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The Impact of Digitalization on Economic Growth in Developing Countries

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Abstract

This study analyzes the impact of digitalization on economic growth in developing countries. In the modern era, digital technology has become a key driver of global economic transformation. Using panel data for 50 developing countries from 2010 to 2020, this study examines the relationship between digitalization and economic growth, measured by real gross domestic product (GDP) per capita growth. The indicators of digitalization include internet penetration, smartphone usage, and digital infrastructure, while education, foreign direct investment (FDI), and urbanization are included as control variables. The empirical analysis employs panel data regression using a Fixed Effects Model (FEM). The results indicate that digitalization makes a significant contribution to economic growth in developing countries. In particular, higher internet penetration, greater smartphone usage, and improved digital infrastructure are associated with enhanced productivity and efficiency across key economic sectors. In addition, education, FDI, and urbanization play important complementary roles by facilitating the adoption and effective use of digital technologies. These findings suggest that policymakers in developing countries should prioritize investment in digital infrastructure and expand digital access to maximize the growth benefits of digitalization.

1. Introduction

Over the past decade, digitalization has emerged as a major driver of economic transformation worldwide [1]. The rapid development of information and communication technologies, including internet access, smartphone penetration, and digital infrastructure, has reshaped production systems, market structures, and patterns of economic interaction [2, 3]. As shown in Figure 1, according to the International Telecommunication Union [4], approximately 5.5 billion people, or around 68% of the global population, were connected to the internet in 2024, reflecting a substantial increase in the adoption of digital technologies worldwide. Nevertheless, this progress remains uneven across regions, resulting in disparities in the level of digitalization [5].

Regional differences in internet penetration rates reveal considerable inequality. According to the International Telecommunication Union [4], in advanced regions such as Europe and the Americas, internet usage has reached 87% to 92% of the total population, approaching near-universal connectivity. In contrast, the Asia-Pacific region exhibits moderate adoption levels, with approximately 66% to 77% of the population connected, reflecting rapid but uneven digital growth. Meanwhile, Africa remains the least connected region, with only around 36% to 38% of

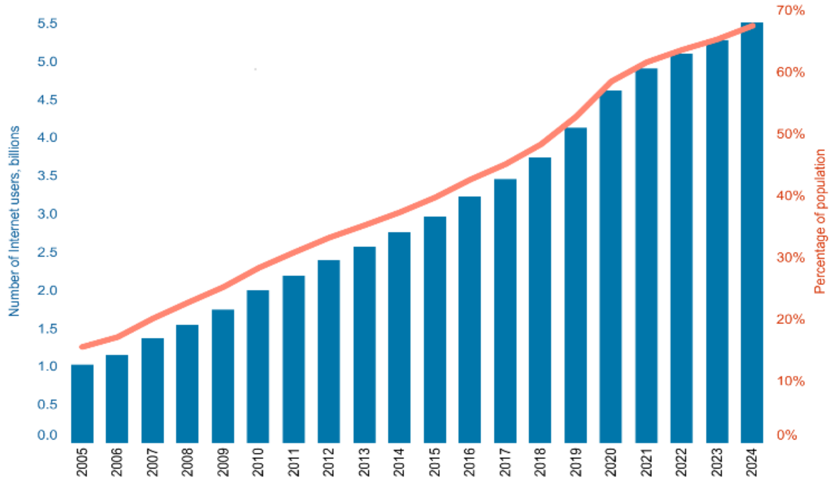

Figure 1. Number of individuals using the internet worldwide, 2005–2024.
(Source: International Telecommunication Union [4])

its population using the internet. This inequality is further reinforced by structural differences across countries, as only about 27% of people in low-income nations have internet access, compared with more than 90% in high-income countries. Moreover, the digital divide also persists within countries: while internet usage in urban areas reaches around 81%, it falls to only about 50% in rural areas. These conditions indicate that digitalization remains unevenly distributed and may generate asymmetric economic effects across regions [6, 7].

Despite these disparities, digitalization is widely recognized as one of the key drivers of economic growth. Theoretically, within the framework of endogenous growth theory, technological innovation, including digital technology, plays a vital role in enhancing productivity and promoting long-term economic growth [8, 9]. Empirical evidence also supports this argument, showing that digital technology contributes significantly to total factor productivity and innovation [10–13]. In developing countries, digitalization provides opportunities to accelerate economic development through leapfrogging, which refers to the ability to bypass traditional development stages through the rapid adoption of digital technologies [14, 15]. For example, greater internet access and mobile connectivity have been shown to reduce transaction costs, improve market efficiency, and expand financial inclusion [16, 17].

However, the relationship between digitalization and economic growth remains complex and continues to be debated in the literature. On the one hand, many studies find that digitalization positively affects productivity and economic growth. On the other hand, concerns remain that unequal access to digital technologies may exacerbate economic inequality. The persistence of the digital divide can widen income disparities and limit the benefits of digitalization, particularly in developing countries [18, 19]. According to United Nations Conference on Trade and Development [20], differences in digital infrastructure, affordability, and digital literacy remain major barriers preventing many countries from fully leveraging digital technologies. Furthermore, the effectiveness of digitalization depends heavily on supporting factors such as human capital quality, institutional strength, and investment capacity [21, 22].

Another limitation in the existing literature is the reliance on partial indicators of digitalization. Many previous studies use a single indicator, such as internet usage [23, 24] or ICT investment [25, 26], which fails to capture the full complexity of digitalization. In reality, digitalization is a multidimensional phenomenon involving interactions among various components, such as internet penetration, smartphone usage, and digital infrastructure [27]. In addition, structural variables such as education, foreign direct investment (FDI), and urbanization play an important role in determining the extent to which digital technologies can be adopted and effectively utilized within an economy [28, 29]. This highlights the need for a more comprehensive analytical framework that integrates multiple dimensions of digitalization with supporting structural factors.

Moreover, empirical evidence focusing on developing countries remains relatively limited and fragmented. Many studies focus only on specific regions or employ narrow samples, thereby failing to capture the diverse experiences of digitalization across developing economies [30–32]. Given the substantial differences in digital readiness, institutional capacity, and economic structures among developing countries, broader cross-country analyses are required to understand the role of digitalization in driving economic growth more comprehensively.

Based on this background, this study aims to analyze the impact of digitalization on economic growth in developing countries by integrating several key dimensions of digitalization: internet penetration, smartphone usage, and digital infrastructure. The study employs panel data for 50 developing countries over the period 2010–2020 and includes control variables such as education, foreign direct investment (FDI), and urbanization to capture broader structural conditions affecting economic performance.

This study contributes in three main respects. First, it offers a more comprehensive measure of digitalization by integrating multiple indicators within a single empirical model. Second, it provides broader empirical evidence through a cross-country analysis of diverse developing economies. Third, it highlights the interaction between digitalization and structural factors, thereby generating more comprehensive policy implications for developing countries seeking to harness digital transformation as a driver of economic growth.

2. Literature Review

2.1. Theoretical Review

Economic growth is defined as a sustained increase in a country's productive capacity, typically measured by the growth of gross domestic product (GDP). Theories of economic growth have evolved from classical approaches to modern endogenous growth models that explicitly incorporate technology and innovation [33].

Classical growth theory posits that growth is driven by the accumulation of three main factors of production: labor, capital, and land, while technology is treated as an external element affecting productivity without being explicitly modeled [34, 35]. The neoclassical growth model developed by Solow [36] advanced this framework by introducing technology as a key determinant of long-run growth. However, technological progress is assumed to be exogenous and therefore beyond the direct control of economic agents or policymakers [8].

Endogenous growth theory extends this perspective by emphasizing that technological progress and human capital accumulation can be shaped by economic incentives, policies, and institutions. Romer and Lucas argue that innovation, research and development (R&D), and human capital investment are internal to the economic system, generating increasing returns to scale through knowledge spillovers and learning effects [34].

Within this theoretical tradition, digitalization represents a contemporary form of technological innovation that influences economic growth through multiple channels. Digitalization refers to the integration of digital technologies into economic and social activities, including the internet, mobile devices, cloud computing, artificial intelligence (AI), big data analytics, and automation across sectors [27]. The diffusion of these technologies enhances production efficiency, reduces transaction costs, enables new forms of coordination, and fosters product and process innovation.

The concept of the digital economy further refines this perspective by focusing on economic systems fundamentally based on digital technologies, such as e-commerce, digital services, and online platforms that rely on high-speed internet, data centers, and digital infrastructure [27]. Investment in digital infrastructure is therefore a crucial prerequisite, particularly for developing countries seeking to keep pace with global technological change.

Theoretically, digitalization promotes economic growth through several specific mechanisms: (1) productivity gains resulting from process automation and supply chain optimization; (2) market expansion through lower entry barriers; (3) greater financial inclusion via digital banking and mobile payment systems; and (4) reduced information asymmetries that enhance innovation [3]. However, the effectiveness of digitalization depends on structural conditions such as adequate digital infrastructure, supportive regulatory frameworks, human capital equipped with digital skills, and efforts to narrow the digital divide [20].

In summary, the theoretical literature identifies digitalization as a powerful driver of economic growth within both neoclassical and endogenous growth frameworks. However, its benefits depend on complementary factors such as infrastructure, human capital, institutional quality, and inclusive access to digital technologies.

2.2. Empirical Review

A growing body of empirical research has examined the relationship between digitalization and economic growth across different country contexts. Early studies on the digital divide, such as Chinn & Fairlie [37], analyze the determinants of computer and internet penetration in developing countries, identifying technological infrastructure and government policies as key drivers of digital adoption.

Studies focusing on developed economies document substantial benefits from digitalization. Ku et al. [38] find that digital technology adoption in European manufacturing and service sectors is associated with higher efficiency and productivity, thereby supporting economic growth. Similarly, Jorgenson & Vu [39] show that information and communication technology (ICT) has been a major driver of productivity growth in advanced economies through the contribution of ICT capital to output expansion.

Evidence from developing countries is more heterogeneous. Nosike [40] highlights the growth opportunities generated by digitalization despite persistent constraints such as limited infrastructure, skill shortages, and institutional weaknesses. Nevertheless, greater internet penetration has been found to promote economic growth by improving access to information, expanding markets, and stimulating innovation. At the microeconomic and mesoeconomic levels, research on mobile phone diffusion further supports the growth-enhancing role of digitalization. For example, Aker & Mbiti [16] demonstrate that mobile phone expansion in Africa improves market information flows, reduces transaction costs, and enables new economic activities.

International organizations have also documented the macroeconomic effects of digital transformation. Their findings suggest that digital technologies can stimulate economic growth and reduce poverty, although these benefits depend on complementary conditions such as effective regulation, skills development, and institutional quality [3, 4, 20, 41].

Overall, the empirical literature indicates that digitalization, measured through indicators such as broadband access, internet usage, and mobile subscriptions, is positively and significantly associated with economic growth. However, the magnitude of these effects varies depending on structural conditions. Important gaps remain in the literature, as relatively few studies integrate multiple dimensions of digitalization, such as internet penetration, smartphone usage, and digital infrastructure, together with structural variables including education, foreign direct investment (FDI), and urbanization across broad samples of developing countries. This study addresses these gaps by employing panel data for 50 developing countries over the period 2010–2020.

3. Materials and Methods

3.1. Data

The study uses annual panel data covering the period 2010–2020. This period was selected for several reasons. First, it captures the rapid global expansion of digital technologies following the global financial crisis, including the widespread diffusion of smartphones and accelerated investment in digital infrastructure. Second, relatively consistent and high-quality panel data are available from sources such as the World Bank's World Development Indicators (WDI), International Telecommunication Union (ITU), and World Economic Forum. Third, the period largely precedes the disruptive effects of the COVID-19 pandemic, thereby avoiding major distortions in economic activity. Fourth, an eleven-year period provides sufficient time-series variation for panel data estimation.

3.2. Population, Sample, and Selection Criteria

The population consists of all developing countries as classified by the World Bank [42]. The sample was selected using purposive sampling to ensure that countries met the following criteria: (1) classification as a developing country by the World Bank; (2) availability of adequate digitalization data for the period 2010–2020; and (3) sufficient variation in digitalization levels and economic growth indicators.

Based on these criteria, the final sample includes 50 developing countries from diverse regions, including Asia, Africa, and Latin America (see Appendix 1). The selection of 50 countries balances the need for a sufficiently large sample for robust panel estimation with the requirement of data completeness across all variables, thereby reducing bias arising from missing observations.

The focus on developing countries is justified because they exhibit heterogeneous experiences of digitalization, substantial digital divides, and significant opportunities for technological leapfrogging. Unlike advanced economies, where digital saturation may limit marginal growth effects, developing countries provide a more suitable context for examining the role of digitalization in accelerating development under infrastructure and skill constraints.

3.3. Variable

As shown in Table 1, this study includes two main groups of variables: dependent and independent variables. The dependent variable is economic growth, measured by the annual growth rate of real gross domestic product (GDP) per capita. Real GDP is preferred to nominal GDP because it adjusts for price changes and inflation, thereby providing a more accurate measure of economic performance.

The main independent variables are: (1) internet penetration, measured as the percentage of the population with internet access and representing a core indicator of digitalization; (2) smartphone usage, measured as the number of smartphone users per 100

Table 1. Variable synopsis.

Status	Name	Measurements	Units	Source
Dependent	Economic Growth	Measured by the annual growth rate of real gross domestic product (GDP) per capita.	Percent	WDI [43]
Main Independent	Internet Penetration	Measured as the percentage of the population with internet access.	Percent	ITU [44]
	Smartphone Usage	Measured as the number of smartphone users per 100 people.	Percent	ITU [44]
	Digital Infrastructure	Measured using a digital infrastructure index that captures communication networks, internet speed, and telecommunications penetration.	Scale from 0 to 100	ITU [44]
Control Independent	Education Level	Measured by the average years of schooling.	Year	WDI [43]
	FDI	Measured as a percentage of GDP.	Percent	WDI [43]
	Urbanization	Measured as the percentage of the population residing in urban areas.	Percent	WDI [43]

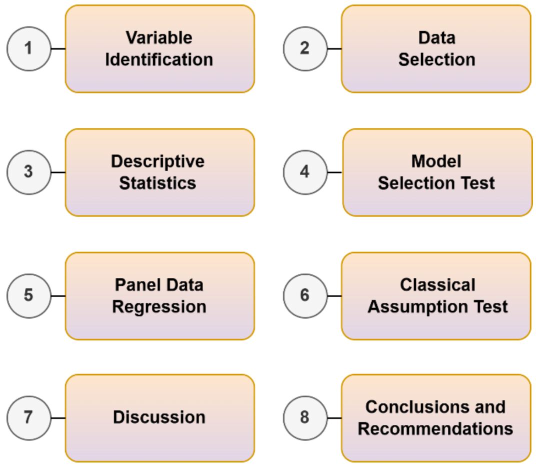

Figure 2. Study flow analysis.

people and serving as a proxy for access to digital technology; and (3) digital infrastructure, measured using a digital infrastructure index that captures communication networks, internet speed, and telecommunications penetration, compiled from annual reports of the International Telecommunication Union and World Economic Forum.

The control independent variables include: (1) education level, measured by average years of schooling as a proxy for human capital; (2) foreign direct investment (FDI), measured as a percentage of GDP and reflecting external investment that may support digital infrastructure development; and (3) urbanization, measured as the percentage of the population residing in urban areas.

3.4. Empirical Model and Estimation Method

This study employs panel data regression models to analyze the relationship between digitalization and economic growth by utilizing both cross-sectional (country) and time-series dimensions. This approach increases statistical power and allows for the control of unobserved heterogeneity.

The primary estimation method is the Fixed Effects Model (FEM), which assumes that country-specific effects are constant over time and may be correlated with the explanatory variables. This specification controls for time-invariant unobserved factors, such as geography, culture, or institutional characteristics, that could otherwise bias the estimates. As an alternative specification, the Random Effects Model (REM) assumes that country-specific effects are random and uncorrelated with the regressors. REM is appropriate when unobserved heterogeneity is not systematically related to the explanatory variables.

Model selection is based on the Hausman test, which evaluates whether FEM provides significantly different and more consistent estimates than REM. A p-value below 0.05 indicates preference for FEM. In addition, the Chow test and the Lagrange Multiplier (LM) test are used to distinguish among the pooled ordinary least squares model, FEM, and REM.

Hypothesis testing is conducted at the 5% significance level ($\alpha = 0.05$) using t-statistics and p-values. Additional validity measures include the R-squared for goodness of fit and the F-statistic for the joint significance of regressors. Diagnostic tests include the Breusch–Pagan test for heteroskedasticity, the Durbin–Watson statistic for autocorrelation, and the Variance Inflation Factor (VIF) for the detection of multicollinearity.

The empirical model is specified as shown in Equation 1.

$$GDP_{it} = \alpha + \beta_1 Inter_{it} + \beta_2 Smart_{it} + \beta_3 Infra_{it} + \beta_4 Educ_{it} + \beta_5 FDI_{it} + \beta_6 Urban_{it} + \varepsilon_{it} \quad (1)$$

Based on the above equation, GDP represents economic growth, $Inter$ refers to internet penetration, $Smart$ denotes smartphone usage, $Infra$ represents the level of digital infrastructure, $Educ$ indicates education level, FDI denotes foreign direct investment as a percentage of

Table 2. Statistical description of variables.

Variable (Units)	Min.	Max.	Mean	Median	Std. Dev.
Economic Growth (GDP) (%)	-2.50	10.50	3.21	3.10	2.45
Internet Penetration (%)	5.10	89.40	45.32	40.20	23.65
Smartphone Users (%)	4.80	88.20	37.89	33.50	22.78
Digital Infrastructure (Scale 0-100)	10.00	80.40	42.11	40.23	18.47
Education Level (Year)	3.00	11.50	7.30	6.50	2.20
FDI (%)	0.50	10.40	3.85	3.45	2.16
Urbanization (%)	20.00	90.00	51.48	50.20	18.45

Table 3. Results of panel data regression model selection tests.

Test	Indicator	Stat.	df	Prob.	Conclusion
Chow Test	Cross-section Chi-square	243.5178***	49	0.0000	FEM
Hausman Test	Chi-square statistic	15.2700**	6	0.0180	FEM
LM Test	Breusch-Pagan	28.9642***	1	0.0000	REM

Note: *** and ** indicate significance at the 1% and 5% levels, respectively.

GDP, $Urban$ captures the level of urbanization, i indicates country, t indicate the study period, α represents the constant term, β denotes the estimated coefficients, and ε is the error term.

3.5. Study Flow Analysis

Figure 2 illustrates the sequential analytical framework employed in this study, consisting of eight interconnected stages. The process begins with variable identification, in which the dependent, independent, and control variables are determined based on theoretical foundations and prior empirical studies, followed by data selection, where relevant panel data sources are collected and screened. The third stage, descriptive statistics, provides an initial overview of the data characteristics. Subsequently, the model selection test is conducted to identify the most appropriate econometric specification. Next, panel data regression is applied to estimate the relationships among the variables, while the classical assumption test is performed to ensure the validity and robustness of the estimated model. The empirical findings are then interpreted in the discussion stage by relating the results to theoretical expectations and previous literature. Finally, the study concludes with conclusions and recommendations, which summarize the main findings, highlight policy implications, and suggest directions for future research.

4. Results and Discussion

4.1. Descriptive Statistics

This study uses panel data from 50 developing countries over the period 2010 to 2020. The data analyzed include variables for economic growth (real GDP per capita growth), internet penetration, smartphone usage, digital infrastructure, education level, foreign direct investment (FDI), and urbanization. Table 1 presents the descriptive statistics of the variables used in this study.

Table 2 reports the descriptive statistics for all variables across 50 developing countries from 2010 to 2020. Economic growth, measured by GDP per capita growth, has a mean of 3.21% with moderate variation (SD = 2.45%), ranging from economic contraction (-2.50%) to strong expansion (10.50%), reflecting the diverse growth experiences of developing economies. Internet penetration exhibits substantial heterogeneity, with a mean of 45.32% and a standard deviation of 23.65%. While some countries have achieved near-universal access (89.40%), others remain below 10%, highlighting the persistence of the digital divide.

Smartphone usage follows a similar pattern, with a mean of 37.89 users per 100 people and a standard deviation of 22.78, indicating considerable differences in mobile technology adoption, which is essential for digital service delivery. The digital infrastructure index, with a mean of 42.11 and a standard deviation of 18.47, reveals significant disparities in infrastructure readiness required to support digital economic development.

The control variables also display sufficient variation. Education level averages 7.30 years of schooling (SD = 2.20), foreign direct investment averages 3.85% of GDP (SD = 2.16), and urbanization averages 51.48% (SD = 18.45). These variations suggest that the variables are suitable for capturing the moderating and supporting roles of structural factors in the relationship between digitalization and economic growth across the panel sample.

4.2. Model Selection

In panel data analysis, selecting the appropriate estimation model among the Common Effects Model

Table 4. Results of panel data regression using the fixed effects model.

Variable	Coef.	Std. Er.	t-Stat.	Prob.
Internet Penetration	0.045***	0.012	3.75	0.000
Smartphone Usage	0.038***	0.009	4.22	0.001
Digital Infrastructure	0.029***	0.011	2.64	0.009
Education Level	0.020**	0.008	2.50	0.012
FDI	0.055***	0.017	3.24	0.002
Urbanization	0.031**	0.014	2.21	0.028
C	-0.215**	0.083	-2.59	0.010
R^2 = 0.72				
F-Stat. = 8.45				
F-Stat. Prob. = 0.00				

Note: *** and ** indicate significance at the 1% and 5% levels, respectively.

Table 5. Results of panel data regression using the random effects model.

Variable	Coef.	Std. Er.	t-Stat.	Prob.
Internet Penetration	0.039***	0.014	2.79	0.005
Smartphone Usage	0.033***	0.011	3.00	0.003
Digital Infrastructure	0.025**	0.010	2.50	0.013
Education Level	0.017*	0.009	1.89	0.059
FDI	0.047**	0.019	2.47	0.014
Urbanization	0.028**	0.013	2.15	0.031
C	-0.180**	0.091	-1.98	0.048
R^2 = 0.68				
F-Stat. = 7.93				
F-Stat. Prob. = 0.00				

Note: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

(CEM), Fixed Effects Model (FEM), and Random Effects Model (REM) is essential to ensure the validity and efficiency of parameter estimates. The Chow test compares CEM and FEM to examine the presence of fixed effects across cross-sectional units. The Hausman test is used to choose between FEM and REM by testing whether the error terms are orthogonal to the explanatory variables. Meanwhile, the Lagrange Multiplier (LM) test compares CEM and REM to detect the presence of random effects (Wooldridge, 2020).

These three tests complement one another within the model selection hierarchy. A significant Chow test indicates that FEM or REM is preferred to CEM, while the Hausman test determines the final choice between FEM and REM. This procedure ensures that the selected model is consistent with the characteristics of the panel data.

Based on the panel testing hierarchy and the test results in Table 3, the significant Chow test rejects the CEM. This is followed by a significant Hausman test, which supports the selection of FEM as the most appropriate model relative to both REM and CEM.

4.3. Regression Results Analysis

The results of the Fixed Effects Model (FEM) presented in Table 4 indicate that all main independent variables exert a statistically significant influence on economic growth. Internet penetration, smartphone usage, and digital infrastructure each display positive and significant coefficients, suggesting that higher levels of digitalization are associated with stronger economic growth. Specifically, the estimated coefficient of internet penetration is 0.045 (p = 0.000), implying that a 1% increase in internet access is associated with a 0.045% increase in real GDP per capita growth. Smartphone usage records a coefficient of 0.038 (p = 0.001), indicating that wider mobile technology adoption contributes positively to economic performance. Digital infrastructure also exerts a positive effect, with a coefficient of 0.029 (p = 0.009), confirming that stronger telecommunications networks and digital systems support higher productivity and growth. These findings imply that improvements in digital connectivity and technological readiness contribute positively to economic performance across developing countries.

The control variables also demonstrate statistically significant positive effects. Education level, measured by average years of schooling, has a coefficient of 0.020 (p = 0.012), indicating that human capital supports economic growth. Foreign direct investment (FDI) records a coefficient of 0.055 (p = 0.002), suggesting that external capital inflows contribute positively to growth. Urbanization also shows a positive coefficient of 0.031

Table 6. Results of Breusch-Pagan-Godfrey heteroscedasticity test.

F-Stat.	Prob.	Obs × R^2	Prob. Chi-Square	Scaled explained SS	Prob. Chi-Square
1.2846	0.2604	7.6128	0.2679	6.9851	0.3215

Note: A Chi-Square probability value above 0.05 indicates the absence of heteroskedasticity.

Table 7. Results of variance inflation factors (VIF) for multicollinearity test.

Variable	VIF	1/VIF
Internet Penetration	1.92	0.5208
Smartphone Usage	1.78	0.5618
Digital Infrastructure	1.84	0.5435
Education Level	1.42	0.7042
FDI	1.61	0.6211
Urbanization	1.51	0.6623
Mean VIF	1.68	

Note: VIF values below 10 indicate the absence of multicollinearity.

Table 8. Results of Durbin-Watson autocorrelation test.

Test	Stat.
Durbin-Watson	1.9847

Note: The Durbin–Watson bounds for autocorrelation are d_L=1.72 and d_U=1.82 at the 5% significance level; a Durbin–Watson statistic above these bounds indicates the absence of autocorrelation.

(p = 0.028), implying that urban development is associated with stronger economic performance.

Although the model selection tests confirm FEM as the most appropriate specification, this study also presents the Random Effects Model (REM) results for comparison purposes and to assess the consistency of the findings. As shown in Table 5, the REM estimates closely mirror the FEM results, indicating that digitalization also has a positive and statistically significant effect on economic growth under the alternative specification. The coefficients for internet penetration, smartphone usage, and digital infrastructure remain positive and significant. The consistency of the estimated signs and significance levels across both FEM and REM provides additional evidence for the robustness of the positive relationship between digitalization and economic growth.

4.4. Classical Assumption test

To ensure that the parameter estimates of the panel regression satisfy the Gauss–Markov assumptions, several diagnostic tests are conducted, including tests for multicollinearity, heteroskedasticity, and autocorrelation. These tests are important because the model assumes homoscedastic and uncorrelated error terms across observations, thereby ensuring that the coefficient estimates are unbiased, consistent, and efficient.

The results of the Breusch–Pagan–Godfrey heteroskedasticity test in Table 6 show a Prob. Chi-Square (6) value of 0.2679, which is greater than the 5% significance level. Therefore, the null hypothesis of homoscedasticity cannot be rejected. This indicates that the Fixed Effects Model is free from heteroskedasticity problems, as the variance of the error term remains constant across observations. Satisfying this assumption supports the efficiency of the regression estimates.

The Variance Inflation Factor (VIF) test results in Table 7 show that all explanatory variables have VIF values below the conventional threshold of 10, namely: internet penetration (1.92), smartphone usage (1.78), digital infrastructure (1.84), education (1.42), foreign direct investment (FDI) (1.61), and urbanization (1.51), with a mean VIF of 1.68. These results indicate the absence of serious multicollinearity among the independent variables, suggesting that the estimated coefficients can be interpreted reliably without distortion caused by high correlations among regressors.

The Durbin–Watson test results in Table 8 yield a statistic of 1.9847, which is close to 2.0, with a lower bound (dL = 1.72) and an upper bound (dU = 1.82) at the 5% significance level. This result indicates the absence of first-order autocorrelation in the residuals of the Fixed Effects Model. Accordingly, the null hypothesis of no autocorrelation cannot be rejected. Meeting this assumption implies that the error terms are independent across time periods in the panel dataset.

Overall, the classical assumption tests confirm that the Fixed Effects Model satisfies the key conditions required for reliable estimation. The Breusch–Pagan test (p = 0.2679 > 0.05) indicates homoscedastic residuals, all VIF values below 10 suggest no multicollinearity, and the Durbin–Watson statistic of 1.9847 confirms the absence of autocorrelation. These findings support the validity and efficiency of the model estimates for analyzing the impact of digitalization on economic growth across 50 developing countries over the period 2010–2020.

4.5. Discussion

The results of the Fixed Effects Model (FEM) indicate that digitalization exerts a positive and statistically significant impact on economic growth across 50 developing countries over the period 2010–2020. The Random Effects Model (REM) produces similar results and confirms this relationship. The R-squared value of 0.72 suggests a strong overall model fit. This finding is consistent with endogenous growth theory, which argues that technological innovation enhances productivity and supports long-term economic growth.

Beginning with internet penetration, the estimated coefficient implies a positive impact, indicating that an increase in internet access is associated with an increase in real GDP per capita growth. This result is consistent with Arvin & Pradhan [2], who identify a positive relationship between broadband diffusion and economic growth through improvements in market efficiency. It also supports the World Bank [3] view that internet expansion reduces transaction costs and broadens market participation in developing economies. Although Chinn & Fairlie [37] document persistently low internet penetration in low-income countries due to infrastructure constraints, the present findings suggest that the rapid diffusion of digital technologies after 2010 has strengthened the growth contribution of internet connectivity. These results imply that policies aimed at expanding rural broadband access may facilitate economic leapfrogging.

This foundation of connectivity extends to smartphone usage, which is also found to have a positive impact. The result suggests that wider mobile technology adoption promotes business efficiency, access to information, and financial inclusion. This finding corroborates Aker & Mbiti [16], who show that mobile phone expansion in Africa reduced information costs and enabled new economic activities. It is further supported by the International Telecommunication Union [4], which highlights the role of smartphones in advancing digital finance and inclusion across emerging markets. From a policy perspective, improving the affordability of smartphones and mobile services, particularly for small and medium-sized enterprises (SMEs), may enhance productivity in both formal and informal sectors.

Digital infrastructure also exerts a positive effect, confirming that stronger telecommunications networks and digital systems contribute to higher productivity and growth. This finding is consistent with Jorgenson & Vu [39], who emphasize the contribution of ICT capital to output growth, and with Bukht & Heeks [27], who stress the multidimensional nature of digitalization. Although Oloyede et al. [18] warn that infrastructure disparities may intensify inequality, the present cross-country evidence indicates that the net economic effect remains positive. This underscores the importance of sustained investment in broadband networks, data systems, and telecommunications infrastructure.

The effectiveness of these digital drivers, however, depends on supporting structural factors. Education level, measured by average years of schooling, is found to have a positive impact, indicating that human capital facilitates the adoption and productive use of digital technologies. This is consistent with studies emphasizing the central role of education in growth and innovation, as well as the World Bank [3] recommendation to strengthen digital literacy. These findings suggest that integrating digital competencies into national education systems is essential for maximizing the returns to digitalization.

Foreign direct investment (FDI) also demonstrates a positive and significant impact, indicating that external capital inflows support economic growth, partly through technology transfer and infrastructure development. This result is aligned with the broader FDI-growth literature and with the United Nations Conference on Trade and Development [20], which notes the importance of investment flows for digital transformation in developing economies. Therefore, policies designed to attract technology-oriented FDI may accelerate modernization and economic expansion.

Urbanization, with a positive coefficient, also contributes positively to economic growth. This suggests that urban concentration may generate productivity gains through agglomeration economies, better infrastructure, and easier access to digital services. The result is consistent with studies linking urban development to technological diffusion [45, 46] and with the International Telecommunication Union [4], which highlights persistent urban-rural disparities in digital access. These findings imply that inclusive urban planning and smart city strategies should be accompanied by policies that narrow regional inequalities.

Overall, the findings indicate that internet penetration and smartphone usage directly strengthen connectivity and inclusion, supported by digital infrastructure. At the same time, education, FDI, and urbanization amplify these benefits through human capital formation, technology transfer, and agglomeration effects. Collectively, the evidence positions multidimensional digitalization as a powerful driver of economic growth in developing countries while also emphasizing the importance of complementary structural conditions.

5. Conclusions and Recommendations

The empirical analysis using the Fixed Effects Model (FEM) with panel data from 50 developing countries over the period 2010–2020 confirms that digitalization, proxied by internet penetration, smartphone usage, and digital infrastructure, exerts a positive and statistically significant impact on real GDP per capita growth. Structural enablers further strengthen these effects, as education facilitates technology absorption, foreign direct investment (FDI) supports infrastructure financing, and urbanization benefits from stronger digital access in urban areas. These findings support endogenous growth theory in the context of developing economies and highlight the leapfrogging potential of digitalization, although persistent digital divides may constrain gains in low-access regions.

Based on these findings, policymakers in developing countries should prioritize several strategic measures. First, governments should expand rural internet access through public-private partnerships to reduce connectivity gaps in underserved areas. Second, policies that improve smartphone affordability, such as targeted tax incentives or reduced import duties on entry-level devices, may broaden digital participation among small businesses and low-income households. Third, sustained investment in digital infrastructure, including broadband networks and telecommunications systems, should be encouraged alongside incentives to attract technology-oriented FDI. Fourth, education systems should integrate digital literacy and ICT competencies at multiple levels to strengthen human capital and improve the productive use of technology. Fifth, urban development strategies should promote smart city initiatives while simultaneously extending digital connectivity to peri-urban and rural areas in order to prevent widening spatial inequality. Collectively, these measures can help ensure that digitalization becomes a more inclusive and sustainable driver of long-term economic growth.

Despite the robustness of the model diagnostics, this study has several limitations that also provide directions for future research. First, data availability restricts the analysis to the 2010–2020 period and does not capture the accelerated digital transformation observed after the COVID-19 pandemic. Future studies should therefore incorporate post-2020 data to assess its long-term economic effects. Second, although digitalization is measured through multiple dimensions, broader information and communication technology (ICT) indicators remain outside the scope of the analysis, suggesting the need for more comprehensive measures. Third, while country fixed effects control for time-invariant heterogeneity, they may not fully address potential endogeneity arising from reverse causality, whereby higher economic growth may itself attract greater digital investment. Dynamic panel techniques such as the generalized method of moments (GMM) may therefore provide a more suitable approach. In addition, future research may examine sector-specific effects across agriculture, manufacturing, and services, apply nonlinear models to test threshold effects or diminishing returns, and use micro-level evidence on firms and households to complement the present macroeconomic findings.

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Appendix.

Appendix 1 – Sample countries.

No.	Country	Region	No.	Country	Region	No.	Country	Region
1	Armenia	Asia	18	Thailand	Asia	35	South Africa	Africa
2	Azerbaijan	Asia	19	Uzbekistan	Asia	36	Tanzania	Africa
3	Bangladesh	Asia	20	Vietnam	Asia	37	Tunisia	Africa
4	Cambodia	Asia	21	Algeria	Africa	38	Uganda	Africa
5	India	Asia	22	Botswana	Africa	39	Zambia	Africa
6	Indonesia	Asia	23	Cameroon	Africa	40	Zimbabwe	Africa
7	Kazakhstan	Asia	24	Egypt	Africa	41	Bolivia	Latin America
8	Kyrgyzstan	Asia	25	Ethiopia	Africa	42	Brazil	Latin America
9	Laos	Asia	26	Ghana	Africa	43	Colombia	Latin America
10	Malaysia	Asia	27	Ivory Coast	Africa	44	Ecuador	Latin America
11	Mongolia	Asia	28	Kenya	Africa	45	El Salvador	Latin America
12	Myanmar	Asia	29	Morocco	Africa	46	Guatemala	Latin America
13	Nepal	Asia	30	Mozambique	Africa	47	Honduras	Latin America
14	Pakistan	Asia	31	Namibia	Africa	48	Mexico	Latin America
15	Philippines	Asia	32	Nigeria	Africa	49	Paraguay	Latin America
16	Sri Lanka	Asia	33	Rwanda	Africa	50	Peru	Latin America
17	Tajikistan	Asia	34	Senegal	Africa			