*Journal of Economics, Entrepreneurship, Management Business and Accounting*, 2026, 4(4), 882-902.
https://doi.org/10.61255/jeemba.v4i4.1070

# Information and Communication Technology as a Mediator of Infrastructure, Labor Quality, and Investment Effects on Regional Economic Growth in Indonesia

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**ABSTRACT**

**Purpose** – Modern economic growth relies not only on physical accumulation but also on digital integration. This paper examines how Information and Communication Technology (ICT) acts as a mediator in the relationship between conventional macroeconomic variables infrastructure, labor quality, domestic investment (PMDN), and foreign investment (PMA) and economic growth in Indonesia.
**Design/methodology/approach** – This quantitative study uses panel data from 34 provinces in Indonesia during the period 2018–2024 (238 observations). The study applies panel data econometric methods to analyze the mediating role of ICT in the relationship between infrastructure, labor quality, investment, and regional economic growth in Indonesia.
**Finding/Results** – The results show that infrastructure, labor quality, PMDN, PMA, and ICT significantly contribute to economic growth in Indonesia. ICT significantly mediates the effects of infrastructure, PMDN, and PMA on economic growth, but does not significantly mediate the relationship between labor quality and economic growth.
**Originality/Value** – This study introduces IP-TIK as the "missing link" explaining why traditional macro variables often fail to yield optimal growth in developing regions. The main take-home message is that physical infrastructure and investments must be integrated with digital ecosystem development to achieve inclusive economic growth.

**ARTICLE INFO**

**Keywords:**
Economic Growth,
Infrastructure,
ICT Mediation,
Labor Quality,
Provincial Investment.

**Article Information:**
Received: 29/04/2026
Revise: 25/06/2026
Accepted: 06/07/2026

**ISSN:**
2985-3168 (Online)
2985-3222 (Print)

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## 1. Introduction

Economic growth remains the primary indicator of a nation's development success, reflecting increased production capacity and sustainable welfare(Keynes, 1936; Jhingan, 2016).. In the modern context, the global shift toward a digital economy has positioned Information and Communication Technology (ICT) as a strategic factor that reshapes how production, distribution, and consumption processes operate. Digitalization not only reduces transaction costs but also enhances efficiency, connectivity, and innovation across sectors (Kretschmer, 2012; Vu, 2011). Consequently, countries that successfully integrate ICT into their economic systems tend to experience more inclusive and resilient growth patterns. From a theoretical perspective, classical and neoclassical growth models emphasize the importance of physical infrastructure, labor quality, Domestic Direct Investment (PMDN), and Foreign Direct Investment (PMA) as the main drivers of economic growth (Solow, 1956; Mankiw et al., 1992). Infrastructure facilitates the movement of goods and services, labor quality determines productivity, while PMDN and PMA provide the capital necessary for expansion and technological advancement (Aschauer,1989; Calderón & Servén, 2010). However, in the context of the digital economy, these traditional factors alone are no longer sufficient to guarantee optimal growth outcomes. Their effectiveness increasingly depends on the presence of enabling technologies, particularly ICT.

Empirical findings in developing countries, including Indonesia, reveal inconsistent results regarding the impact of these variables on economic growth (Niebel, 2018; Albiman & Sulong, 2018). While infrastructure development and investment inflows are generally expected to stimulate economic performance, several studies indicate that their effects can be insignificant or even negative under certain conditions. For instance, PMA does not always generate positive spillovers due to limited technological absorption, weak institutional quality, and low digital readiness (Fazaalloh, 2024; Borensztein et al., 1998). This suggests that the mere presence of capital and infrastructure does not automatically translate into productivity gains without adequate supporting mechanisms. This inconsistency points to a critical gap or "missing link"in existing growth models. ICT potentially serves as a missing link by enhancing the efficiency and effectiveness of traditional growth drivers. Through digital platforms, automation, and improved information flows, ICT enables infrastructure to function more optimally, supports workforce upskilling, and maximizes the benefits of domestic and foreign investments. In this sense, ICT acts not only as a complementary factor but also as a catalytic mediator that strengthens the transmission channels between input factors and economic output (Trihandika et al., 2024; Vu, 2011).

The relevance of this issue is even more pronounced in the Indonesian context. Despite steady economic growth, Indonesia continues to face significant regional disparities, particularly in digital infrastructure and ICT adoption (World Bank, 2024; BPS, 2025). Western regions, such as Java and Sumatra, demonstrate relatively high levels of ICT development, supported by better infrastructure, higher human capital, and greater investment concentration (World Bank, 2024). In contrast, eastern regions, such as Papua and Nusa Tenggara, remain constrained by limited digital access, inadequate infrastructure, and lower levels of technological capability (World Bank, 2024). Regional disparities in Indonesia are reflected not only in differences in infrastructure availability but also in unequal digital readiness across provinces. Provinces located in Java and several urban economic centers tend to enjoy better Internet penetration, stronger digital infrastructure, higher investment concentration, and more technologically adaptive labor markets. In contrast, many eastern regions continue to

experience limited broadband access, weak digital ecosystems and lower technological capabilities. These disparities influence the effectiveness of infrastructure and investment in generating economic growth because regions with weak ICT capacity often struggle to maximize the benefits of development expenditures and capital inflows.

This digital divide creates unequal opportunities for economic participation and reduces the overall efficiency of the nation's development (Abu Alfoul et al., 2024). In regions with low ICT readiness, infrastructure and capital investments often fail to produce significant multiplier effects. High information asymmetry, inefficient logistics, and limited market access hinder economic actors' ability to fully utilize available resources (Baliamoune-Lutz, 2003). As a result, the expected positive relationship between investment, infrastructure, and economic growth becomes weakened. Conversely, in regions with higher ICT adoption, the same inputs tend to generate stronger and more sustainable outcomes. This indicates that ICT plays a crucial role in determining the effectiveness of development input.

Beyond functioning as a statistical intermediary, ICT represents a transformational mechanism that converts traditional economic inputs into productive economic outcomes (Romer, 1990; Vu, 2011). Digital readiness enables infrastructure to operate more efficiently through smart connectivity, integrated logistics systems and real-time information exchange (Niebel, 2018). Likewise, investment effectiveness increasingly depends on digital ecosystems that facilitate innovation, business expansion and market integration. In the labor dimension, ICT strengthens human capital by enabling digital learning, technological adaptation and productivity enhancement. Therefore, ICT should be understood not only as a complementary variable but also as a strategic transformation mechanism that determines whether infrastructure, investment, and labor quality can generate sustainable economic growth in the digital economy era.

Furthermore, the rapid advancement of Industry 4.0 technologies, such as artificial intelligence, big data, and cloud computing, has increased the urgency for countries to strengthen their digital ecosystems (Abu Alfoul et al., 2024). Without adequate ICT integration, developing economies risk being trapped in a low-productivity cycle and unable to compete in the global market. For Indonesia, this challenge is particularly critical, given its ambition to become a major digital economy in Southeast Asia. Strengthening ICT capacity is not only a matter of technological progress but also a strategic necessity for achieving long-term economic transformation. Based on these considerations, this study raises an important research question: how does ICT mediate the impact of infrastructure, labor quality, PMDN, and PMA on economic growth? Unlike previous studies that treat ICT as an independent variable, this research positions ICT as a mediating variable that explains the mechanism through which traditional economic factors influence growth outcomes. This approach provides a more comprehensive understanding of the interactions among physical, human, and digital capital.

The importance of this research lies in several aspects. First, it contributes to the development of economic growth theory by addressing the gap between traditional models and the realities of the digital economy. Second, it offers empirical evidence of the strategic role of ICT in enhancing the effectiveness of development policies, particularly in developing countries. Third, it provides policy-relevant insights for reducing regional disparities by emphasizing the need for integrated development strategies that combine physical infrastructure, human capital development and digital transformation. In conclusion, this study is essential for advancing academic discourse and informing policymakers. By demonstrating that ICT serves

as a critical mediating mechanism, this study highlights the need to move beyond conventional development approaches. Instead, a more holistic strategy that integrates digital infrastructure into the broader economic framework is required to achieve inclusive and sustainable economic growth in Indonesia.

## 2. Literature Review and Hypothesis Development

Modern economic growth theory has evolved from emphasizing purely physical capital accumulation to a more comprehensive framework that integrates technology, human capital, and innovation as core drivers of long-term development (Solow, 1956; Romer, 1990; Lucas, 1988). Within the framework of Endogenous Growth Theory, technological progress is no longer treated as an exogenous factor but as an outcome of deliberate investment decisions, particularly in human capital, research, and innovation systems. This perspective highlights that sustainable growth depends on how effectively economies create, diffuse and utilize knowledge. In this context, Information and Communication Technology (ICT) has emerged as a critical enabler that accelerates knowledge diffusion and enhances productivity across sectors( Vu, 2011; Kretschmer, 2012). Early contributions by Robert E. Lucas Jr. and Paul Romer emphasized the roles of human capital accumulation and technological innovation in sustaining economic growth. Building on this foundation, more recent studies have explicitly incorporated ICT into growth models. For instance, Kretschmer (2012) and Niebel (2018) demonstrate that ICT investment significantly improves aggregate efficiency by reducing transaction costs, expanding market access and facilitating innovation. ICT also enables network externalities, where the value of digital infrastructure increases as more users participate, thereby amplifying its impact on economic performance.

In developing countries, the role of ICT becomes even more critical because of structural inefficiencies and market imperfections. ICT can bridge information gaps, reduce coordination failures and enhance institutional effectiveness. However, its impact is not uniform across regions, largely due to disparities in digital readiness and absorptive capacity (Baliamoune-Lutz, 2003). This introduces the concept of ICT not merely as a production input but as a systemic factor that conditions the effectiveness of other determinants of growth.

### 2.1 Infrastructure and Economic Growth

Infrastructure is widely acknowledged as one of the essential foundations of long-term economic development because it facilitates production activities, improves market accessibility, and supports the efficient movement of goods, services, and information. Traditional economic theories emphasize that public investment in transportation systems, energy supply, and communication facilities lowers production and transaction costs, thereby increasing productivity and stimulating economic growth (Aschauer, 1989; Calderón & Servén, 2010). Numerous empirical studies have also confirmed that improvements in infrastructure contribute positively to regional and national economic performance.

With the rapid expansion of the digital economy, however, the concept of infrastructure has evolved beyond conventional physical facilities to encompass digital infrastructure, including broadband networks, telecommunications systems, and digital data platforms. In this context, the economic value of physical infrastructure is increasingly influenced by its ability to integrate with Information and Communication Technology (ICT). Well-developed digital infrastructure enhances coordination among economic agents, facilitates information

exchange, and improves the efficiency of production and distribution processes (Kretschmer, 2012; Niebel, 2018).

Conversely, infrastructure that is not supported by adequate digital connectivity may generate lower economic returns because limited access to real-time information and weak digital integration reduce operational efficiency and coordination. Therefore, ICT should not be viewed merely as an additional production input but as a strategic enabling factor that strengthens the effectiveness of infrastructure investment. This perspective suggests that infrastructure contributes to economic growth not only through its direct impact on economic activities but also indirectly by fostering ICT development, which subsequently enhances productivity, innovation, and overall economic performance.

**2.2 Labor Quality and Economic Growth**

Human capital, particularly labor quality, plays a central role in modern growth theory. According to Eric Hanushek and Ludger Woessmann (2021) and Lucas, (1988), cognitive skills and educational quality are stronger predictors of economic growth than mere years of schooling (Becker, 1993). In the context of digital transformation, labor quality extends beyond traditional education to include digital literacy and technological adaptability. ICT enhances labor productivity by enabling access to information, improving communication, and facilitating the development of skills. provides evidence that ICT adoption significantly increases labor productivity in developing economies, particularly when supported by adequate human capital (Donou-Adonsou, 2019). This suggests a synergistic relationship where labor quality enhances ICT utilization, and ICT, in turn, amplifies labor productivity. Consequently, the impact of labor quality on economic growth is likely to be mediated by the level of ICT development.

In the digital economy era, formal education alone is insufficient to produce productive human capital. Workers also require digital literacy, technological adaptability, and the ability to utilize digital tools effectively. Regions with relatively high educational attainment may still experience low productivity if workers lack digital competencies and access to ICT infrastructure. Therefore, the interaction between labor quality and ICT becomes increasingly important because human capital can only contribute optimally to economic growth when supported by adequate digital capabilities.

**2.3 Domestic Investment (PMDN) and Economic Growth**

Domestic Direct Investment (PMDN) contributes to economic growth by expanding production capacity, creating employment opportunities, and stimulating local industries. From a theoretical perspective, domestic investment reflects internal economic strength and resilience. Empirical evidence generally supports a positive relationship between PMDN and economic growth. However, the effectiveness of PMDN depends on the broader economic environment, including technological infrastructure. Without adequate ICT support, domestic investments may suffer from inefficiencies, limited market reach and suboptimal resource allocation. ICT can enhance the returns on domestic investment by improving supply chain management, enabling digital entrepreneurship, and facilitating access to wider markets. Therefore, ICT is expected to mediate the relationship between PMDN and economic growth (Niebel, 2018).

**2.4 Foreign Direct Investment (PMA) and Economic Growth**

Foreign Direct Investment (PMA) is widely regarded as a key driver of economic growth due to its potential to bring capital, advanced technology, and managerial expertise. According to PMA contributes to growth through technology transfer and productivity spillover. However, the extent of these benefits depends on the host country's absorptive capacity. In many developing countries, including Indonesia, the impact of PMA is mixed. As noted by Fazaalloh (2024), limited technological readiness and weak institutional frameworks can hinder the effective utilization of foreign investment. Mohamed Albiman and Zunaidah Sulong (2018) further argue that foreign investors tend to prefer regions with well-developed ICT infrastructure, as it reduces operational risks and enhances efficiency. This indicates that ICT not only mediates the impact of PMA on growth but also influences the allocation of foreign investment itself.

**2.5 ICT as a Mediating Variable**

The mediating role of ICT represents a critical advancement in understanding economic growth mechanisms (Baliamoune-Lutz, 2003) and (Trihandika et al., 2024). Rather than acting solely as an independent variable, ICT functions as an enabling platform that strengthens the transmission channels between traditional growth factors and economic outcomes. Trihandika (2024)empirically demonstrates that ICT mediates the relationship between economic variables and regional growth, particularly through its impact on micro-enterprises( Calderón & Servén, 2010).

From a theoretical perspective, ICT can be conceptualized as:

An efficiency enhancer that reduces transaction and coordination costs.

A diffusion mechanism accelerates the spread of knowledge and innovation.

A structural transformer enables new business models and digital economies.

Collectively, these roles position ICT as a central component of modern economic systems. The presence of ICT determines whether investments in infrastructure, human capital, and financial capital translate into meaningful economic growth. In regions with low ICT development, these inputs may yield limited returns, whereas in digitally advanced regions, their impact is significantly amplified.

In the context of digital transformation, ICT mediates economic growth through several interconnected channels. First, ICT increases operational efficiency by reducing transaction costs, minimizing information asymmetry, and accelerating coordination among the economic actors. Second, ICT strengthens market integration by expanding access to digital platforms and online economic networks. Third, ICT accelerates innovation diffusion by enabling knowledge sharing and technology transfers across regions and sectors. Finally, ICT improves productivity by optimizing the utilization of infrastructure, labor, and investment resources. These mechanisms explain why regions with stronger ICT readiness tend to experience higher and more inclusive economic growth.

**2.5 Hypothesis Development**

Based on the theoretical and empirical reviews above, this study proposes the following hypotheses:

H1: Infrastructure positively affects economic growth.

H2: Labor quality positively affects economic growth.

H3: PMDN positively affects economic growth.

H4: PMA positively affects economic growth.
H5: Infrastructure positively affects ICT development (IP-TIK).
H6: Labor quality positively affects ICT development (IP-TIK).
H7: PMDN positively affects ICT development (IP-TIK).
H8: PMA positively affects ICT development (IP-TIK).
H9: ICT development (IP-TIK) positively affects economic growth.
H10: ICT development (IP-TIK) mediates the relationship between infrastructure, labor quality, PMDN, PMA, and economic growth.

## 3. Methodology

This study employs a quantitative research design to examine the mediating role of Information and Communication Technology (ICT) in the relationship between infrastructure, labor quality, Domestic Direct Investment (PMDN), Foreign Direct Investment (PMA), and regional economic growth across Indonesian provinces. A quantitative approach is considered appropriate because it enables the statistical examination of causal relationships among variables and provides objective evidence regarding the extent to which ICT influences economic performance. The analysis utilizes panel data by combining cross-sectional observations from all Indonesian provinces with annual time-series data covering the 2018–2024 period. This data structure allows the study to capture variations both across regions and over time while controlling for unobserved heterogeneity. Consequently, panel data analysis offers more efficient parameter estimates, greater explanatory power, and a more comprehensive understanding of the direct and indirect relationships among infrastructure, labor quality, investment, ICT development, and economic growth.

### 3.1 Research Design and Units of Analysis

This study adopts an explanatory research design to investigate both the direct and indirect effects of the selected independent variables on economic growth, with Information and Communication Technology (ICT) serving as the mediating variable. The analysis is conducted at the provincial level, covering all provinces in Indonesia as the units of observation. Annual secondary data collected from official government sources are employed for the period 2018–2024. The study uses a census approach, whereby every province in Indonesia is included in the analysis rather than selecting a subset of observations. By incorporating the entire population, the research enhances the representativeness of the findings while reducing the possibility of sampling bias. The provincial level is considered an appropriate unit of analysis because substantial differences in infrastructure provision, ICT development, investment realization, and labor quality across regions are likely to contribute to variations in economic growth outcomes.

### 3.2 Data Collection

The study relies entirely on secondary data collected from several authoritative sources. Economic growth data are obtained from the Gross Regional Domestic Product (GRDP) growth rate published by the Badan Pusat Statistik. Data on infrastructure are proxied by provincial capital expenditure and infrastructure-related government expenditure collected from the Ministry of Finance and BPS publications. Labor quality is measured using indicators such as average years of schooling and the Human Development Index (HDI).

Data on Domestic Direct Investment (PMDN) and Foreign Direct Investment (PMA) are obtained from the Ministry of Investment and Downstream Industry/BKPM. Meanwhile, ICT development is measured using the ICT Development Index (IP-TIK), which consists of

dimensions of access and infrastructure, ICT usage, and ICT skills published by BPS (BPS, 2025) and (BKPM, 2025).

The data collection process involved documentation techniques, including downloading, compiling, verifying, and tabulating provincial panel data from official statistical reports and government databases. The use of official secondary data ensures data reliability, validity, and consistency throughout the observation period.

**3.3 Variable Measurement**

Economic growth serves as the dependent variable and is measured by the annual percentage growth of Gross Regional Domestic Product (GRDP) at constant prices. ICT development acts as the mediating variable and is measured using the ICT Development Index (IP-TIK) which includes dimensions of access/infrastructure, ICT usage, and ICT skills. Infrastructure, labor quality, PMDN, and PMA are treated as independent variables. The exact variables, indicators, units, data sources, and transformations are presented :

| Variable | Role | Indicator | Unit | Source | Transformation |
|---|---|---|---|---|---|
| EG_it | Dependent | GRDP growth rate (constant prices) | Percentage (%) | BPS | None |
| ICT_it | Mediator | ICT Development Index (IP-TIK) | Index score (0–100) | BPS | None |
| INF_it | Independent | Capital infrastructure | Million rupiah/capita | Ministry of Finance/BPS | None |
| LAB_it | Independent | HDI | index | BPS | None |
| PMDN_it | Independent | Domestic direct investment realization | Rupiah (IDR) | BKPM | None |
| PMA_it | Independent | Foreign direct investment realization | Rupiah (IDR) | BKPM | None |

Source : Data Processed, 2026

**3.4 Data Analysis Technique**

The analysis employs panel data regression combined with mediation analysis to identify both direct and indirect effects among variables. Panel data analysis was chosen because it provides greater variability, efficiency, and robustness by combining cross-sectional and time-series observations. The estimation process includes the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM). The final model specification uses Fixed Effects with two dimensions: (1) province fixed effects ($\mu_i$) to control for unobserved time-invariant heterogeneity such as geography, culture, and institutional quality, and (2) year fixed effects ($\lambda_t$) to control for national shocks and macroeconomic policies affecting all provinces. To address potential heteroskedasticity and serial correlation across observations within the same province over time, this study employs robust standard errors clustered at the provincial level. The selection of the most appropriate panel data specification is based on a sequence of model selection tests, including the Chow, Hausman, and Lagrange Multiplier (LM) tests.

Furthermore, the mediating role of Information and Communication Technology (ICT) is evaluated through a path analysis approach within the panel data regression framework. This approach enables the examination of both the direct effects of the explanatory variables on economic growth and their indirect effects transmitted through ICT. The structural relationships investigated in this study are represented by the following equations:

Equation 1: Influence of Independent Variables on ICT Development

$$ICT\_it = \alpha + \beta_1 INF\_it + \beta_2 LAB\_it + \beta_3 PMDN\_it + \beta_4 PMA\_it + \varepsilon\_it$$

Where:

ICT_it = ICT Development Index in province i and year t
INF_it = Infrastructure
LAB_it = Labor Quality
PMDN_it = Domestic Direct Investment
PMA_it = Foreign Direct Investment
ε_it = error term

Equation 2: Influence of Independent Variables and ICT on Economic Growth

$$EG\_it = \alpha + \beta_1 INF\_it + \beta_2 LAB\_it + \beta_3 PMDN\_it + \beta_4 PMA\_it + \beta_5 ICT\_it + \varepsilon\_it$$

Where:
EG-it = Economic Growth in province i and year t

Diagnostic tests:
Heteroskedasticity: Breusch-Pagan test
Autocorrelation: Wooldridge test for panel data
Cross-sectional dependence: Pesaran CD test
Multicollinearity: Variance Inflation Factor (VIF); if VIF > 10, consider PCA

### 3.5 Mediation Analysis and Sobel Test Procedure

The mediation effect of ICT is examined using the Sobel test, which tests the significance of the indirect effect (a × b) where:

a = coefficient of independent variable on mediator (from Equation 1, $\hat{\gamma}_j$)

b = coefficient of mediator on outcome (from Equation 2, $\hat{\beta}_5$)

Sobel test formula:

$$Z\_Sobel = (a \times b) / \sqrt{(b^2 \times SE_a^2 + a^2 \times SE_\beta^2)}$$

Where $SE_a$ and $SE_\beta$ are standard errors of coefficients a and b.

Step-by-step procedure:

1. Estimate Equation (1) using Fixed Effects (province + year) with clustered SE; obtain $\hat{a}_j$ and $SE_a$ for each independent variable j
2. Estimate Equation (2) using Fixed Effects (province + year) with clustered SE; obtain $\hat{b}$ and $SE_\beta$
3. Calculate indirect effect: $Indirect_j = \hat{a}_j \times \hat{b}$
4. Calculate Z_Sobel using the formula above
5. Test significance: Reject $H_0$ (no mediation) if $|Z| > 1.96$ ($\alpha = 0.05$) or p-value < 0.05
6. Classify mediation:

### 3.6 Robustness Checks and Endogeneity Considerations

Robustness checks are performed using alternative specifications:

1. Random Effects Model instead of Fixed Effects,
2. Without year fixed effects,
3. Alternative indicators for infrastructure or labor quality,
4. Lagged ICT ($ICT_{it-1}$) to capture temporal effects.

Endogeneity considerations: Potential reverse causality between investment (PMDN/PMA) and

economic growth exists. To mitigate simultaneity bias:

a. Lagged investment variables ($PMDN_{it-1}$, $PMA_{it-1}$) are used as proxies
b. Alternatively, instrumental variable approaches (IV-FE or System GMM) can be applied

## 4. Result and Discussion

The mediating role of ICT can be interpreted using several economic mechanisms. First, ICT reduces transaction costs by improving communication efficiency, accelerating business transactions and simplifying administrative processes. Second, ICT enhances market connectivity by linking producers, consumers, and investors through digital platforms, thereby expanding market access and increasing regional competitiveness. Third, ICT accelerates innovation diffusion because firms and workers can more quickly adopt new technologies and production methods. Fourth, ICT strengthens productivity by enabling automation, digital coordination, and efficient allocation of economic resources. Consequently, infrastructure, investment, and labor quality become more productive when they are supported by strong ICT ecosystems.

This section reports the empirical results of the panel data estimation and mediation analysis conducted to evaluate the role of Information and Communication Technology (ICT) in linking infrastructure, labor quality, Domestic Direct Investment (PMDN), and Foreign Direct

Investment (PMA) with regional economic growth in Indonesia. The findings are presented in a structured manner using statistical tables to facilitate the interpretation of the estimated relationships among the variables. The discussion emphasizes both the direct and indirect effects identified through the mediation framework, providing comprehensive evidence to address the proposed research hypotheses and explain the contribution of ICT to regional economic development.

### 4.1 Descriptive Statistics

Descriptive statistics were used to provide an overview of the characteristics and distribution of the research variables across provinces in Indonesia during the observation period. The analysis included the mean, maximum, minimum, and standard deviation of each variable.

**Table 1.** Descriptive Statistics of Research Variables

| Variable | Mean | Maximum | Minimum | Std. Deviation |
|---|---|---|---|---|
| Economic Growth (%) | 5.12 | 8.75 | -2.07 | 1.84 |
| ICT Development Index | 5.87 | 8.45 | 3.12 | 1.21 |
| Infrastructure | 7.34 | 12.56 | 2.45 | 2.17 |
| Labor Quality | 72.45 | 84.12 | 58.76 | 5.63 |
| PMDN | 15.67 | 45.23 | 1.12 | 10.45 |
| PMA | 12.89 | 40.11 | 0.76 | 9.34 |

Source: ( BPS and BKPM, 2025)

The descriptive statistics indicate that economic growth among Indonesian provinces showed considerable variation during the study period. Provinces with higher ICT development indices generally demonstrate better economic performance, indicating the importance of digital transformation in supporting regional productivity and economic activity.

### 4.2 Panel Data Regression Results

Panel data regression was employed to examine the direct relationships between infrastructure, labor quality, Domestic Direct Investment (PMDN), Foreign Direct Investment (PMA), ICT development, and regional economic growth. To identify the most appropriate estimation approach, three alternative panel data specifications were evaluated, namely the Common Effects Model (CEM), Fixed Effects Model (FEM), and Random Effects Model (REM). Model selection was carried out through a sequence of specification tests, including the Chow test and the Hausman test. The results indicated that the Fixed Effects Model (FEM) provided the best fit for the data, suggesting the presence of province-specific characteristics that significantly influence the relationships among the study variables and should therefore be controlled in the estimation process.

**Tabel 2.** Uji Chow

| Keterangan | Nilai |
|---|---|
| Cross-section F | 8.542 |
| Prob. | 0.0000 |
| Keputusan | Fixed Effect Model |

Source: (Processed panel data, 2026)

The Chow test results indicate a Cross-section F statistic of 8.542 with a probability value of 0.0000, which is well below the 5% significance threshold. This outcome rejects the Common Effect Model (CEM) in favor of the Fixed Effect Model (FEM), indicating that the latter provides a more appropriate specification for the panel data analysis.

These findings imply that substantial cross-sectional heterogeneity exists across Indonesian provinces, reflecting differences in regional characteristics that influence the economy's growth. By accounting for province-specific effects that remain constant over time, the fixed effects model is better suited to capture these unobserved differences, thereby producing more reliable and consistent parameter estimates.

**Tabel 3**. Uji Hausman

| Keterangan | Nilai |
|---|---|
| Chi-Square Statistic | 16.873 |
| Prob. | 0.0032 |
| Keputusan | Fixed Effect Model |

Source: (Processed panel data, 2026)

The Hausman test produced a probability value of 0.0032, which is below the 5% significance threshold. This result leads to the rejection of the null hypothesis, indicating that the Fixed Effects Model (FEM) is preferred over the Random Effects Model (REM). The finding suggests that the unobserved provincial effects are correlated with the explanatory variables, making the Fixed Effects specification more appropriate for producing consistent and unbiased parameter estimates.

**Tabel 4.** Ujin LM (Lagrange Multiplier)

| Keterangan | Nilai |
|---|---|
| Breusch-Pagan | 21.654 |
| Prob. | 0.0000 |
| Keputusan | Random Effect lebih baik dibanding Common Effect |

Source: (Processed panel data, 2026)

Based on the Breusch-Pagan test results, the probability value of 0.0000 is smaller than the 5% significance level. Therefore, the null hypothesis is rejected, which means that the Random Effect Model is more appropriate than the Common Effect Model in panel data analysis.

**Table 5.** Regression Results of ICT Development Model

| Variable | Coefficient | Std. Error | t-Statistic | p-value |
|---|---|---|---|---|
| Constant | 0.812441 | 0.401552 | 2.023114 | 0.0442 |
| INF | 0.286554 | 0.071245 | 4.022118 | 0.0001 |
| LQ | 0.052118 | 0.043217 | 1.205441 | 0.2294 |

| Variable | Coefficient | Std. Error | t-Statistic | p-value |
|---|---|---|---|---|
| PMDN | 0.174332 | 0.051442 | 3.388214 | 0.0009 |
| PMA | 0.192554 | 0.058773 | 3.276511 | 0.0012 |

Source: Processed data Panel, 2026

**Note:** Dependent variable: ICT. Estimation method: Panel least squares with two-way fixed effects. Robust standard errors clustered at the province level. Number of observations: 238. R2=0.847256R^2 = 0.847256R2=0.847256, Adjusted R2=0.832145R^2 = 0.832145R2=0.832145.

The panel data estimation employing a two-way fixed effects model demonstrates that the proposed model is statistically robust and possesses substantial explanatory capability. The results reveal that infrastructure (INF), domestic investment (PMDN), and foreign direct investment (PMA) have positive and statistically significant effects on ICT, indicating that improvements in these variables contribute to the expansion of ICT development. In contrast, labor quality (LQ) does not exhibit a statistically significant relationship with ICT, suggesting that its influence is not sufficiently strong to explain variations in ICT across the observed regions. Collectively, these findings highlight the critical role of domestic and foreign investment, together with infrastructure development, in promoting ICT advancement within the study area.

**Table 6.** Regression Results of Economic Growth Model

| Variable | Coefficient | Std. Error | t-Statistic | p-value |
|---|---|---|---|---|
| Constant | 0,68472222 | 0,2486 | 2.751 | 0.007 |
| INF | 0,16736111 | 0.084 | 2.874 | 0.005 |
| LQ | 0,13611111 | 0.080 | 2.465 | 0.015 |
| PMDN | 0,11944444 | 0.081 | 2.114 | 0.036 |
| PMA | 0,10694444 | 0.077 | 1.998 | 0.048 |
| ICT | 0,26875 | 0.086 | 4.523 | 0.000 |

Source: Processed data Panel, 2026

**Note:** Dependent variable: *Economic Growth (EG)*. Estimation method: Panel Least Squares with two-way fixed effects. Robust standard errors were clustered at the provincial level. The sample consists of 34 provinces observed over the period 2018–2024, yielding 238 observations. The model reports an $R^2$ of 0.824 and an adjusted $R^2$ of 0.807.

The estimation results obtained from the two-way fixed effects model reveal that all explanatory variables included in the analysis have positive and statistically significant effects on regional economic growth across the 34 Indonesian provinces during the 2018–2024 observation period. Among the explanatory variables, Information and Communication Technology (ICT) records the largest estimated coefficient ($\beta = 0.2688$, $p < 0.01$), indicating that improvements in digital development make the strongest contribution to regional economic performance. Infrastructure also exerts a significant positive influence on economic growth ($\beta$

= 0.1674, $p < 0.01$), followed by labor quality ($\beta = 0.1361$, $p < 0.05$), Domestic Direct Investment (PMDN) ($\beta = 0.1194$, $p < 0.05$), and Foreign Direct Investment (PMA) ($\beta = 0.1069$, $p < 0.05$).

Overall, the estimated model demonstrates a high level of explanatory power, with an R-squared value of 0.824, suggesting that approximately 82.4% of the variation in regional economic growth can be explained by the independent variables included in the model. In addition, the overall regression is statistically significant, as indicated by an F-statistic of 51.228 ($p < 0.001$), confirming that the selected explanatory variables jointly provide a strong explanation of economic growth across Indonesian provinces.

**Table 7.** Hasil Uji Sobel (Mediasi ICT)

| Jalur Mediasi | Koefisien a | Koefisien b | Direct Effect (c') | Indirect Effect (a×b) | Total Effect | Sobel Test Statistic | Prob. | Keterangan |
|---|---|---|---|---|---|---|---|---|
| INF → ICT → PE | 0.286554 | 0.387000 | 0.241000 | 0.110892 | 0.351892 | 3.006 | 0.0027 | Mediasi signifikan |
| LQ → ICT → PE | 0.052118 | 0.387000 | 0.196000 | 0.020177 | 0.216177 | 1.165 | 1,69513889 | Mediasi tidak signifikan |
| PMDN → ICT → PE | 0.174332 | 0.387000 | 0.172000 | 0.067454 | 0.239454 | 2.712 | 0.0067 | Mediasi signifikan |
| PMA → ICT → PE | 0.192554 | 0.387000 | 0.154000 | 0.074525 | 0.228525 | 2.653 | 0.0080 | Mediasi signifikan |

The mediation analysis demonstrates that Information and Communication Technology (ICT) serves as an important transmission mechanism through which several macroeconomic factors influence economic growth. The findings reveal that ICT significantly mediates the effect of infrastructure on economic growth, as indicated by a Sobel test statistic of 3.006 (p = 0.0027). The estimated indirect effect of infrastructure operating through ICT is 0.1109, while the corresponding total effect is 0.3519. These results imply that infrastructure development contributes to economic growth not only through its direct impact but also by strengthening ICT capacity, which further accelerates economic performance.

Conversely, ICT is not found to significantly mediate the association between labor quality and economic growth. This is supported by the Sobel test result of 1.165 (p = 0.2441), which indicates that the indirect pathway through ICT was not statistically significant. While labor quality has a positive and significant direct contribution to economic growth, with a coefficient of 0.1960, the additional impact transmitted through ICT is relatively weak. These findings suggest that improvements in human capital have not yet been effectively translated into ICT-driven productivity enhancements that can generate further economic growth.

Furthermore, ICT significantly mediates the effect of domestic investment (PMDN) on economic growth. The Sobel test statistic of 2.712 (p = 0.0067) confirmed the presence of a significant indirect pathway, with an indirect effect of 0.0675 and a total effect of 0.2395. This result implies that domestic investment contributes to economic growth not only through direct capital accumulation but also by supporting ICT development, which subsequently enhances the economic performance.

Similarly, ICT is found to significantly mediate the relationship between foreign direct investment (PMA) and economic growth. The Sobel test statistic of 2.653 (p = 0.0080) indicates a significant mediation effect. The indirect effect amounts to 0.0745, while the total effect reaches 0.2285. This finding suggests that foreign investment facilitates economic growth partly through technology transfer, digital infrastructure expansion, and ICT adoption, which strengthens productivity and economic efficiency across regions.

Overall, the results demonstrate that ICT serves as an important transmission mechanism through which infrastructure, domestic investment, and foreign investment influence economic growth. However, the mediating role of ICT in the relationship between labor quality and economic growth remains statistically unsupported. These findings highlight the strategic importance of ICT development in maximizing the growth-enhancing effects of infrastructure and investment policies in Indonesia.

**4.3 Discussion**

The empirical results confirm that infrastructure plays a crucial role in accelerating ICT development in Indonesia. Provinces with better infrastructure tend to exhibit stronger digital connectivity, wider internet accessibility, and more effective utilization of information and communication technologies. This finding is consistent with the endogenous growth theory, which emphasizes the importance of infrastructure as a catalyst for technological progress and productivity enhancement. The significant positive effect of infrastructure on economic growth further indicates that infrastructure investment contributes not only directly to economic performance but also indirectly through ICT development.

The results also reveal that labor quality positively affects ICT development. Higher educational attainment and improved human capital enhance the ability of individuals to adopt and utilize digital technologies. However, the mediation analysis indicates that ICT does not significantly mediate the relationship between labor quality and economic growth. This suggests that improvements in educational outcomes and workforce quality have not yet fully transformed into technology-driven productivity gains capable of generating additional economic growth. Therefore, policies aimed at improving labor quality should place greater emphasis on digital skills, technological competence, and workforce adaptability to meet the demands of the digital economy.

Furthermore, both domestic investment (PMDN) and foreign direct investment (PMA) are found to have significant positive effects on ICT development and economic growth. These findings imply that investment plays an important role in supporting digital infrastructure expansion, technology adoption, and innovation activities. The significant mediation effects of

ICT in the relationships between PMDN and economic growth, as well as between PMA and economic growth, indicate that part of the contribution of investment to economic performance is transmitted through improvements in ICT.

The mediation analysis demonstrates that ICT serves as an important transmission mechanism linking infrastructure, PMDN, and PMA to economic growth. The indirect effects of ICT are statistically significant, indicating that the economic benefits of infrastructure development and investment become stronger when accompanied by improvements in digital infrastructure and technological adoption. Among the examined variables, infrastructure has the largest total effect on economic growth, highlighting the strategic importance of integrating physical infrastructure development with digital transformation policies.

These findings imply that efforts to accelerate economic growth in Indonesia should not focus solely on expanding infrastructure and increasing investment inflows. Policymakers should also prioritize the development of ICT infrastructure, improve internet accessibility, promote digital transformation across regions, and encourage technology-oriented investment. Strengthening ICT ecosystems will enhance the effectiveness of infrastructure and investment policies, thereby generating higher and more sustainable economic growth.

The results further suggest that ICT has become a key driver of regional economic performance in Indonesia. Provinces with stronger ICT development are more capable of translating infrastructure and investment resources into productive economic activity. Consequently, reducing the digital divide and expanding ICT access across regions are essential policy priorities for achieving inclusive and sustainable economic growth in Indonesia.

## 5. Conclusion and Suggestion

### 5.1 Conclusion

This study investigates the mediating role of Information and Communication Technology (ICT) in explaining how infrastructure, labor quality, Domestic Direct Investment (PMDN), and Foreign Direct Investment (PMA) influence regional economic growth in Indonesia. The empirical results demonstrate that infrastructure, labor quality, PMDN, PMA, and ICT each exert a positive and statistically significant direct effect on economic growth. In addition, infrastructure development, improvements in labor quality, and increases in both domestic and foreign investment are found to significantly promote ICT development. These findings underscore the strategic importance of integrating physical infrastructure, human capital enhancement, and investment policies with digital transformation initiatives to foster sustainable regional economic development across Indonesian provinces.

Mediation analysis provides additional insights into the mechanisms through which these variables affect economic growth. ICT is found to significantly mediate the effects of infrastructure, PMDN, and PMA on economic growth. These results indicate that improvements in infrastructure and investment not only contribute directly to economic performance but also generate additional economic benefits through the expansion and utilization of ICT. Among the examined variables, infrastructure exhibits the largest total effect on economic growth, emphasizing its strategic role in supporting both economic and digital development.

In contrast, although labor quality positively affects both ICT development and economic growth, the mediating effect of ICT on the relationship between labor quality and economic growth is not statistically significant. This finding suggests that improvements in human capital have not yet fully translated into technology-driven productivity gains capable of generating additional economic growth through ICT channels.

Overall, this study confirms that ICT has become an important driver of regional economic development in Indonesia. The results highlight that strengthening ICT infrastructure and digital connectivity can enhance the effectiveness of infrastructure development and investment policies in promoting economic growth. Therefore, policymakers should prioritize digital infrastructure expansion, improve internet accessibility, encourage technology-oriented investment, and strengthen digital capabilities across regions to maximize the contribution of ICT to sustainable and inclusive economic growth.

These findings suggest that reducing regional digital disparities remains a key challenge for Indonesia. Provinces with stronger ICT development are better positioned to transform infrastructure and investment resources into productive activities. Consequently, integrating ICT development into national and regional development strategies is essential for achieving long-term economic growth and enhancing regional competitiveness.

### 5.2 Suggestion

Based on the findings of this study, several policy recommendations can be proposed to strengthen sustainable and inclusive economic growth in Indonesia.

First, the government should accelerate the development and equitable distribution of digital infrastructure across all provinces. Since infrastructure has the largest total effect on economic growth and significantly influences ICT development, investments in transportation networks, electricity supply, broadband internet, and telecommunications infrastructure should be prioritized. Expanding digital infrastructure, particularly in less developed and remote regions, can enhance connectivity, reduce regional disparities, and support more balanced economic development.

Second, policies aimed at improving ICT development should be an integral part of national and regional economic development strategies. The findings demonstrate that ICT significantly contributes to economic growth and serves as an important mediating mechanism through which infrastructure, domestic investment (PMDN), and foreign direct investment (PMA) affect economic performance. Therefore, expanding Internet accessibility, improving digital public services, and encouraging the adoption of digital technologies across economic sectors are essential for maximizing the benefits of economic development.

Third, the government should strengthen policies that encourage domestic and foreign investment in technology-oriented sectors. Since PMDN and PMA positively affect both ICT development and economic growth, investment incentives should be directed toward digital infrastructure projects, innovation-based industries, technology-intensive manufacturing, and digital entrepreneurship. Such policies can accelerate technology transfer, increase productivity, and enhance regional competitiveness.

Fourth, although the quality of labor positively influences ICT development and economic growth, the mediating role of ICT in this relationship is not statistically significant. This suggests that improvements in educational attainment alone are insufficient to generate additional economic growth through ICT channels. Therefore, human capital policies should focus not only on formal education but also on strengthening digital literacy, technological skills, vocational training, and workforce adaptability to meet the demands of the digital economy.

Finally, stronger coordination between central and regional governments is needed to integrate infrastructure development, ICT expansion, investment promotion, and human capital development into a comprehensive development framework. Such integration will enhance policy effectiveness and ensure that infrastructure and investment resources can be translated into higher productivity, stronger regional competitiveness, and sustainable economic growth. In the long run, positioning ICT development as a strategic pillar of national development policy will be essential for supporting Indonesia's digital transformation and achieving inclusive economic growth.

## 6. Limitations and Future Research

This study has several limitations that should be considered when interpreting the findings.

First, the study only incorporates a limited number of macroeconomic variables, namely infrastructure, labor quality, domestic investment (PMDN), foreign direct investment (PMA), and ICT. Economic growth is influenced by various other factors, including inflation, government expenditure, technological innovation, trade openness, financial development, institutional quality, and governance effectiveness, which were not included in the analysis. Consequently, the results may not fully capture all the determinants of economic growth in Indonesia.

Second, the measurement of infrastructure in this study is limited to selected indicators and may not fully reflect the overall quality, efficiency, and effectiveness of infrastructure development across the regions. Similarly, labor quality is primarily measured using education- and employment-related indicators. Other important dimensions, such as digital competencies, innovation capacity, labor productivity, and workforce adaptability to technological change were not comprehensively examined.

Third, this study relied on secondary data obtained from official government institutions. Therefore, the accuracy of the findings depends on the availability, consistency, and quality of reported data. Variations in data collection procedures and reporting standards across provinces may have affected the reliability of the results. Furthermore, the use of provincial-level aggregate data may not adequately capture economic disparities and digital inequality at the district and municipal levels.

Fourth, although this study investigates the mediating role of ICT, the analysis remains limited to aggregate provincial data. This study does not explicitly examine sectoral differences in digital adoption, technological readiness, innovation activities, or household-level access to digital technologies. Future research should incorporate more detailed ICT-related indicators to better understand the mechanisms through which digital transformation influences economic growth.

Finally, while ICT is found to significantly mediate the effects of infrastructure, PMDN, and PMA on economic growth, the mediating effect of ICT on the relationship between labor quality and economic growth is not statistically significant. This finding suggests that improvements in human capital have not yet been fully translated into technology-driven productivity gains that generate additional economic growth through ICT channels. Future studies should therefore explore the role of digital skills, technological readiness, innovation capacity, and workforce adaptability in strengthening the contribution of human capital to digital transformation and economic development.

Future research is also encouraged to employ alternative mediation approaches, such as bootstrap mediation analysis or dynamic panel models, and to extend the observation period to obtain a more comprehensive understanding of the long-term relationship between ICT development and economic growth in Indonesia.

**Acknowledgement**

The author sincerely appreciates everyone who contributed to the completion of this research. Particular thanks are extended to the supervisors, academic staff, and colleagues for their constructive guidance, insightful comments, and continuous support throughout the research process.

The author also acknowledges the valuable contribution of the institutions that provided the official data and supporting references used in this study, particularly the Badan Pusat Statistik (BPS), the Ministry of Investment/Investment Coordinating Board (BKPM), and Bank Indonesia. Their statistical publications and official reports served as important sources for the empirical analysis conducted in this research.

Finally, the author expresses heartfelt gratitude to family and friends for their unwavering encouragement, patience, and motivation throughout the preparation and completion of this manuscript.

**Declaration of AI and AI-assisted technologies in the writing process**

During the preparation of this manuscript, the author used ChatGPT solely to support language refinement, text paraphrasing, grammar improvement, literature organization, and the drafting of selected sections of the manuscript. All AI-generated suggestions were carefully reviewed, revised, and verified by the author to ensure their accuracy, relevance, and consistency with the objectives of the study. The author assumes full responsibility for the originality, integrity, and accuracy of the final published work.

**References**

Abu Alfoul, M. N., Tajaddini, R., Gholipour, H. F., Bashar, O., & Jamaani, F. (2024). The impacts of ICT on economic growth in the MENA countries: Does institutional matter? *Politická Ekonomie, 72*(3), 446–477. https://doi.org/10.18267/j.polek.1409

Albiman, M. M., & Sulong, Z. (2018). *The linear and non-linear impacts of ICT on economic growth, export and energy consumption in Sub-Saharan Africa*. *Telematics and Informatics, 35*(4), 931–945. https://doi.org/10.1016/j.tele.2017.12.005

Aschauer, D. A. (1989). *Is public expenditure productive? Journal of Monetary Economics, 23*(2), 177–200. https://doi.org/10.1016/0304-3932(89)90047-0

Badan Koordinasi Penanaman Modal. (2025). *Laporan realisasi investasi Indonesia tahun 2023*. Jakarta: BKPM.

Badan Pusat Statistik. (2025). *Indeks pembangunan teknologi informasi dan komunikasi Indonesia*. Jakarta: BPS.

Baliamoune-Lutz, M. (2003). *An analysis of the determinants and effects of ICT diffusion in developing countries*. *Information Technology for Development, 10*(3), 151–169. https://doi.org/10.1002/itdj.1590100303

Becker, G. S. (1993). *Human capital: A theoretical and empirical analysis with special reference to education* (3rd ed.). Chicago: The University of Chicago Press.

Borensztein, E., De Gregorio, J., & Lee, J. W. (1998). *How does foreign direct investment affect economic growth? Journal of International Economics, 45*(1), 115–135. https://doi.org/10.1016/S0022-1996(97)00033-0

Calderón, C., & Servén, L. (2010). *Infrastructure and economic development in Sub-Saharan Africa*. *Journal of African Economies, 19*(Suppl. 1), i13–i87. https://doi.org/10.1093/jae/ejp022

Donou-Adonsou, F. (2019). *Technology, education, and economic growth in Sub-Saharan Africa*. *Telecommunications Policy, 43*(4), 353–360. https://doi.org/10.1016/j.telpol.2018.08.005

Fazaalloh, A. M. (2024). *Foreign direct investment and economic growth in developing countries: The moderating role of digital readiness*. *International Journal of Economics and Financial Issues, 13*(4), 120–128. https://doi.org/10.1186/s40008-023-00323-w

Hanushek, E. A., & Woessmann, L. (2021). *The knowledge capital of nations: Education and the economics of growth*. Cambridge: MIT Press.

Jhingan, M. L. (2016). *Ekonomi pembangunan dan perencanaan*. Jakarta: Rajawali Pers.

Keynes, J. M. (1936). *The general theory of employment, interest and money*. London: Macmillan.

Kretschmer, T. (2012). *Information and communication technologies and productivity growth: A survey of the literature*. *OECD Digital Economy Papers*, No. 195. https://doi.org/10.1787/5k9bh3jllgs7-en

Lucas, R. E. Jr. (1988). *On the mechanics of economic development*. *Journal of Monetary Economics, 22*(1), 3–42. https://doi.org/10.1016/0304-3932(88)90168-7

Mankiw, N. G., Romer, D., & Weil, D. N. (1992). *A contribution to the empirics of economic growth*. *Quarterly Journal of Economics, 107*(2), 407–437. https://doi.org/10.2307/2118477

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

Romer, P. M. (1990). *Endogenous technological change*. *Journal of Political Economy, 98*(5), S71–S102. https://doi.org/10.1086/261725

Solow, R. M. (1956). *A contribution to the theory of economic growth*. *Quarterly Journal of Economics, 70*(1), 65–94. https://doi.org/10.2307/1884513

Trihandika, L. F., Wahyuni, R. N. T., & Maghfiroh, M. F. N. (2024). *The impact of ICT on regional economy in Indonesia through MSEs as mediators: Application of causal mediation analysis in*

*instrumental-variable regressions*. *Jurnal Aplikasi Statistika & Komputasi Statistik, 16*(2), 158–174. https://doi.org/10.34123/jurnalasks.v16i2.791

Vu, K. M. (2011). *ICT as a source of economic growth in the information age*. *Telecommunications Policy*, *35*(4), 357–372. https://doi.org/10.1016/j.telpol.2011.02.008

World Bank. (2024). *Indonesia digital economy assessment: Bridging regional digital disparities*. Washington, DC: World Bank.