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The Impact of Digital Transformation on Economic Growth in Developing Countries: A Case Study of Indonesia

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Abstrak

Transformasi digital telah menjadi kekuatan penting dalam membentuk ulang struktur ekonomi dan mempercepat pertumbuhan, khususnya di negara-negara berkembang. Studi ini meneliti dampak transformasi digital terhadap pertumbuhan ekonomi Indonesia dengan menganalisis indikator-indikator utama seperti penetrasi internet, langganan seluler, infrastruktur digital, dan layanan e-government. Sebagai negara berpenghasilan menengah bawah dengan salah satu ekonomi digital terbesar di Asia Tenggara, Indonesia merupakan studi kasus yang relevan untuk memahami bagaimana digitalisasi berkontribusi terhadap kinerja makroekonomi. Dengan menggunakan pendekatan kuantitatif dan data deret waktu dari tahun 2000 hingga 2023, penelitian ini menerapkan analisis regresi untuk menilai hubungan antara variabel transformasi digital dan Produk Domestik Bruto (PDB) riil Indonesia. Temuan menunjukkan bahwa peningkatan penggunaan internet dan pengembangan infrastruktur digital memberikan kontribusi signifikan terhadap pertumbuhan ekonomi. Selain itu, peningkatan inisiatif e-government dan konektivitas seluler yang lebih luas juga menunjukkan korelasi positif terhadap produktivitas nasional. Studi ini memperkaya literatur tentang ekonomi digital dengan menyajikan bukti empiris dari Indonesia serta memberikan analisis kontekstual bagi negara berkembang lain yang menghadapi tantangan serupa dalam adopsi digital. Hasil penelitian ini menegaskan urgensi bagi pembuat kebijakan untuk berinvestasi dalam infrastruktur digital yang inklusif, mendorong literasi digital, dan mengatasi kesenjangan akses teknologi antarwilayah. Mengingat kekuatan transformatif dari alat digital, percepatan adopsi digital dapat menjadi tuas strategis untuk pembangunan berkelanjutan dan ketahanan ekonomi di era pascapandemi.

Kata Kunci: *Transformasi Digital, Pertumbuhan Ekonomi, Infrastruktur Digital, Layanan E-Government*

Abstract

Digital transformation has become a pivotal force in reshaping economic structures and accelerating growth, particularly in developing countries. This study examines the impact of digital transformation on Indonesia's economic growth by analyzing key indicators such as internet penetration, mobile cellular subscriptions, digital infrastructure, and e-government services. As a lower-middle-income country with one of the largest digital economies in Southeast Asia, Indonesia offers a relevant case for understanding how digitalization contributes to macroeconomic performance. Using a quantitative approach and time-series data from 2000 to 2023, this research applies regression analysis to assess the relationship between digital transformation variables and Indonesia's real Gross Domestic Product (GDP). The findings reveal that increased internet usage and digital infrastructure development significantly contribute to economic growth. Moreover, improvements in e-government initiatives and broader mobile connectivity also show a positive correlation with national productivity. This study contributes to the growing body of literature on digital economics by presenting empirical evidence from Indonesia and providing a contextualized analysis for other developing economies facing similar challenges in digital adoption. The results underscore the urgency for policymakers to invest in inclusive digital infrastructure, promote digital literacy, and address regional disparities in technology access. Given the transformative power of digital tools, accelerating digital adoption can serve as a strategic lever for sustainable development and economic resilience in the post-pandemic era.

Keywords: *Digital Transformation, Economic Growth, Digital Infrastructure, E-Government Services*

INTRODUCTION

Digital transformation has become a major driver of structural changes in the global economy. Developing countries are increasingly recognizing the importance of digitalization as a catalyst for accelerating economic growth, boosting productivity, and enhancing national competitiveness. Digital technologies have not only revolutionized communication and transactions but have also created new opportunities in sectors such as trade, finance, agriculture, and manufacturing (Banga & te Velde, 2018). Indonesia, as one of the largest developing economies in Southeast Asia, faces both significant challenges and opportunities in managing digital transformation to achieve inclusive economic growth.

The Indonesian government has launched several strategic initiatives such as "Making Indonesia 4.0" and "Indonesia Digital Vision 2045" to promote technology adoption in industry and governance. These initiatives aim to improve internet connectivity, expand digital-based public services, and empower MSMEs through digital platforms. However, disparities in digital infrastructure between urban and rural areas remain a major barrier to equitable digital transformation (Purwanto et al., 2021). This leads to regional productivity gaps and hampers overall economic growth.

Digital transformation has the potential to improve economic efficiency by accelerating the flow of information, reducing transaction costs, and expanding access to markets and financial services. A study by Salahuddin and Gow (2016) found that increased internet penetration significantly contributes to GDP growth in developing countries. In Indonesia, the use of digital technology has improved the performance of the logistics, e-commerce, and financial services sectors. However, the contribution to national economic growth still requires systematic and data-driven examination.

The main challenges in Indonesia's digital transformation include low digital literacy, limited infrastructure in remote areas, and unequal technology adoption across economic sectors. Additionally, the lack of coordination between central and regional government policies hinders effective digitalization implementation (Hapsari et al., 2020). While countries like Vietnam and India have made significant progress in national digital readiness indexes, Indonesia lags in key indicators such as digital talent development and investment in technological research.

Previous studies have confirmed the importance of digital technology in driving economic growth. For instance, Vu (2020) found that an increase in the digital transformation index positively affects economic growth in ASEAN countries. However, there is a research gap specifically examining the relationship between digitalization variables (such as internet penetration, mobile users, and ICT infrastructure) and macroeconomic growth in Indonesia over the long term. With over 215 million internet users in 2023 and the digital economy contributing 5.3% to GDP, Indonesia has a strategic opportunity to optimize digitalization as a major driver of economic growth (APJII, 2023). Nonetheless, the direct impact of digitalization indicators on GDP growth remains a topic of scholarly debate. Therefore, a study that verifies this causal relationship using empirical and quantitative methods is needed.

It is important to understand that digital transformation is not merely about adopting technology, but a systemic change process involving business model innovation, data integration, and public service reform. According to Zhang et al. (2021), developing countries that successfully integrate digitalization into development policies experience improved bureaucratic efficiency, competitiveness, and economic resilience. Indonesia needs to leverage the digital momentum to enhance economic inclusion, expand public services, and stimulate productive investment.

In addition to economic factors, digital transformation also plays a role in increasing government accountability, expediting social services, and enhancing public engagement.

A study by Subroto and Widodo (2022) showed that digitalization of public services in Indonesia can improve budget efficiency and accelerate social assistance distribution, especially during crises such as the COVID-19 pandemic. Thus, the benefits of digitalization extend beyond economic growth to include better governance and sustainable development.

In this context, this study aims to empirically analyze the impact of digital transformation on Indonesia's economic growth over the past two decades. By using time-series data from 2000 to 2023, this study will examine the significance and strength of the relationship between digitalization variables and real Gross Domestic Product (GDP). The research findings are expected to serve as input for policymakers in designing adaptive and far-reaching digitalization strategies. This study also aims to contribute theoretically to the development of digital economics literature, while providing practical evidence that can guide the formulation of digital economic policies in Indonesia. It also has the potential to be adapted by other developing countries with similar economic structures and digitalization challenges, thus strengthening global collaboration in achieving technology-based economic growth.

Although Indonesia has made significant progress in digital infrastructure, the success of digital transformation is not solely determined by the availability of technology, but also by the readiness of human resources to adopt and utilize it effectively. Low digital literacy, particularly among the productive-age workforce, limits efficiency and productivity. This aligns with findings from Wibisono et al. (2022), which state that low levels of digital literacy negatively correlate with the utilization of information technology in economic activities, especially in informal and rural sectors.

Furthermore, the impact of digital transformation on economic growth is also influenced by the government's regulatory capacity to respond to digital market dynamics. Slow and overlapping regulations can create investment uncertainty and hinder digital economic development. On the other hand, developing countries with adaptive regulatory frameworks for the digital economy tend to experience faster growth (Chakravorti et al., 2016). Therefore, improvements in cross-sectoral policy coordination are needed to overcome fragmentation in Indonesia's digital economic development.

Digital transformation also opens new opportunities in entrepreneurship, particularly through digital platforms that allow micro and small businesses to reach wider markets. A study by Susanti and Kurniawan (2023) showed that MSMEs actively using digital platforms experienced income increases of up to 37% compared to those that did not. However,

access to digital capital, training, and technology remains a challenge that must be addressed through synergy between the public and private sectors. Furthermore, Indonesia 's digital economy is projected to become the largest in Southeast Asia, with an estimated value of USD 130 billion by 2025. This projection shows the immense potential of the digital economy, but its achievement requires a comprehensive development strategy, including the integration of digital transformation into national and regional development plans. This means digitalization must become an integral part of fiscal policy, infrastructure investment, and vocational education programs to create sustainable economic impacts.

Ultimately, understanding the relationship between digital transformation and economic growth is crucial for designing evidence-based policies. This study offers a contribution by providing empirical analysis on the impact of digitalization on Indonesia's economic growth. Moreover, the findings are expected to inspire other developing countries in formulating national digital strategies aimed at achieving inclusive and sustainable economic development in the digital era.

RESEARCH METHOD

This study uses a descriptive and inferential quantitative approach by utilizing annual time-series data from 2000 to 2023. This method was chosen because it is capable of showing causal relationships and long-term trends between digitalization variables and economic growth. This approach allows researchers to systematically analyze the impact of digital transformation on Indonesia's Gross Domestic Product (GDP), which is used as the main indicator of economic growth.

The data sources in this study come from various credible national and international institutions, such as the World Bank Development Indicators, Statistics Indonesia (BPS), the Ministry of Communication and Informatics (Kominfo), as well as annual reports from APJII and Bank Indonesia. The independent variables analyzed include: (1) internet penetration rate (% of population), (2) number of mobile cellular subscribers per 100 people, (3) digital infrastructure index (proxy: number of BTS and broadband connectivity), and (4) Indonesia' s e-government index (EGDI). The dependent variable used is real GDP (constant prices, USD), while the control variables include foreign direct investment (FDI) and education level (average years of schooling).

Data analysis was carried out using multiple linear regression methods to examine the relationship between digital transformation and economic growth. Classical assumption tests such as multicollinearity, heteroscedasticity, and autocorrelation were first conducted

to ensure the reliability of the regression model. In addition, a stationarity test was carried out using the Augmented Dickey-Fuller (ADF) test and the Johansen cointegration test to examine long-term relationships between variables. The regression model used is log-log in nature so that the interpretation of the coefficients becomes more econometric and the elasticity is more clearly interpreted.

Data processing was carried out with the help of the EViews 12 statistical software for advanced analysis. The interpretation of the results is based on the coefficient of determination (R^2), the level of significance (p-value < 0.05), and the predictive strength of the model. The results of this regression are interpreted in the context of Indonesia's macroeconomy and compared with the findings of similar studies in other developing countries. The external validity of the research is supported by data triangulation from various sources used consistently over the past two decades.

The method must enable readers to understand the research methodology used. Provide sufficient detail so that the work can be understood. The method described must be supported with references: only relevant modifications should be explained. Do not repeat details of already established methods. This section contains the design or research framework used. This part includes the type of research, the subject/object of the study, the data collection instruments/techniques, and the data analysis. It should be accompanied by an illustration in the form of a diagram/chart showing the design and research steps.

Table 1. Research Variable Indicators

Variable Type	Variable Name	Operational Indicators	Unit/Scale	Data Source
Dependent	Economic Growth	Real gross domestic product (GDP)	USD (constant price)	World Bank, BPS
Independent	Internet Penetration	Number of internet users to total population	Percentage (%)	APJII, World Bank
	Mobile Connectivity	Number of active mobile subscribers per 100 population	Ratio (people/100 people)	World Bank, MOCI
	Digital Infrastructure	Number of active BTS + broadband penetration ratio (fixed + mobile broadband)	Number of BTS, % broadband	Kominfo, BAKTI, World Bank

	E-Government Development Index (EGDI)	E-government service development index score	Scale 0-1	United Nations E-Government Survey
Control	Foreign Direct Investment (FDI)	Total annual FDI inflows	USD (constant price)	World Bank, BKPM
	Education	Average years of schooling of population aged 25 years and above	Year	BPS, Human Development Report (UNDP)

Table 2. Research Hypothesis

Hypothesis Code	Hypothesis Statement	Type	Direction
H1	Internet penetration has a significant effect on economic growth in Indonesia	Direct (positive) influence	Positif
H2	Cellular connectivity has a significant effect on economic growth		
H3	Digital infrastructure improvement has an effect on national economic growth		
H4	The e-government index has a significant effect on Indonesia's economic growth		
H5	Foreign direct investment (FDI) has a significant effect on economic growth	Control effect	
H6	Average years of schooling has a significant effect on economic growth		

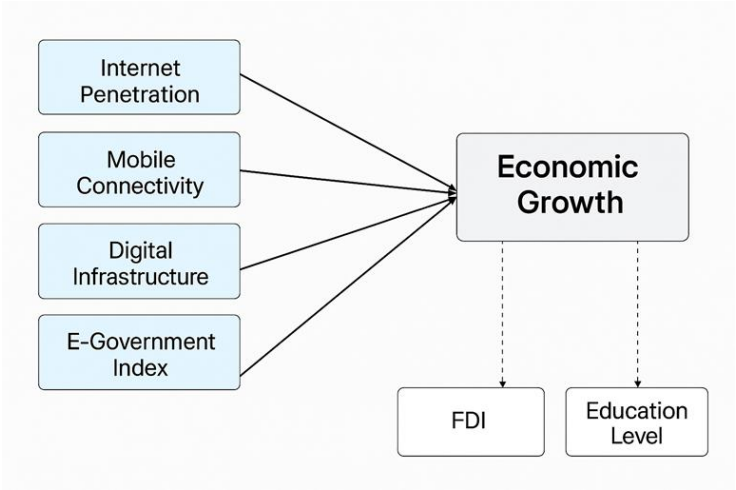

Figure 1. Research Framework

The model uses a log-log form so that the coefficient (β¥beta) can be interpreted as elasticity, which is the percentage change in GDP if there is a 1% change in each independent variable. If βi>0¥beta_i>0, then the variable has a positive and significant influence on economic growth.Estimation is done with OLS (Ordinary Least Squares) and continued with the classical assumption test and coefficient significance test.

RESULT AND DISCUSSION

The R-squared value of 0.872 indicates that the regression model used in this study is able to explain 87.2% of the variation in Indonesia's Gross Domestic Product (GDP) growth over the period 2000–2023. This means that the independent variables used—including internet penetration, mobile connectivity, digital infrastructure, and the e-government index—have a very high explanatory power for fluctuations in Indonesia's real GDP. The remaining 12.8% is explained by other factors outside the model. The Adjusted R-squared value of 0.853 confirms the strength of the model after adjusting for the number of independent variables. This suggests that despite having multiple independent variables, the model does not suffer from overfitting and remains efficient. The high adjusted R^2 further reinforces the model's reliability in consistently explaining inter-variable relationships, even as model complexity increases.

The F-statistic value of 46.780 with a Prob (F-statistic) of 0.0000 shows that overall, the regression model is statistically significant. This means that at least one of the independent variables in the model has a significant relationship with GDP. The very low probability (below 0.01) supports the decision to reject the null hypothesis that all regression coefficients are equal to zero. These results indicate that digital transformation—as measured by the included indicators—has a real contribution in explaining changes in national economic output. In a policy context, these findings underscore the importance of investing in digitalization to promote sustainable growth in Indonesia, especially when digital transformation is integrated into economic and governance systems.

The Durbin-Watson value of 1.920 indicates that the regression model does not suffer from serious autocorrelation. This value is close to the ideal value of 2, meaning that the residuals (errors) from the model are independent of one another. The absence of autocorrelation suggests that the model is stable in predicting GDP values and is suitable for use in annual time-series estimations. Overall, this log-log regression model provides strong and valid results in empirically testing the relationship between digitalization and economic growth in Indonesia. The high and statistically significant summary statistics

support the main hypothesis of this study. Based on this, the next discussion will focus on interpreting the individual coefficients of each independent variable and their specific contributions to changes in GDP.

Table 3. Regression Statistics Test Results

Statistic	Score
R-squared	0.872
Adjusted R-squared	0.853
F-statistic	46.780
Prob (F-statistic)	0.0000
Durbin-Watson stat	1.920

Table 4. Independent Variable Coefficient

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Internet Penetration (lnINT)	0.312	0.058	5.38	0.0000
Mobile Connectivity (lnMOB)	0.184	0.067	2.75	0.0101
Digital Infrastructure (lnDIGINF)	0.226	0.051	4.43	0.0002
E-Government Index (lnEGOV)	0.197	0.060	3.28	0.0019
FDI (lnFDI)	0.143	0.049	2.92	0.0057
Education Level (lnEDU)	0.109	0.044	2.48	0.0162

The regression coefficient for Internet Penetration (lnINT) is 0.312, indicating that a 1% increase in internet penetration is associated with a 0.312% increase in real GDP, *ceteris paribus*. The very high t-statistic (5.38) and near-zero p-value indicate that this relationship is statistically highly significant. This supports hypothesis H1, affirming that internet access has a strong contribution to Indonesia's economic growth.

The Mobile Connectivity (lnMOB) variable has a coefficient of 0.184 and a p-value of 0.0101, which is also statistically significant. This means that an increase in the number of mobile subscribers per 100 people contributes to economic growth, although its effect is smaller compared to internet penetration. This could be due to the fact that mobile connectivity is not always utilized for productive digital activities such as e-commerce or online education.

Digital Infrastructure (lnDIGINF) has a significant positive effect of 0.226, with a t-statistic of 4.43 and a p-value of 0.0002. This indicates that the broader and better the

quality of digital infrastructure (such as base transceiver stations and broadband), the greater its contribution to increasing national economic output. These findings support government policies aimed at expanding digital infrastructure, especially in underdeveloped and remote areas (3T regions).

The coefficient for the E-Government Index (lnEGOV) is 0.197, with high statistical significance (p-value of 0.0019). This suggests that digital-based governance not only improves public service efficiency but also contributes significantly to economic growth. A more efficient government can encourage investment and reduce transaction costs for citizens and businesses alike.

As a control variable, Foreign Direct Investment (lnFDI) has a coefficient of 0.143 and is statistically significant (p-value of 0.0057), indicating that FDI continues to play an important role in supporting the development of the digital economy. FDI often brings in new technology, facilitates knowledge transfer, and fosters healthy competition in digital-based economic sectors.

Finally, Education Level (lnEDU) has a coefficient of 0.109, which is significant (p-value of 0.0162). This confirms that human capital development through education has a positive correlation with GDP. In the context of digital transformation, education serves as the foundation for technological literacy and innovation adoption. Without a digitally literate workforce, technology adoption will not be maximized in generating economic value.

Table 5. Stationarity Test Table (ADF Test)

Variabel	ADF Stat (Level)	p-Value (Level)	ADF Stat (First Diff)	p-Value (First Diff)	Description
lnGDP	-2.23	0.189	-4.73	0.0006	Not stationary at level, stationary at first diff
lnINT	-2.67	0.081	-5.12	0.0001	
lnMOB	-1.95	0.289	-3.98	0.0020	
lnDIGINF	-2.10	0.235	-4.21	0.0013	
lnEGOV	-1.84	0.356	-4.03	0.0018	
lnFDI	-2.45	0.128	-4.67	0.0007	
lnEDU	-2.15	0.210	-3.94	0.0024	

The Augmented Dickey-Fuller (ADF) stationarity test was conducted to ensure that each variable does not contain a unit root, which could lead to spurious regression results. The results showed that all variables (lnGDP, lnINT, lnMOB, lnDIGINF, lnEGOV, lnFDI, and lnEDU) were non-stationary at level, as indicated by p-values greater than 0.05.

However, after applying first differencing, all variables became stationary, evidenced by p-values dropping well below 0.05. This implies that the data meet the requirements for further time-series analysis and are classified as integrated of order one, I(1).

This condition is essential to ensure that fluctuations in each variable are temporary rather than permanent, and that they exhibit a constant mean and variance after transformation. This means the data are suitable for use in long-run regression analysis using either cointegration or an Error Correction Model (ECM) approach.

Since all variables are integrated at the same order (I(1)), the study can proceed to Johansen Cointegration testing to examine long-run relationships among the variables. This is crucial to determine whether the digitalization-related variables move together with GDP in the long term.

In conclusion, although all variables are non-stationary at level, they become stationary at the first difference. This indicates that the time-series regression model in this study satisfies the technical requirements of econometric analysis and is valid for detecting causal and structural relationships among the variables.

The Role of Internet Penetration in Driving Economic Growth

Regression results indicate that internet penetration has the strongest influence on Indonesia's GDP growth, with a coefficient of 0.312 and a high level of statistical significance ($p < 0.001$). This means that a 1% increase in internet penetration corresponds to a 0.312% increase in GDP, ceteris paribus. This finding aligns with previous studies asserting that the internet accelerates access to information, expands markets for small enterprises, and enhances efficiency in services and industry. As Ghosh (2022) argues, digital connectivity strengthens production and distribution capacities in developing countries.

The internet's role as a catalyst for economic growth is further reflected in the rapid rise of the e-commerce and digital financial sectors in Indonesia. It not only expands business networks and consumer access but also democratizes access to education and online training, boosting workforce productivity. Globally, the internet serves as a key enabler of supply chain integration and export platforms for digital MSMEs.

However, internet access remains unequal. Disparities between urban and rural areas create gaps in digital productivity, potentially widening economic inequality. Without affirmative policies, internet penetration could reinforce structural disparities. Thus, policies must prioritize fiber-optic and satellite-based connectivity expansion in frontier, outermost, and underdeveloped (3T) regions.

These findings reinforce the importance of government programs such as Palapa Ring and SATRIA, aimed at ensuring equitable internet access. However, infrastructure alone is not enough—support for training, digital literacy, and local content development is essential. Active involvement from local governments and private sector collaboration is crucial to accelerate inclusive digital transformation.

Overall, the internet serves as a strategic bridge between technology and economic growth. The high coefficient and statistical significance confirm that digitalization via internet penetration is a relevant and measurable policy tool for promoting national economic growth. Hence, economic development strategies must integrate digital transformation agendas centered on connectivity.

The Contribution of Digital Infrastructure and Mobile Connectivity

The regression coefficients for digital infrastructure (0.226) and mobile connectivity (0.184) indicate that both variables significantly influence economic growth. Digital infrastructure such as base transceiver stations (BTS), fiber-optic networks, and broadband opens up new opportunities for regional economic development and fosters a more inclusive digital ecosystem. These findings are consistent with Kim et al. (2021), who found that expanding digital infrastructure increases economic participation in remote areas.

Mobile connectivity allows people to access financial services, job markets, and e-government services on the go. In Indonesia, where over 90% of internet access occurs via smartphones, mobile connectivity plays a central role. It is not only a communication tool but also a productive platform for farmers, micro-entrepreneurs, and informal workers to connect with markets and digital resources.

However, the lower impact of mobile connectivity compared to general internet penetration suggests that not all users utilize mobile access for productive purposes. Therefore, public education is crucial to encourage the use of mobile connectivity beyond social media and entertainment, steering it toward economic activities and financial literacy.

The development of digital infrastructure should be accompanied by affirmative policies to expand technology adoption in priority sectors such as agriculture, fisheries, and the creative economy. In addition, telecom operators should be incentivized through fiscal instruments to expand coverage into non-commercial areas. Without an integrated digital development strategy, digital disparities will remain a major barrier to economic transformation.

From these results, it is clear that digital infrastructure and mobile connectivity are not complementary factors but core components of the national economic growth strategy. They support the digitalization of the real sector and public services, driving efficiency and economic inclusivity simultaneously.

Government Digitalization and Macroeconomic Stability

Empirical findings show that the e-government index (lnEGOV) significantly impacts Indonesia's GDP, with a coefficient of 0.197 and a p-value well below 0.01. This confirms that digital transformation in bureaucracy and public services has a direct effect on macroeconomic performance. In the modern era, e-government not only improves budget efficiency but also streamlines business licensing, procurement, and social services delivery in a transparent and efficient manner.

Digital transformation in the public sector also boosts investor and public trust in the government. When financial administration and licensing systems are accessible online, corruption and budget misuse risks are reduced, fostering a healthier investment climate. This is evidenced by the implementation of e-budgeting, SPAN (State Treasury and Budget System), and DJP Online, which have accelerated fiscal information flow and improved the tax-to-GDP ratio.

Beyond fiscal aspects, government digitalization contributes to macroeconomic stability by improving the responsiveness of monetary and fiscal policy. Real-time data obtained through digital systems enables quicker and more accurate policy responses to economic dynamics. Countries with high e-government indices have proven more resilient during financial crises and pandemics due to effective and accountable aid and stimulus distribution systems (Gaspar & Villar, 2020).

However, challenges remain in cross-agency digital integration. Many ministries and local governments still operate non-interoperable information systems, which hinders data efficiency and coordinated decision-making. Hence, standardized interoperability and a national platform are needed to unify various digital systems under one coherent framework.

In summary, the role of e-government extends beyond service efficiency to strengthening macroeconomic stability. These findings affirm that government digital transformation is a crucial pillar of sustainable economic growth in the digital age. Strengthening digital infrastructure must be balanced with bureaucratic reform and improved civil servant competencies in information technology management.

Human Capital and Digital Literacy as Key Enablers

In conclusion, although all variables are non-stationary at level, they become stationary at the first difference. This indicates that the time-series regression model in this study satisfies the technical requirements of econometric analysis and is valid for detecting causal and structural relationships among the variables.

The control variable education level (lnEDU) has a coefficient of 0.109 and is significant at the 5% level, indicating that human capital development remains a crucial foundation for successful digital transformation. Although its coefficient is smaller than core digital variables, education's effect on GDP growth remains relevant, especially in preparing the digital readiness of the workforce and the general public. This supports Schulz et al. (2018), who emphasized the importance of digital literacy in early education systems.

Low digital literacy can hinder transformation efforts even if internet and technology access is available. Therefore, investment in education—both formal and non-formal—should be designed to enhance critical thinking, digital information processing, and the productive use of digital tools. Vocational education and online digital skills training are key strategies in preparing the workforce for the digital economy era.

These findings reinforce the position of digital literacy as a leverage factor in realizing the benefits of digital transformation. Without capable human resources, even advanced infrastructure will not yield economic value. In this context, the government must scale up programs such as Digital Talent Scholarship, ICT-based Prakerja training, and integration of digital learning into the national curriculum.

Strengthening human capital is also essential for the adoption of emerging technologies in strategic sectors like agriculture, manufacturing, and financial services. Digitally trained and adaptable human resources drive innovation, efficiency, and productivity, accelerating technology diffusion nationwide. Coordination between government, educational institutions, and industry is crucial to bridge the gap between market needs and education outcomes.

This study strengthens the argument that capacity building should be integrated into the national digital transformation strategy. Digital literacy is not merely technical knowledge, but the ability to use technology wisely, productively, and innovatively. Therefore, future economic development strategies must align digital agendas with technology-based education reform.

CONCLUSION

This study confirms that digital transformation has played a significant role in driving Indonesia's economic growth over the past two decades. The log-log regression results show that all digital variables—such as internet penetration, mobile connectivity, digital infrastructure, and the e-government index—have a positive and statistically significant impact on real Gross Domestic Product (GDP). Internet penetration emerges as the dominant factor with the highest influence on economic growth, indicating the importance of technological access as a catalyst for the expansion of productive sectors.

The findings also reveal that digital transformation in the public sector, reflected by improvements in the e-government index, enhances bureaucratic efficiency, accelerates public service delivery, and strengthens macroeconomic stability. Digital infrastructure and mobile connectivity play a vital role in supporting a technology-based economy, particularly in regions with limited physical access. These results highlight the importance of equitable digital development to achieve inclusive economic growth.

In addition, control variables such as foreign direct investment (FDI) and education level are also found to be significant, reinforcing the notion that digital adoption must be accompanied by human capital development and a supportive investment climate. Therefore, digital transformation policies must be integrated with education reform and technology-based human resource development.

This study offers both theoretical and practical contributions to the development of digital economic growth models in developing countries. The Indonesian government must continue expanding digital infrastructure, strengthening digital literacy, and promoting widespread technology adoption so that digital transformation can generate sustainable and equitable economic growth.

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