

When Technology Meets Institutions: Digitalization, Governance, and Human Development in Emerging Economies

By Ali Alsubaie¹

ABSTRACT:

Purpose: This study examines the joint impact of digitalization and governance quality on human development in emerging economies.

Approach: Using yearly data from 30 countries (2002–2023), we analyze both direct and moderating effects by combining fixed-effects estimation with a two-step Difference GMM approach.

Findings: Digitalization shows a positive relationship with the Human Development Index (HDI). The interaction between digitalization and governance is negative—statistically significant in the fixed-effects model and negative, albeit less precise, in the Difference GMM model—suggesting that the gains from digitalization diminish as governance improves. Control variables act as slow-changing fundamentals; primary school enrollment is positive and significant in the dynamic model, while urbanization and the dependency ratio are not significant.

Originality: The findings suggest that digital policies alone are insufficient; institutional quality determines the extent of the “digital dividend.” We recommend combining investments in connectivity and digital public services with reforms to strengthen the rule of law, regulatory quality, and accountability, thereby promoting fair and lasting improvements in human development.

Keywords: Digital transformation; Governance quality; Rule of Law; Human Development Index; Emerging economies; Difference GMM; Interaction effects; Inclusive growth

1. Introduction

The spread of digital technologies is transforming production, service delivery, and civic participation worldwide. However, for emerging economies, turning digital advances into widespread improvements in human well-being is not automatic. Although internet penetration and ICT adoption have increased rapidly, the institutional environment—especially the rule of law, regulatory quality, and accountability—determines how technology translates into outcomes measured by the Human Development Index (HDI).

Building on Sen’s (1999) capabilities perspective, human development is understood as the expansion of people’s substantive freedoms in areas such as health, education, and income. Digitalization can improve these capabilities by reducing information barriers, increasing access to public services and education, and creating new livelihood opportunities. However, weak institutions can limit or distort these benefits, entrenching digital divides, misallocating public resources, or eroding trust. For example, in emerging economies with weak administrative capacity, digital platforms for education or health

¹PhD, Assistant Professor, King Fahad Security College, Riyadh, Saudi Arabia.

services often substitute for inefficient public delivery systems. Online learning portals, mobile health applications, and digital identification systems can partially bypass bureaucratic bottlenecks, improving access even when formal institutions underperform. This illustrates how digitalization may temporarily compensate for institutional weaknesses rather than reinforce them.

Existing evidence on the connection between digitalization and development is mixed. Studies show that digital adoption can improve efficiency and welfare, but also warn that institutional weaknesses can offset or even reverse these benefits. This suggests that digitalization and governance influence each other, rather than simply adding together; the developmental benefits of technology may depend on the quality of institutions.

This paper contributes three key elements. First, it provides panel evidence from 30 emerging economies (2002–2023) on how digitalization and governance (measured by the Rule of Law index) jointly influence human development. Second, it employs both fixed-effects and two-step Difference GMM models to address persistence and potential endogeneity in the HDI process. Third, it measures the interaction through marginal effects analysis across governance levels, highlighting where digital investments yield the most significant incremental benefits.

We find that digitalization is positively related to HDI; the interaction with governance is negative and significant in the fixed-effects model and negative but less precise in the dynamic specification, implying diminishing marginal digital returns as governance improves. Policy-wise, digital infrastructure and services should be combined with governance reforms to achieve lasting, inclusive improvements in human development.

While some literature emphasizes complementarity between digitalization and governance—arguing that strong institutions amplify the benefits of ICT—other studies highlight compensatory or substitutive dynamics in weaker institutional contexts. Differences in country coverage, development stages, and empirical strategies help explain these divergent findings. By focusing on emerging economies and accounting for interaction effects in both fixed-effects and dynamic GMM frameworks, this study demonstrates how digitalization delivers larger marginal gains precisely where institutional capacity is limited.

2. Literature Review

The relationship between digitalization, governance quality, and human development has garnered increasing attention in recent development economics research. Early studies on human development mainly focused on traditional aspects such as education, income, and health, as reflected in the United Nations Development Programme's (UNDP) Human Development Index (HDI) (1990). However, the digital transformation of economies has changed how countries pursue inclusive and sustainable progress. Digitalization enhances access to information, improves service delivery, and encourages citizen participation, thereby advancing welfare and equality (Asongu & Odhiambo, 2019; Qureshi, 2019; Vu, 2020). Still, these benefits largely depend on the institutional framework in which technology is implemented and governed.

From an institutional economics perspective, governance structures determine how technological change leads to development outcomes. North (1990) and Acemoglu and Robinson (2012) argue that institutions shape incentives, resource distribution, and innovation capacity, affecting long-term social and economic paths. Effective governance—based on transparency, accountability, and the rule of law—creates an environment where technology can improve welfare. Conversely, weak institutions can misallocate resources, raise inequality, or promote rent-seeking behavior. Kaufmann *et al.* (2010) operationalized these dimensions through the Worldwide Governance Indicators (WGI), including the Rule of Law index used in this study to measure adherence to legal and institutional norms.

Empirical research has increasingly explored how digital transformation and governance interact. Bannister and Connolly (2020) argue that digital governance enhances public sector transparency and responsiveness, thereby boosting citizen engagement. Asongu and Odhiambo (2019) demonstrate that digital inclusion supports human development only when accompanied by institutional reforms that improve accountability and regulatory quality. Similarly, Le Caous and Huarng (2021) highlight those broader economic and structural factors—such as logistics and migration—shape how digital and institutional forces together influence development outcomes, emphasizing the importance of context in achieving inclusive progress.

The quality of governance has also been linked to the success of technological and economic reforms. Gaygısız (2013) and Malanski and Póvoa (2021) find that institutional trust, corruption control, and economic freedom are essential for turning economic growth into social well-being. In environments with weak rule of law or ongoing corruption, digital initiatives may inadvertently worsen inequality or reinforce elite dominance—a phenomenon often called digital inequality. This view aligns with Sen's (1999) capability approach, which regards development as the expansion of people's freedoms supported by strong institutions. Therefore, good governance not only helps people access digital technologies but also ensures their benefits are shared fairly.

Other studies highlight that the developmental impacts of digitalization vary across different institutional settings. Albiman and Sulong (2017) and Niebel (2018) provide evidence that the economic and social outcomes of ICT adoption differ depending on institutional quality, while Chakravorti *et al.* (2020) demonstrate that the COVID-19 pandemic sped up digital adoption but also revealed governance and capacity weaknesses in many developing economies. Collectively, these findings indicate that digitalization and governance are interconnected factors that influence how countries turn technological progress into human development.

Despite the growing body of literature, gaps still exist. Many studies treat governance only as a control variable rather than as an active mechanism that shapes how digitalization affects development. Additionally, much of the empirical evidence is limited to single-country or regional analyses, which restricts its broader applicability to emerging economies. This research aims to fill these gaps by integrating digitalization and governance within a unified empirical framework for human development. Using the Rule of Law index as a measure of institutional quality, it investigates whether governance moderates the effect of digital progress on welfare outcomes across thirty emerging economies from 2002 to 2023. By applying both fixed-effects and dynamic Difference

GMM estimations, the study offers new insights into how institutional capacity influences the digital-development relationship, highlighting that sustainable human progress depends on both technological innovation and strong governance foundations.

3. Theoretical and Conceptual Framework

The link between digitalization, governance, and human development can be understood through an integrated theoretical view that combines institutional economics, endogenous growth theory, and the capability approach. These frameworks together show how technology and institutions interact to shape countries' social and economic progress.

From the perspective of institutional economics, the quality of governance determines how resources and innovations are turned into productive and fair results. North (1990) highlighted that institutions—defined as formal and informal rules that govern human interaction—shape incentives, lower uncertainty, and affect economic outcomes. Similarly, Acemoglu and Robinson (2012) argue that inclusive institutions promote participation, innovation, and investment in human capital, while extractive institutions concentrate power and hinder progress. In this framework, governance quality serves as a key mechanism, ensuring that technological and economic advances translate into real improvements in human well-being.

The capability approach proposed by Sen (1999) offers a complementary normative basis by redefining development as the expansion of people's freedoms and opportunities. Human development, as reflected in the Human Development Index (HDI), embodies this multidimensional concept encompassing health, education, and income. Digital technologies, when integrated within supportive governance systems, can improve human capabilities by increasing access to knowledge, enhancing service delivery, and encouraging participation in social and economic activities. Conversely, weak institutions may block these improvements by creating information gaps, restricting access, or misallocating digital resources. Therefore, governance determines whether digitalization acts as a tool for empowerment or exclusion.

From the perspective of endogenous growth theory, technological progress and institutional quality jointly shape long-term development paths (Aghion & Howitt, 2009; Romer, 1990). Digitalization promotes economic growth and human capital development by increasing productivity, lowering transaction costs, and fostering innovation. However, realizing these benefits depends on a country's absorptive capacity—its ability to adopt and regulate new technologies effectively. This capacity is mainly institutional, rooted in the rule of law, regulatory quality, and policy consistency. Therefore, governance not only accompanies digitalization but also mediates its impact on broader social outcomes.

Combining these views, the conceptual framework of this study is based on three main propositions:

- **Direct technological effect:** Digitalization positively influences human development by increasing access to information, education, healthcare, and economic opportunities.

- Direct institutional effect: Governance quality—represented by the Rule of Law—improves human development by strengthening accountability, reducing corruption, and providing better public services.
- Interactive (moderating) effect: Governance influences how digitalization affects human development. In settings with weak governance, digital tools can help offset institutional shortcomings by providing alternative service channels and promoting transparency. However, as governance quality improves, the additional benefits from digitalization decrease because institutions already deliver welfare effectively.

This framework underlines the complex relationship between technology, governance, and human development. The third proposition shows a substitutive relationship between digitalization and governance, consistent with the empirical findings in this study: the interaction term is negative and significant in the fixed-effects model and negative but less precise in the Difference GMM estimation. It suggests that digitalization offers the most developmental benefits when institutional weaknesses are most significant, highlighting its compensatory role in fragile governance environments.

3.1. Conceptual Integration

The integrated conceptual model (Figure 1) summarizes the theoretical relationships between digitalization, governance, and human development. Digitalization and governance each have direct effects on human development, while their interaction emphasizes the moderating role of institutional quality in shaping the strength and direction of digitalization's influence. Control variables—urbanization, primary education, and dependency ratio—capture structural, educational, and demographic factors that also impact human development paths.

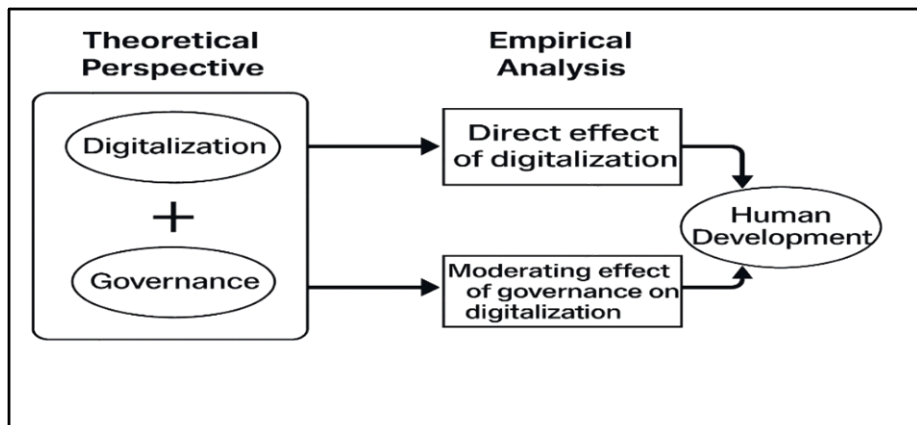


Figure 1. Conceptual Integration of Digitalization, Governance, and Human Development. Source: Author's elaboration based on institutional and development theory.

In operational terms, human development is measured by the Human Development Index (HDI), digitalization by internet user penetration (% of the population), and governance quality by the Rule of Law index from the Worldwide Governance Indicators (WGI). The interaction between digitalization and governance acts as the moderating channel through which institutional capacity influences the digital–development link. This conceptual and empirical synthesis forms the basis for the model and estimation strategy outlined in the next section.

4. Methodology and Data

4.1. Empirical Framework

Building on the conceptual model introduced in Section 3, this study explores how digitalization impacts human development and how this effect is influenced by governance quality in emerging economies. Drawing on the literature on technological diffusion and institutional economics, the analysis uses a dynamic panel-data framework to account for persistence in human development and possible endogeneity among regressors. The baseline specification is expressed as:

$$HDI_{it} = \alpha_i + \lambda_t + \delta HDI_{i,t-1} + \beta_1 Digital_{it} + \beta_2 Gov_{it} + \beta_3 (Digital_{it} \times Gov_{it}) + \gamma' X_{it} + \varepsilon_{\{it\}}$$

Where HDI_{it} represents the Human Development Index for country i in year t ; ($Digital_{it}$) denotes digitalization, measured by the percentage of individuals using the internet; and (Gov_{it}) measures governance quality, proxied by the Rule of Law index from the World Bank's Worldwide Governance Indicators (WGI) (World Bank, 2024). This variable reflects public confidence in and adherence to the legal framework, the quality of contract enforcement, and respect for property rights—core dimensions of institutional capacity in emerging economies.

The interaction term ($Digital_{it} \times Gov_{it}$) captures whether the developmental impact of digitalization depends on institutional strength. (X_{it}) is a vector of control variables representing structural and demographic characteristics. The parameters (α_i) and (λ_t) denote unobserved country-specific and time-specific effects, respectively, while ($\varepsilon_{\{it\}}$) is an idiosyncratic error term.

4.2. Estimation Strategy

Given the potential endogeneity among digitalization, governance, and human development, as well as the dynamic nature of the dependent variable, the study employs the two-step Difference GMM estimator developed by Arellano and Bond (1991). This estimator is particularly suitable for panels with a moderate time span and a small number of countries, as it removes fixed effects through first differencing and utilizes lagged levels of the dependent variable as internal instruments.

The choice of Difference GMM over System GMM reflects the data structure: the HDI series exhibits moderate persistence but no unit root behavior, and the instrument count is intentionally kept low to prevent overfitting. Collapsed instruments are used to reduce instrument proliferation, enhancing the validity of the Hansen and Sargan tests. Cluster-robust standard errors are employed to account for heteroskedasticity and cross-sectional dependence.

In addition to the dynamic estimation, fixed-effects (FE) regressions are conducted as a robustness check. FE estimates provide consistent within-country coefficients while accounting for time-invariant heterogeneity. The agreement between FE and GMM results strengthens the reliability of the empirical findings.

All models include year dummies to account for global shocks, such as the 2008 financial crisis and the COVID-19 pandemic. The estimation process follows three steps:

1. Conduct panel unit-root tests (Levin–Lin–Chu and Im–Pesaran–Shin) to confirm the absence of $I(2)$ variables.
2. Estimate the FE baseline model and test the moderating effect of governance.
3. Apply a two-step robust Difference GMM with collapsed instruments to address endogeneity and dynamic bias.

4.3. Variable Definitions and Data Sources

The variables used in this study include the Human Development Index (HDI) as the dependent variable, the percentage of individuals using the Internet as a proxy for digitalization, and the Rule of Law Index from the Worldwide Governance Indicators (WGI) as a measure of governance quality. The control variables comprise urbanization, primary school enrollment, and the dependency ratio. It should be noted that the use of national-level indicators may conceal subnational disparities in digital access and governance quality; regional or sector-specific heterogeneity is therefore not captured in the current framework.

All data were obtained from internationally recognized sources, including the United Nations Development Programme (UNDP) Human Development Reports, the World Bank's World Development Indicators (WDI), and the Worldwide Governance Indicators (WGI). A complete list of variables, definitions, and data sources is provided in Appendix A (Table A1), while the full list of the 30 emerging economies analyzed in this study is presented in Appendix B (Table B1).

4.4. Panel Unit-Root and Stationarity Tests

Before estimation, panel unit-root tests confirm that all variables are integrated of order $I(0)$ or $I(1)$, with none exceeding $I(1)$. Table I summarizes the results of the Levin–Lin–Chu (LLC) and Im–Pesaran–Shin (IPS) tests, both including intercept and trend terms. These results verify the suitability of the Difference GMM specification, which assumes at most first-order integration.

Table I. Panel Unit-Root Test Results

Variable	Levin–Lin–Chu	Im–Pesaran–Shin	Order of Integration
HDI	−2.83 ***	−3.12 ***	I(1)
Internet Users	−5.07 ***	−4.91 ***	I(1)
Governance (Rule of Law)	−2.41 **	−2.76 **	I(0)
Urbanization	−3.27 ***	−3.50 ***	I(0)
Primary Enrollment	−4.61 ***	−4.12 ***	I(0)
Dependency Ratio	−2.22 **	−2.56 **	I(1)

Note: *** $p < 0.01$, ** $p < 0.05$. Rejection of H_0 implies stationarity.

4.5. Descriptive Statistics and Correlation Structure

The descriptive results (Table II) reveal significant variation across countries. The average HDI is 0.70 ($\sigma = 0.08$), with a range of 0.45 to 0.87, while internet penetration reaches 45% of the population. Governance quality—measured by the Rule of Law Index—varies from -1.8 to +1.1 standard deviations, indicating diverse institutional capacities across the sample.

Table II. Summary Statistics

Variable	Mean	Std. Dev.	Min	Max	Obs
HDI	0.701	0.082	0.450	0.872	527
Internet Users (%)	45.28	27.14	1.30	98.21	527
Gov	0.00	1.00	−1.82	1.11	527
Urbanization (%)	62.17	16.93	23.85	91.74	527
Primary Enrollment (%)	102.38	12.76	65.44	127.41	527
Dependency Ratio	56.17	11.02	37.11	87.30	527

Correlation diagnostics indicate that internet use is strongly and positively linked to both HDI ($r = 0.72$) and governance quality ($r \approx 0.7$), aligning with the theoretical expectation that digital growth and institutional strength support each other. The relationships among the structural controls—urbanization, primary enrollment, and dependency ratio—are moderate and behave as expected.

Multicollinearity was further assessed using the Variance Inflation Factor (VIF) tests after mean-centering the continuous variables to create the interaction term. VIF values ranged from 1.17 to 8.09, with an average VIF of 3.56, confirming the absence of serious multicollinearity and affirming the stability of the estimated coefficients. The full correlation matrix is included in Appendix C (Table C1), and the detailed VIF diagnostics are shown in Appendix C (Table C2).

4.6. Model Diagnostics and Validity Tests

For the Difference GMM estimator, several specification tests ensure model validity:

- Arellano–Bond AR(1) and AR(2) tests: verify the absence of serial correlation in first-differenced residuals.
- Hansen and Sargan tests: evaluate the exogeneity and validity of instruments; the results ($p = 0.751$ and 0.974 , respectively) indicate that the instrument set is appropriate.
- Wald test: confirms the joint significance of regressors ($F = 219.64$, $p < 0.001$).

Collectively, these diagnostics validate the consistency and reliability of the estimation procedure. The Difference GMM results complement the fixed-effects estimates, confirming that digitalization and governance are significant long-term drivers of human development, with governance moderating the impact of digitalization.

5. Empirical Results

5.1. Fixed-Effects Estimates

The baseline Fixed Effects (FE) model provides the initial empirical test of how digitalization and governance jointly influence human development in emerging economies. Table III displays the estimated coefficients with robust standard errors clustered by country.

The findings show that digitalization has a positive and statistically significant impact on the Human Development Index ($\beta = 0.26$, $p < 0.05$). This suggests that increasing internet access enhances educational attainment, information dissemination, and service delivery, ultimately contributing to improved human well-being. Governance quality, measured by the Rule of Law index, also shows a positive coefficient ($\beta = 0.78$), approaching statistical significance ($p \approx 0.08$), suggesting that strong institutions support ongoing improvements in welfare outcomes.

Importantly, the interaction between digitalization and governance is negative and statistically significant ($\beta = -0.38$, $p < 0.05$). This suggests a substitutive relationship: the additional benefits of digitalization decrease as governance quality improves. In weaker institutional settings, digital technologies seem to offset inefficiencies by expanding access to services and information outside formal bureaucratic systems. As governance strengthens, the additional benefits from digitalization diminish because effective institutions already achieve many of these outcomes.

Among the control variables, urbanization and primary school enrollment are positive but not statistically significant, while the dependency ratio shows no measurable effect. These results align with the slow-changing structural and demographic traits typical of emerging economies. The within-country R^2 of 0.91 indicates a strong model fit, confirming that most variation in human development occurs within countries over time rather than between different countries.

Table III. Fixed-Effects Estimation Results (Clustered SEs)

Variable	Coefficient	Std. Error	t-stat	p-value
Internet Users	0.2599**	0.1119	2.32	0.027

Governance (Rule of Law)	0.7776*	0.4305	1.81	0.081
Digital × Gov	-0.3755**	0.1557	-2.41	0.022
Urbanization	0.1011	0.1515	0.67	0.510
Primary Enrollment	0.0057	0.0266	0.21	0.832
Dependency Ratio	0.0238	0.0429	0.55	0.583
Country FE, Year FE	Yes			
R ² (within)	0.913			
N	439			

Notes: **p < 0.05, *p < 0.10. Standard errors clustered at the country level.

5.2. Dynamic GMM Robustness Analysis

To address persistence in human development and potential endogeneity between digitalization and governance, the study employs a two-step robust Difference GMM estimator with collapsed instruments (Table IV). This approach corrects for dynamic bias and accounts for country-specific differences.

The lagged dependent variable (L.HDI) is positive ($\delta = 0.54$) but statistically insignificant ($p = 0.456$), indicating that while human development shows some persistence, short-term adjustments are more influential than inertia effects. Both digitalization and governance quality have positive coefficients, aligning with theoretical expectations; however, their individual effects are not statistically significant when dynamic feedback is considered. The interaction term remains negative, confirming the direction of the moderating effect observed in the FE model, even if its magnitude is minor and statistically uncertain ($p = 0.224$).

Among the control variables, primary school enrollment remains the only significant factor influencing HDI ($p = 0.045$), underscoring the crucial role of education in enhancing human development outcomes in emerging economies.

Diagnostic statistics, presented in Appendix D (Table D1), confirm the validity of the GMM specification:

- AR(1) and AR(2) tests show no serial correlation in differenced residuals ($p = 0.327$ and $p = 0.788$, respectively).
- Sargan ($p = 0.974$) and Hansen ($p = 0.751$) tests indicate that the chosen instruments are valid and not over-identified.
- The Wald test confirms joint model significance ($F(26,30) = 219.64$, $p < 0.001$).
- These results validate the robustness of the FE findings and confirm that the dynamic specification provides consistent and unbiased estimates.

Table IV. Difference GMM Estimation Results

Variable	Coefficient	Std. Error	z-stat	p-value
L.HDI	0.5404**	0.7158	0.75	0.456
Internet Users	0.00008	0.00010	0.77	0.444
Governance (Rule of Law)	0.00249	0.00357	0.70	0.491

Interaction	-0.00097	0.00078	-1.24	0.224
Primary Enrollment	0.00042**	0.00020	2.09	0.045
Urbanization	0.00086	0.00117	0.73	0.469
Dependency Ratio	0.00110	0.00093	1.18	0.247
AR(1)	$z = -0.98$	$p = 0.327$		
AR(2)	$z = 0.27$	$p = 0.788$		
Hansen test	$\chi^2(4) = 1.92, p = 0.751$			
Sargan test	$\chi^2(4) = 0.49, p = 0.974$			

Notes: ** $p < 0.05$. Instruments: lagged levels (L4–L8) of HDI and exogenous regressors. Cluster-robust standard errors applied.

5.3. Marginal Effects of Digitalization Across Governance Levels

To interpret the moderating relationship, the marginal effect of digitalization on human development is calculated at various levels of governance quality (–1 to +1 standard deviations from the mean). Results in Table V and Figure 2 show that the positive effect of digitalization gradually decreases as governance improves.

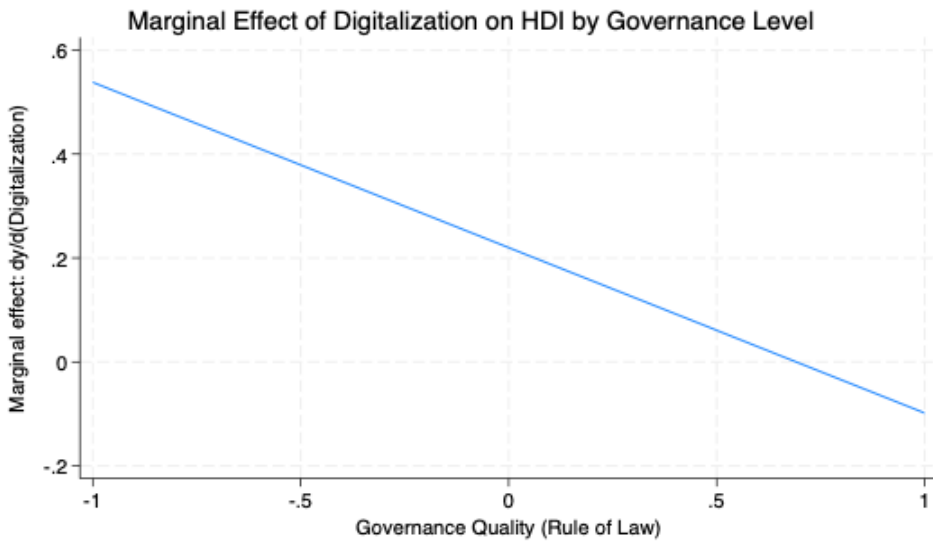


Figure 2. Marginal Effect of Digitalization on Human Development by Governance Quality (Rule of Law)

This pattern reflects the ability of digital tools to substitute for missing or inefficient public services in weak-governance environments, often allowing individuals to bypass informal or ineffective institutional channels. At low governance levels (–1 SD), digitalization significantly boosts human development ($dy/dx = 0.26, p < 0.05$). This marginal effect declines to 0.15 and becomes statistically insignificant at +1 SD. These results confirm that the advantages of digitalization are most prominent in weaker

institutional settings, where digital tools help fill governance gaps. In better-governed environments, however, the institutional system already supports service delivery and transparency, reducing the additional impact of technology.

Table V. Marginal Effects of Digitalization by Governance Level

Governance Level	dy/dx (Digitalization)	Std. Err.	p-value
-1 SD	0.26**	0.11	0.020
-0.5 SD	0.23**	0.10	0.028
0 SD	0.21**	0.10	0.031
+0.5 SD	0.18*	0.11	0.087
+1 SD	0.15	0.12	0.142

Notes: **p < 0.05, *p < 0.10. Computed using margins, at (gov= (-1(0.5)1))

dydx(r_internet_users)

The figure shows that digitalization has a bigger impact on human development in countries with weaker governance. As institutional quality improves, the additional benefits from digital technologies decrease, suggesting that digitalization and institutional strength can complement each other in promoting human development.

5.4. Summary of Empirical Evidence

The combined evidence from the FE and GMM estimations confirms three key insights:

- Digitalization enhances human development in emerging economies, although its impact depends on the quality of institutions.
- Governance quality remains a fundamental determinant of welfare, but its interaction with digitalization is negative, indicating a substitutive rather than complementary relationship.
- Education (primary enrollment) is the only consistently significant control variable, highlighting the long-term importance of human capital in turning technological and institutional reforms into human development gains.
- Overall, the results support the idea that institutions shape the developmental benefits of technology. Digital expansion can compensate for weak governance but cannot replace institutional reform in the long term. These empirical findings provide a foundation for the discussion and policy recommendations in the next section.

6. Discussion

The empirical results of this study show that digitalization has a positive and statistically significant impact on human development in emerging economies. However, this effect depends on the quality of governance. Both the Fixed-Effects and Difference GMM estimations indicate that while increased internet access improves the Human

Development Index (HDI), the interaction between digitalization and governance quality is negative. This implies that the marginal benefits of digitalization decrease as institutional quality improves—suggesting a substitutive relationship between technology and governance in promoting welfare improvements.

This finding closely aligns with the institutional economics framework developed by North (1990) and Acemoglu and Robinson (2012), which argues that the structure and quality of institutions fundamentally determine economic and social outcomes. In settings with weak or inefficient governance, digital technologies can bridge institutional gaps by providing access to services, information, and markets that might otherwise be unavailable. Digital tools help reduce administrative barriers, minimize information asymmetries, and deliver essential services to communities excluded from traditional systems. As a result, the developmental impact of digitalization is most significant in countries with fragile institutional frameworks, where technology effectively offsets governance weaknesses.

As governance quality improves, however, the additional benefits of digitalization diminish. In countries with strong institutions, governments already offer transparent, accountable, and efficient service delivery systems. In these contexts, digitalization adds less marginal value because many functions it improves—such as transparency, accountability, and effective administration—are already part of existing governance systems. Therefore, digitalization and governance seem to act as substitutes at lower levels of institutional development but gradually become complementary as institutional maturity grows. This nonlinear dynamic illustrates how digital and institutional capacities evolve in tandem over the long term, shaping development trajectories.

The positive and significant role of education, as reflected in primary school enrollment, supports Sen's (1999) capability approach, which views human development as the growth of individual freedoms and opportunities. Education enhances people's ability to turn digital access into meaningful capabilities by improving literacy, skills, and innovation potential. This highlights that technological progress alone cannot produce inclusive welfare gains; it must be backed by human capital investment that enables effective use of technology. Meanwhile, the limited impact of structural variables, such as urbanization and the dependency ratio, suggests that demographic and spatial changes tend to evolve slowly compared to the digital and institutional shifts shaping human development.

The results also offer a framework for reconciling mixed findings in the empirical literature. Studies like Asongu and Odhiambo (2019) highlight the positive impact of ICT and digital inclusion on social and economic development, while others, including Qureshi (2019), warn that technology may worsen inequality or reinforce inefficiencies if institutional safeguards are weak. This analysis combines these views by showing that the developmental benefits of digitalization depend on institutional quality. When governance is weak, digitalization serves as a compensatory tool. Still, when governance is strong, its additional contribution lessens because the institutional framework already ensures efficient resource allocation and service delivery. These results align with those of Le Caous and Huarng (2021), who emphasize that structural and contextual factors—such as migration and logistics—shape the conditions under which digital and institutional forces produce inclusive development.

From a policy perspective, the implications are clear. Digital transformation, although essential, cannot achieve sustainable human development on its own. Policymakers in emerging economies should develop integrated strategies that combine technological growth with institutional reforms to enhance transparency, accountability, and service quality. Strengthening regulatory frameworks for data protection, cybersecurity, and e-government is crucial for building public trust and ensuring that digital systems benefit the entire population, rather than deepening existing inequalities. Likewise, expanding digital literacy and educational initiatives can help citizens effectively use technology for learning, entrepreneurship, and civic participation—especially among marginalized groups such as youth, women, and rural communities.

International cooperation and public–private partnerships can accelerate progress by providing access to expertise, funding, and infrastructure needed for digital and institutional growth. Collaborative efforts that combine good governance with technological innovation are likely to yield the most lasting results.

Overall, the findings confirm that neither technology nor governance alone can drive human progress. Digitalization provides tools for expanding opportunities, while governance determines how effectively these tools are utilized to enhance welfare and inclusion. The interaction between the two is dynamic: digitalization may initially replace weak institutions but ultimately depends on institutional maturity to sustain its benefits. Over time, as institutions strengthen, digital and governance improvements become mutually supportive, reinforcing each other in promoting fair and sustainable human development.

In summary, digitalization presents both challenges and opportunities for emerging economies. It can temporarily compensate for institutional weaknesses, but sustained progress relies on establishing strong, transparent, and accountable governance systems. Only when digital transformation is integrated into solid institutional frameworks and supported by education and inclusion policies can it fully realize its potential to promote human development.

7. Conclusion

The central contribution of this study is to show that digitalization delivers its largest human development gains precisely where institutional quality is weakest, highlighting technology's compensatory—rather than purely complementary—role in emerging economies.

This study examined the joint influence of digitalization and governance quality on human development in emerging economies from 2002 to 2023. Using a balanced panel of 30 countries and applying both Fixed-Effects and two-step Difference GMM estimators, the analysis revealed that digitalization has a positive and statistically significant impact on human development. However, this impact is moderated by governance quality: the interaction between digitalization and governance is negative, indicating that the marginal benefits of digital progress decrease as institutional quality improves. These findings highlight a dynamic in which technology and institutions can substitute for one another in shaping welfare outcomes.

The results support the institutional economics view that development outcomes depend on governance structures that mediate technological and economic changes. In

countries with weak institutions, digital technologies can fill governance gaps by expanding access to services, information, and opportunities. However, as institutional capacity strengthens, the added value of digitalization declines, indicating that digital and institutional progress need to develop in tandem. Education also plays a crucial role in translating technology into capability growth, underscoring the enduring importance of human capital in digital transformation.

From a policy standpoint, these findings stress that digitalization alone cannot guarantee inclusive and sustainable human development without effective governance. Emerging economies should therefore align their digital strategies with institutional reforms that enhance transparency, accountability, and the rule of law. Investing in digital literacy, education, and mechanisms that foster public trust will enable citizens to use technology effectively and fairly. Additionally, improving regulatory frameworks—covering data protection, cybersecurity, and e-government—can ensure that technological innovation promotes broad welfare rather than increasing inequalities. International cooperation and partnerships with the private sector can also support the development of the institutional and technical capacity necessary for responsible digital governance.

While this study adds new evidence on how digitalization interacts with governance, several limitations should be acknowledged. The analysis relies on national-level indicators, which may conceal regional or sectoral disparities in digital access and institutional performance. Future research could address this limitation by using subnational or micro-level data to better capture within-country heterogeneity. Moreover, governance is measured here by the Rule of Law Index, which, although robust, represents only one dimension of institutional quality. Subsequent studies may incorporate broader governance indicators—such as government effectiveness, regulatory quality, or corruption control—to examine alternative moderating channels. Finally, an important extension would be to explore potential nonlinear or threshold effects in the digitalization–governance relationship, as well as sector-specific mechanisms, particularly in health, education, and fiscal governance, using regional or micro-level data.

In summary, digital transformation offers both opportunities and challenges for emerging economies. Technology can temporarily substitute for weak institutions, but long-term success depends on strong, inclusive, and adaptable governance systems. Sustainable development requires more than just digital connectivity—it needs institutional integrity, public trust, and equitable access. By combining technological advancement with governance reforms and human capital development, emerging economies can turn digital progress into genuine human development and foster more inclusive and resilient growth.

Abbreviations:

The following abbreviations are used in this manuscript:

- HDI: Human Development Index
- WGI: Worldwide Governance Indicators
- ICTs: Information and communication technologies
- FE: Fixed-effects
- WDI: World Development Indicators (WDI)

LLC: Levin–Lin–Chu tests
 IPS: Im–Pesaran–Shin tests

References

- Acemoglu, D., & Robinson, J. A. (2012). *Why nations fail: the origins of Power, prosperity, and poverty*. Crown Business.
- Aghion, P., & Howitt, P. (2009). *The economics of growth*. MIT Press.
- Albiman, M. M., & Sulong, Z. (2017). The linear and non-linear impacts of ICT on economic growth, of disaggregate income groups within SSA region. *Telecommunications Policy*, 41(7–8), 555–572. <https://doi.org/10.1016/j.telpol.2017.07.007>.
- Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies*, 58(2), 277–297. <https://doi.org/10.2307/2297968>.
- Asongu, S. A., & Odhiambo, N. M. (2019). Basic formal education quality, information technology, and inclusive human development in sub-Saharan Africa. *Sustainable Development*, 27(3), 419–428. <https://doi.org/10.1002/sd.1914>.
- Bannister, F., & Connolly, R. (2020). The future ain't what it used to be: forecasting the impact of ICT on the public sphere. *Government Information Quarterly*, 37(1), 101410. <https://doi.org/10.1016/j.giq.2019.101410>.
- Chakravorti, B., Chaturvedi, R. S., Filipovic, C., & Brewer, G. (2020). Digital in the time of COVID: trust in the digital economy and its evolution across 90 economies as the planet paused for a pandemic. The Fletcher School at Tufts University.
- Gaygisiz, E. (2013). How are cultural dimensions and governance quality related to socioeconomic development? *Journal of Socio-Economics*, 47, 170–179. <https://doi.org/10.1016/j.socec.2013.02.012>.
- Kaufmann, D., Kraay, A., & Mastruzzi, M. (2010). The worldwide governance indicators: methodology and analytical issues. World Bank. <https://doi.org/10.1596/1813-9450-5430>.
- Le Caous, E. S., & Huarng, F. (2021). Economic complexity and human development: moderated by logistics and international migration. *Sustainability*, 13(4), 1867. <https://doi.org/10.3390/su13041867>.
- Malanski, L. K., & Póvoa, A. C. S. (2021). Economic growth and corruption in emerging markets: does economic freedom matter? *International Economics*, 166, 58–70. <https://doi.org/10.1016/j.inteco.2021.02.001>.
- Niebel, T. (2018). ICT and economic growth—Comparing developing, emerging, and developed countries. *World Development*, 104, 197–211. <https://doi.org/10.1016/j.worlddev.2017.11.024>.
- North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge University Press. <https://DOI.ORG/10.1017/CBO9780511808678>.
- Qureshi, S. (2019). Perspectives on development: why does studying information and communication technology for development (ICT4D) matter? *Information Technology for Development*, 25(3), 381–389. <https://doi.org/10.1080/02681102.2019.1658478>.
- Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, 98(5, Part 2, Pt. 2), S71–S102. <https://doi.org/10.1086/261725>.
- Sen, A. (1999). *Development as freedom*. Oxford University Press.
- United Nations Development Programme (UNDP). (1990). *Human development report 1990*. Oxford University Press.
- Vu, K. M. (2020). Sources of growth in the world economy: A comparison of G7 and E7 economies. In *Measuring economic growth and productivity* (pp.55–74). Academic Press. <https://doi.org/10.1016/B978-0-12-817596-5.00004-4>.
- World Bank. (2024). *Worldwide Governance Indicators (WGI), 2024 Update*. <https://www.govindicators.org>.