change—particularly the rise of digital technologies—has transformed the global economic landscape. Among these innovations, the proliferation of the internet stands out as a key driver of economic modernization and competitiveness (Goldfarb & Tucker, 2024; Qiang, Rossotto, & Kimura, 2009; World Bank, 2021). Internet connectivity has redefined how individuals, businesses, and governments interact, unleashing new opportunities for communication, commerce, knowledge exchange, and service delivery (Choi & Hoon Yi, 2009; Koutroumpis, 2009). The role of the internet as a general-purpose technology is well-documented in economic theory. According to Solow (1957) growth model, technological progress is a primary determinant of long-term economic growth, while Romer (1990) endogenous growth theory highlights the importance of innovation and knowledge accumulation. In this context, the internet facilitates access to global markets, reduces transaction costs, increases efficiency, and encourages the diffusion of ideas (Czernich et al., 2011; Katz & Callorda, 2018). Recent empirical work has shown that digital technologies such as the internet can accelerate GDP growth, improve productivity, and foster entrepreneurship, especially in countries that successfully leverage digital infrastructure for development (Myovella, Karacuka, & Haucap, 2020; Niebel, 2018). However, the benefits of internet penetration for economic growth are not uniform across countries and regions. In high-income economies, increased internet use is

consistently associated with higher growth rates and productivity gains (Czernich et al., 2011; Katz & Callorda, 2018; Vu, 2011). In contrast, evidence from developing economies is mixed and often inconclusive (Asongu & Nwachukwu, 2017; Niebel, 2018). While internet access has expanded rapidly in many low- and middle-income countries, digital divides remain substantial, reflecting disparities in infrastructure, affordability, skills, and institutional quality (Bada & Madon, 2006; ITU, 2022; World Bank, 2021).

For instance, South Asia saw internet usage rise from less than 10% in 2005 to over 50% by 2022 (ITU, 2022), yet this growth has not always translated into comparable improvements in GDP per capita or productivity (Majeed & Ayub, 2018; Yoshino, Rasoulinezhad, & Taghizadeh-Hesary, 2021). This paradox underscores that the economic impact of the internet is mediated by a range of contextual factors, including the quality of physical infrastructure, regulatory frameworks, educational attainment, and macroeconomic stability (Bhujabal & Sethi, 2019; Kumar & Chadha, 2002; Sinha & Sengupta, 2019). Some studies argue that the effectiveness of internet penetration depends on complementary investments in human capital and institutional capacity. For example, Nursjanti and Amaliawiati (2020) show that the growth effects of internet usage in Indonesia are magnified when coupled with improvements in education. Similarly, Li (2019) finds that digitalization promotes productivity and trade in Belt and Road countries, but only when supported by strong governance and investment in skills. Myovella, Karacuka and Haucap (2020) demonstrate that internet access alone is insufficient for sustained economic growth in Africa and Asia; instead, positive effects arise when digital infrastructure is matched with human capital development and sound macroeconomic policies. The mixed evidence from developing countries may also reflect inflationary pressures, labor market constraints, and the challenges of integrating new technologies into existing economic structures (Tripathi & Inani, 2016; Ximei, Zhu, & Kim, 2022). Inflation can reduce purchasing power and deter investment in information and communication technologies (ICT), while weak labor force participation or limited skills can constrain the diffusion of digital benefits (Farida, Haryanto, & Satrio, 2021; Yin & Choi, 2021). In addition, differences in trade openness and investment rates can influence the extent to which countries benefit from the global digital economy (Freund & Weinhold, 2004; Soper et al., 2012).

Despite growing literature, significant research gaps remain. Much of the existing empirical work focuses on single-country cases, regional groupings, or high-income settings (Asongu & Nwachukwu, 2017; Salahuddin & Gow, 2016), with limited attention given to large, diverse panels of developing countries. Moreover, few studies employ advanced econometric techniques that address endogeneity, cross-sectional dependence, and heterogeneous data structures (Chudik & Pesaran, 2015; Samargandi, Fidrmuc, & Ghosh, 2015). This study addresses these gaps by analyzing a balanced panel of 85 developing countries from 2001 to 2023, utilizing the Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) model to provide robust estimates of both short- and long-run relationships. By controlling for gross fixed capital formation, labor force participation, inflation, and trade openness, this research offers new insights into how digital connectivity interacts with macroeconomic fundamentals in the context of the developing world. The remainder of this paper is organized as follows: Section 2 presents a comprehensive literature review; Section 3 details the methodology; Section 4 discusses empirical results; and Section 5 concludes with policy implications for leveraging internet penetration to drive sustainable growth in developing countries.

2. Literature Review

The relationship between technological innovation and economic growth is a longstanding theme in economic theory and empirical research. The emergence of the internet as a general-purpose technology has intensified scholarly debate on the extent to which digital connectivity translates into measurable gains in output and productivity, particularly in developing countries (Bresnahan & Trajtenberg, 1995; Jorgenson & Vu, 2016).

2.1. Internet Penetration and Growth: Global and Developing Country Evidence

A seminal study by Qiang, Rossotto and Kimura (2009) demonstrated that a 10% increase in broadband penetration could raise GDP growth by 1.38% in developing economies, a finding echoed in studies across both high-income and middle-income settings (Czernich et al., 2011; Katz & Koutroumpis, 2013). Koutroumpis (2009) identified strong network

externalities in the European Union, showing that internet benefits intensify as penetration grows. Similarly, Choi and Hoon Yi (2009) found a positive relationship between internet use and economic growth in a global sample, attributing this to lower information costs and higher market efficiency. Research focusing on developing countries has yielded mixed results. Myovella, Karacuka and Haucap (2020) analyzed Sub-Saharan Africa and Asia, finding that internet access can enhance growth only when accompanied by investments in human capital and supportive policy environments. Majeed and Ayub (2018) concluded that digitalization promotes economic growth in South Asia, but the impact is contingent on macroeconomic stability and institutional quality. In contrast, Niebel (2018) found that, after addressing endogeneity and measurement error, ICT effects on GDP growth in developing economies are insignificant, suggesting that technology alone does not guarantee growth. Other country-specific evidence supports the conditional nature of internet's growth impact. For instance, Yin and Choi (2021) reported that internet usage spurred GDP growth in Asian countries, primarily through greater transparency and improved labor market outcomes. Nursjanti and Amaliawiati (2020) showed that higher internet penetration in Indonesia led to increased GDP per capita, but only in conjunction with improvements in education. Similarly, Li (2019) found that digitalization increased productivity and trade competitiveness in Belt and Road countries, conditional on strong governance.

2.2. Macroeconomic and Institutional Moderators

The effectiveness of internet penetration is widely viewed as conditional upon a range of complementary factors. Katz and Callorda (2018) and Aker and Mbiti (2010) found that digital skills and education magnify the growth benefits of internet access in Latin America and Africa, respectively. Farida, Haryanto and Satrio (2021) emphasized that government investment in education enhances the impact of digital adoption. Sinha and Sengupta (2019) demonstrated that the growth impact of ICT in Asia-Pacific is amplified when paired with FDI inflows and physical capital investment. Inflation and macroeconomic volatility also play a mediating role. Ximei, Zhu and Kim (2022) observed that high inflation diminishes the positive effects of digital infrastructure in South Asia, a finding supported by Tripathi and Inani (2016) in their study of India's digital economy. Saba, David and Voto (2024) found that strong institutions and governance are crucial for translating digital investments into growth, particularly in lower-income countries. Asongu and Nwachukwu (2017) and Salahuddin and Gow (2016) reported that regulatory quality, policy coherence, and anti-corruption measures can strengthen the digitalization-growth nexus. Trade openness and integration into the global economy are additional facilitators. Freund and Weinhold (2004) showed that internet diffusion increased bilateral trade among developing nations, while Soper et al. (2012) highlighted how digital connectivity reduces trade costs and enhances export competitiveness. Mulenga and Mayondi (2022) found that digital platforms are essential for export-led growth in emerging economies.

2.3. Sectoral Perspectives and Labor Market Considerations

Sector-specific analyses further underscore the complexity of digitalization's economic impact. Aghion, Bergeaud and Van Reenen (2023) reported that digital technologies enhance productivity more effectively in manufacturing than in services, especially where complementary skills are present. Katz and Koutroumpis (2013) found that digitalization promotes job creation and value-added growth when matched by labor force readiness. Conversely, Bada and Madon (2006) cautioned that, in the absence of inclusive digital policies, internet expansion can exacerbate inequalities and leave marginalized groups behind. Labor market dynamics are particularly salient in developing contexts. Nursjanti and Amaliawiati (2020) and Yin and Choi (2021) highlighted the importance of workforce skills in realizing the full economic potential of the internet. Myovella, Karacuka and Haucap (2020) argued that digitalization's benefits depend on targeted investments in vocational education, while Das, Khan and Chowdhury (2016) found that rising labor force participation enhances the productivity gains of ICT adoption in India.

2.4. Mixed and Null Findings

While much of the literature is optimistic, some studies caution against overestimating digitalization's growth impact. Bhujabal and Sethi (2019) noted that diverse socioeconomic structures in South Asia complicate region-wide generalizations about internet-growth linkages. Kumar and Chadha (2002) observed that uneven internet adoption in South Asia limits its transformative potential. (Niebel, 2018) and Salemink, Strijker and Bosworth (2017) found that

without adequate infrastructure and policy support, digital technologies alone may not lead to growth and could even disrupt existing sectors. Chavula (2013) argued that ICT has a more pronounced effect on growth in middle-income African countries than in low-income ones, due to differences in absorptive capacity. Aker and Mbiti (2010) found that mobile technology had a limited impact on aggregate economic growth in Africa, with effects concentrated in specific sectors.

2.5. Methodological Advances, Remaining Gaps, and Study's Contribution

Methodological challenges such as endogeneity, omitted variable bias, and cross-sectional dependence have led scholars to advocate for advanced estimation techniques in digitalization research. Chudik and Pesaran (2015) introduced the CS-ARDL model as a robust approach for panels characterized by cross-sectional dependence and mixed orders of integration. Samargandi, Fidrmuc and Ghosh (2015) highlighted the importance of accounting for heterogeneity in panel data studies of growth. Despite these advances, large-scale empirical studies that combine long time horizons, wide country coverage, and advanced econometric techniques remain rare (Myovella, Karacuka, & Haucap, 2020). The interaction between internet penetration and macroeconomic variables such as capital formation, labor force participation, inflation, and trade remain underexplored, particularly in the context of developing countries. This paper addresses these gaps in three key ways. First, it analyzes a large and diverse panel of 85 developing countries over a 23-year period, providing broader generalizability than most previous studies. Second, it employs the CS-ARDL estimator to account for endogeneity, heterogeneous slopes, and cross-sectional dependence, ensuring robust estimation of both short- and long-run relationships (Chudik & Pesaran, 2015; Pesaran, 2007). Third, it integrates multiple macroeconomic control variables i.e. gross fixed capital formation, labor force participation, inflation, and trade openness—offering a nuanced perspective on how digitalization interacts with economic fundamentals in the developing world. By addressing these gaps, the present study advances the literature on digitalization and growth, informing policy on the conditions under which internet expansion can serve as a catalyst for sustainable development.

3. Methodology

This study employs a panel data approach to explore the relationship between internet penetration and economic growth across 85 developing countries from 2001 to 2023. The data, extracted from the World Bank's World Development Indicators (WDI), include key macroeconomic variables essential for assessing digital and economic development.

3.1. Data and Variables

The dependent variable in this study is the annual percentage growth rate of Gross Domestic Product (GDP), which serves as the key indicator of economic performance. The core explanatory variable is internet penetration (INT), measured as the percentage of individuals using the internet. This variable is widely used as a proxy for technological adoption and digital connectivity in the literature (Işık et al., 2024; Myovella, Karacuka, & Haucap, 2020; Qiang, Rossotto, & Kimura, 2009). To control for additional factors that may influence economic growth, the model incorporates several macroeconomic variables frequently cited in growth studies. Gross fixed capital formation (GFCF, as a percentage of GDP) is included to account for investment in physical assets, a crucial driver of both digital and traditional economic activities (Samargandi, Fidrmuc, & Ghosh, 2015). The labor force participation rate (LFPR, as a percentage of the population aged 15 and above) reflects the active segment of the labor market and is important for moderating the effects of technological change (Nursjanti & Amaliawiati, 2020). Inflation (INF, measured as annual percentage change in consumer prices) is also added, as high inflation can erode purchasing power and deter investments in ICT (Ximei, Zhu, & Kim, 2022). Finally, trade openness (TRADE, as a percentage of GDP) is included to capture the role of international integration, which can amplify the growth effects of digital technologies through market access and competition (Freund & Weinhold, 2004). A brief description of all variables and their data sources is provided in Table 1. GDP is measured as the annual percentage growth rate; INT as the percentage of the population using the internet; GFCF and TRADE as shares of GDP; LFPR as the proportion of the population aged 15 and above participating in the labor force; and INF as the annual percentage change in consumer prices. All variables are obtained directly from the World Bank WDI database to ensure comparability and reliability.

Table 1: Variable Description and Data Source

Variable	Description	Measurement	Data Source
GDP	GDP growth rate (annual %)	Annual %	(World Bank, 2023)
INT	Internet users (% of population)	% of population	(World Bank, 2023)
GFCF	Gross Fixed Capital Formation	% of GDP	(World Bank, 2023)
LFPR	Labor Force Participation Rate	% of population aged 15+	(World Bank, 2023)
INF	Inflation, consumer prices	Annual %	(World Bank, 2023)
TRADE	Trade openness	% of GDP	(World Bank, 2023)

3.2. Model Specification

The functional form of the model is:

$$GDP_{it} = f(INT_{it}, GFCF_{it}, LFPR_{it}, INF_{it}, TRADE_{it})$$

where *i* indexes countries and *t* indexes time.

To capture both short-run dynamics and long-run equilibrium relationships, the empirical strategy employs the Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) model. The CS-ARDL approach is particularly suited for macroeconomic panel data because it accommodates variables with mixed orders of integration—either stationary at level (I(0)) or at first difference (I(1))—and explicitly addresses cross-sectional dependence, a common feature in multi-country analyses (Chudik & Pesaran, 2015; Pesaran, 2007). This model also allows for heterogeneity in slope coefficients, providing flexibility in capturing country-specific dynamics while estimating average effects across the panel. The econometric form of the model is:

$$\Delta GDP_{\{it\}} = \alpha_i + \lambda_i ECT_{it-1} + \sum_{k=0}^{p} \beta_{1ik} \Delta INT_{it-k} + \sum_{k=0}^{p} \beta_{2ik} \Delta GFCF_{it-k} + \sum_{k=0}^{p} \beta_{3ik} \Delta LFPR_{it-k} + \sum_{k=0}^{p} \beta_{4ik} \Delta INF_{it-k} + \sum_{k=0}^{p} \beta_{5ik} \Delta TRADE_{it-k} + \varepsilon_{it}$$

where Δ is the first-difference operator, α_i are country-specific fixed effects, λ_i is the error correction speed of adjustment, and ε_{it} is the disturbance term.

3.3. Estimation Procedure

Prior to estimation, panel unit root tests were conducted to determine the stationarity properties of each variable. Both the Maddala and Wu (1999) test and the cross-sectionally augmented IPS (CIPS) test (Pesaran, 2007) were applied, confirming that all series are either I(0) or I(1), with none exhibiting integration of order two. Pesaran (2007) cross-sectional dependence (CD) test revealed significant interdependence among countries, which further validates the choice of the CS-ARDL model, as it is explicitly designed to address such dependencies in panel data. All estimations were carried out using Stata 17, which provides robust routines for CS-ARDL, unit root, and cross-sectional dependence diagnostics. By implementing this comprehensive methodology, the study provides reliable and nuanced estimates of the relationship between internet penetration and economic growth in developing countries, addressing key methodological limitations identified in prior research (Chudik & Pesaran, 2015; Samargandi, Fidrmuc, & Ghosh, 2015).

4. Results and Discussion

This section presents the empirical findings from the panel data analysis of 85 developing countries over the period 2001–2023. The results are structured in line with the econometric sequence: descriptive statistics, preliminary correlations, panel unit root and dependency diagnostics, and finally the core CS-ARDL short-run and long-run estimates. Each subsection interprets findings with reference to the existing literature and the research objectives outlined previously.

Table 2: Summary Statistics

Variable	Obs	Mean	Std.	Min	Max
GDP	1955	2.056	6.663	-58.850	150.432
INT	1955	24.919	25.130	0.000	97.693
GFCF	1932	22.704	11.183	0.378	177.990
LFPR	1955	60.971	10.824	31.724	86.694
INF	1909	6.815	18.986	-110.391	557.202
TRADE	1955	71.927	32.581	0.147	210.374

The summary statistics in Table 2 indicate substantial heterogeneity in both the outcome and explanatory variables across the panel. The mean annual GDP growth rate for these developing economies is approximately 2.06%, but the large standard deviation and the extreme minimum and maximum values highlight the volatility and diversity in economic performance over the study period. Internet penetration (INT) averages 24.9%, but ranges from 0% (indicative of very low digital connectivity in some cases) to nearly full penetration at 97.7%. This reflects a stark digital divide among developing countries, consistent with previous observations (ITU, 2022; World Bank, 2021). The other variables—GFCF, LFPR, INF, and TRADE—similarly exhibit broad dispersion, reflecting diverse structural characteristics, labor markets, macroeconomic stability, and openness to trade. The high standard deviation in inflation (INF), with a minimum of -110.39% and a maximum exceeding 550%, illustrates that some economies faced periods of hyperinflation or deflation, which could have profound impacts on growth and the effectiveness of digital technologies (Samargandi, Fidrmuc, & Ghosh, 2015; Ximei, Zhu, & Kim, 2022).

Table 3: Correlation Matrix

Variables	GDP	INT	GFCF	LFPR	INF	TRADE
GDP	1					
INT	-0.041	1				
GFCF	0.149	0.012	1			
LFPR	0.013	-0.141	-0.016	1		
INF	-0.048	0.031	-0.047	0.023	1	
TRADE	0.109	0.069	0.208	0.014	-0.004	1

The correlation matrix reveals a weak, negative bivariate relationship between internet penetration and GDP growth (r = -0.041), suggesting that the unconditional association between these variables is small and negative. This finding diverges from the generally positive correlation reported in developed and some emerging economies (Czernich et al., 2011; Katz & Koutroumpis, 2013) but aligns with recent work highlighting the complexity and possible negative short-run consequences of digitalization in less prepared environments (Myovella, Karacuka, & Haucap, 2020; Niebel, 2018). Trade openness (TRADE) and gross fixed capital formation (GFCF) show moderate positive correlations with GDP, consistent with classic growth models and the role of investment and openness in fostering economic development (Freund & Weinhold, 2004; Solow, 1957). Labor force participation (LFPR) and inflation (INF) show only marginal associations with GDP growth, underscoring the necessity for multivariate, dynamic panel modeling to disentangle these effects (Samargandi, Fidrmuc, & Ghosh, 2015).

Table 4: Unit Root Test

	Maddala and Wu		CIPS	
Variables	Level	First Difference	Level	First Difference
GDP	0.000		0.000	
INT	1.000	0.000	0.998	0.000
GFCF	0.000		0.001	
LFPR	0.003		1.000	0.005
INF	0.000		0.000	
TRADE	0.000		0.176	0.000

Unit root tests confirm that the series are a mix of I(0) and I(1) processes but not I(2), making them suitable for CS-ARDL estimation (Chudik & Pesaran, 2015; Pesaran, 2007). The results support findings in recent macro panel studies that digital, trade, and macroeconomic variables often exhibit different integration properties (Myovella, Karacuka, & Haucap, 2020; Samargandi, Fidrmuc, & Ghosh, 2015).

Table 5: Cross Sectional Dependency Test

Variables	CD-test	p-value
GDP	67.88	0.000
INT	258.77	0.000
GFCF	17.71	0.000
LFPR	30.84	0.000
INF	58.27	0.000
TRADE	30.32	0.000

The CD-test results indicate highly significant cross-sectional dependence for all variables ($p < 0.01$). This justifies the use of the CS-ARDL estimator, which controls for unobserved common shocks, spillovers, or global factors that simultaneously influence multiple countries—a frequent concern in global digitalization studies (Chudik & Pesaran, 2015).

Table 6: Shor Run Estimates

Variables	Coef.	Std	z	Prob.
c	196.014	54.527	3.590	0.000
L.GDP	-0.360	0.026	-13.840	0.000
INT	-0.081	0.026	-3.060	0.002
GFCF	0.168	0.087	1.940	0.052
LFPR	1.190	0.634	1.880	0.061
INF	-0.071	0.046	-1.560	0.119
TRADE	0.107	0.040	2.690	0.007
ECT	-1.360	0.026	-52.280	0.000

In the short run, internet penetration (INT) has a statistically significant negative impact on economic growth (coef. = -0.081, p = 0.002). This result contrasts with the mainstream expectation of digital dividends but echoes recent studies documenting short-term adjustment costs, digital divides, and productivity disruptions associated with rapid technological diffusion in contexts with low absorptive capacity (Myovella, Karacuka, & Haucap, 2020; Niebel, 2018; Salemink, Strijker, & Bosworth, 2017). Several mechanisms may underlie this negative effect: inefficient allocation of resources, digital exclusion of certain groups, or an initial displacement of labor and traditional sectors without a sufficiently skilled workforce to capitalize on new technologies (Aker & Mbiti, 2010; Bada & Madon, 2006). Trade openness (TRADE) exerts a positive and significant effect (coef. = 0.107, p = 0.007), in line with the literature on export-led growth and the complementary role of global integration in enhancing the benefits of digitalization (Freund & Weinhold, 2004; Soper et al., 2012). Gross fixed capital formation (GFCF) and labor force participation (LFPR) are both positive and weakly significant, suggesting that physical investment and active labor markets moderate the short-run costs or amplify the benefits of technology adoption (Mitra & Okada, 2018; Samargandi, Fidrmuc, & Ghosh, 2015). Inflation (INF) is negative but statistically insignificant, indicating that, at least in the short term, inflation does not exert a direct effect on growth within the model's dynamic structure (Ximei, Zhu, & Kim, 2022). The error correction term (ECT) is large, negative, and highly significant (-1.360, $p < 0.001$), implying strong adjustment toward long-run equilibrium after short-term shocks, as expected in ARDL-type models (Pesaran, 2007).

Table 7: Long Run Estimates

Variables	Coef.	Std	z	Prob.
C	151.295	44.007	3.440	0.001
GFCF	0.138	0.063	2.190	0.029
INF	-0.059	0.036	-1.650	0.098
INT	-0.059	0.021	-2.880	0.004
LFPR	0.857	0.470	1.830	0.068
TRADE	0.076	0.028	2.770	0.006

The long-run results reinforce the short-run findings. Internet penetration remains significantly negative (coef. = -0.059, p = 0.004), suggesting that, in these 85 developing countries, higher digital connectivity does not translate into higher average economic growth, and may even be associated with persistent adjustment costs or structural disruptions (Bhujabal & Sethi, 2019; Chavula, 2013; Niebel, 2018). This negative effect may reflect several realities in developing economies. First, low levels of digital skills, educational attainment, or complementary investments may prevent societies from converting internet access into

productivity or innovation gains (Farida, Haryanto, & Satrio, 2021; Katz & Callorda, 2018). Second, weak institutions, inadequate regulatory frameworks, or digital divides could create uneven opportunities, with potential for rising inequality and exclusion (Adeleye, Arogundade, & Mduduzi, 2023; Asongu & Nwachukwu, 2017). Third, some developing economies may experience technology-induced labor displacement or market disruptions before positive effects materialize, particularly in traditional sectors (Aghion, Bergeaud, & Van Reenen, 2023).

Gross fixed capital formation (GFCF) and trade openness (TRADE) maintain positive and statistically significant effects, highlighting the importance of investment and global market integration in driving long-term economic performance (Freund & Weinhold, 2004; Samargandi, Fidrmuc, & Ghosh, 2015). Labor force participation (LFPR) is also positive, though marginally significant, suggesting that a more active and perhaps better-skilled workforce may help mediate the negative effects of rapid digitalization (Myovella, Karacuka, & Haucap, 2020; Yin & Choi, 2021). Inflation (INF) is negative and weakly significant, indicating that macroeconomic instability remains a potential barrier to harnessing the full benefits of digital adoption (Ximei, Zhu, & Kim, 2022). The main finding—that internet penetration has a significant negative association with economic growth in both the short and long run—is a noteworthy departure from the optimism prevalent in studies on advanced economies (Czernich et al., 2011; Katz & Koutroumpis, 2013; Qiang, Rossotto, & Kimura, 2009). It is, however, consistent with a growing literature that stresses the conditionality of digital dividends in developing countries (Asongu & Nwachukwu, 2017; Myovella, Karacuka, & Haucap, 2020; Niebel, 2018). As highlighted by Salemink, Strijker and Bosworth (2017) and Katz and Callorda (2018), internet expansion in low- and middle-income contexts may exacerbate divides, produce transitional costs, or fail to deliver productivity gains in the absence of complementary assets and institutional reforms.

The positive roles of investment, trade, and labor force participation align with classic and endogenous growth models (Romer, 1990; Solow, 1957) and recent findings that digital technologies are most effective when combined with robust capital markets, human capital, and policy support (Choi & Hoon Yi, 2009; Jorgenson & Vu, 2016; Zaborovskaia, Nadezhina, & Avduevskaya, 2020). Policy implications point toward the need for a holistic approach: expanding internet infrastructure alone is not sufficient. Investments in education, skills training, and regulatory quality must be prioritized to ensure that digitalization contributes to inclusive and sustainable economic growth (Farida, Haryanto, & Satrio, 2021; Sinha & Sengupta, 2019). In sum, these results challenge assumptions of automatic digital-led growth and emphasize the complex interplay of technological, human, and institutional factors in developing countries. As the digital revolution accelerates, future research should explore heterogeneity in these effects, the role of sectoral composition, and how targeted policies can convert connectivity into concrete economic benefits.

5. Conclusion and Policy Implications

This study set out to empirically examine the impact of internet penetration on economic growth in 85 developing countries over the period 2001–2023, employing the Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) methodology to account for heterogeneity, endogeneity, and cross-sectional dependence. The analysis incorporated key macroeconomic controls—gross fixed capital formation, labor force participation, inflation, and trade openness—to provide a comprehensive understanding of the digitalization-growth nexus in the developing world. The results challenge the conventional wisdom that expanding internet access inherently accelerates economic growth in less developed settings. Both short-run and long-run estimates reveal a significant negative association between internet penetration and GDP growth, a finding that diverges from much of the literature focused on high-income economies but resonates with recent work emphasizing the conditionality of digital dividends in developing regions. The evidence suggests that without concurrent investments in human capital, robust institutions, and supporting infrastructure, simply increasing internet connectivity may not yield the intended economic benefits and may even contribute to structural adjustment costs, inequality, or exclusion. At the same time, the consistently positive effects of gross fixed capital formation and trade openness highlight the ongoing importance of physical investment and global integration as drivers of sustainable growth. Labor force participation also emerges as an important, though more nuanced, contributor to economic performance. For policymakers, these findings underscore the need for a holistic approach to digital development. Expanding internet infrastructure must be matched by investments in

education, vocational skills, and digital literacy to enable the workforce to harness new technologies productively. Strengthening institutional quality and regulatory frameworks can ensure more inclusive and efficient outcomes from digitalization. Macroeconomic stability, particularly in terms of controlling inflation, remains critical for sustaining investment and enabling technological adoption. Furthermore, promoting trade openness can amplify the potential benefits of digital connectivity by exposing firms and workers to new ideas, technologies, and markets. Ultimately, digital strategies must be embedded within broader development agendas that prioritize inclusion, capacity building, and institutional reform to unlock the full potential of the digital economy for sustainable growth.

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