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The Effect of Research & Development Investment, E-commerce Transactions, and Digital Infrastructure on Economic Growth in Indonesia

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A B S T R A C T

Economic growth is a key indicator of a country's economic performance and is influenced by investment, technology, and infrastructure. Over the past decade, Indonesia's digital economy has grown rapidly, reflected in increased R&D investment, the expansion of e-commerce, and the development of digital infrastructure. This study analyzes the effects of R&D investment, e-commerce transactions, and digital infrastructure on Indonesia's economic growth using multiple linear regression with time-series data from 2015–2024. The results show that R&D investment has a positive and significant effect on economic growth, while e-commerce transactions and digital infrastructure have negative and significant effects. Simultaneously, all variables significantly influence economic growth, with the model explaining 90.21% of the variation. These findings highlight the importance of strengthening the innovation ecosystem and promoting more inclusive and integrated digital development to support sustainable economic growth.

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INTRODUCTION

Economic growth is a primary concern for most countries worldwide, as it serves as a key indicator in assessing a nation's economic health and is often a central objective of national economic policy. Stable and sustainable economic growth has a significant positive impact on public welfare, including the creation of employment opportunities, increased income, improved living standards, and enhanced national capacity to provide high-quality public services (Rappana & Sukarno, 2017). Economic development is influenced by several major factors, such as infrastructure development, increased investment, and technological advancement. Economic growth reflects a country's ability to generate additional national income within a given period. This growth is quantitative in nature and is reflected in rising per capita income and increased national production output (Paramitha & Ervani, 2024). The dynamics of national economic activity are influenced by several factors, including investment, infrastructure, and e-commerce technology as one of the key drivers of the modern economy.

Research and Development (R&D) refers to a series of procedures aimed at improving existing products and creating new ones (Trianto, 2011). Investment in R&D activities is undertaken to promote innovation within the economy, thereby contributing to the effectiveness and sustainability of economic growth. Developing countries, including Indonesia, have implemented relatively effective investment strategies in the R&D sector. These strategies are based on the optimal utilization of human resources and knowledge. Innovations generated through R&D activities aim to continuously improve the quality and quantity of goods and services, ultimately driving national economic growth. Investment in R&D plays a strategic role not only as a catalyst for technological and industrial advancement but also as a crucial instrument in creating and maintaining competitive advantage, particularly for business actors (Sumahir et al., 2022). The implementation of R&D investment, accompanied by the maximum utilization of human resources and knowledge, is expected to generate innovations that enhance corporate competitiveness, thereby contributing to the achievement of sustainable economic advantage. Thus, investment in the R&D sector becomes an essential element in supporting Indonesia's sustainable economic growth through enhanced competitiveness and the creation of innovations aligned with global market needs.

Indonesia's economic development over the past eight years has shown relatively stable progress, despite a decline in 2020 due to the COVID-19 pandemic. Stable economic growth is marked by several factors, including investment in R&D, e-commerce transactions, and digital infrastructure. Rapid technological advancement has had a significant impact on various sectors, particularly the industrial sector. The Fourth Industrial Revolution has transformed conventional industrial paradigms by integrating digital technologies with physical systems to create production systems that are more flexible, efficient, and interconnected (Andian, 2023). This transformation presents substantial opportunities for industrial growth while simultaneously introducing strategic challenges.

One concrete manifestation of the Fourth Industrial Revolution is the emergence of the digital economy, characterized by fundamental and rapid changes across various aspects of economic activity. E-commerce represents a clear example of digital technological advancement, enabling online buying and selling transactions through electronic media. This phenomenon has been widely adopted globally, spanning sectors such as telecommunications, transportation, and trade. In Indonesia, e-commerce has grown rapidly and has become an integral part of everyday life. The wide range of offerings and the dynamic innovations within e-commerce platforms indicate that this sector plays a central role in advancing the national digital economy. With high internet penetration and continuously improving digital literacy, e-commerce has strong potential to become a key driver of Indonesia's economic progress in the current era of digital transformation.

Indonesia's economic development over the past eight years has been relatively stable, despite a downturn in 2020 due to the COVID-19 pandemic. Stable economic growth is marked by several factors, including investment in R&D, e-commerce transactions, and digital infrastructure. Rapid technological advancement has had a significant impact on various sectors, particularly the industrial sector. The Fourth Industrial Revolution has transformed conventional industrial paradigms by integrating digital technologies with physical systems to create production systems that are more flexible, efficient, and interconnected (Andian, 2023). This transformation has created substantial opportunities for industrial growth while simultaneously presenting strategic challenges.

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Despite the significant potential for digital economic growth in Indonesia, a number of negative impacts emerged during the period from 2019 to 2021. The main challenges included inadequate infrastructure support, low internet network quality, and weaknesses in national-level cybersecurity systems. These issues have hindered the optimal utilization of digital technology, particularly in the e-commerce sector. This phenomenon is reflected in the increasing number of fraud cases involving digital platform users, both consumers and business actors, as well as the rising incidence of critical data breaches. These conditions indicate that digital economic growth must be accompanied by the strengthening of supporting ecosystems, especially in terms of information technology

infrastructure and cybersecurity, in order to ensure protection for all parties involved in digital transactions. Along with improvements in infrastructure quality, cybersecurity systems, and digital services, it is expected that users will also enhance their digital literacy and act more prudently when conducting online transactions through various e-commerce platforms. User awareness and caution are essential in preventing the misuse of technology and in supporting the creation of a safe, trustworthy, and sustainable digital ecosystem.

Indonesia's digital economic conditions from 2018 to 2024 have continued to improve, as indicated by a stable annual increase in key indicators. This growth has been driven by the continuous rise in the number of internet users in Indonesia and by changes in public behavior that increasingly rely on online-based services for various activities. Within the context of the digital economy, the internet serves as a primary supporting element; therefore, the development of its infrastructure is critically important.

The e-commerce sector and digital infrastructure play a significant role in strengthening the national economy, particularly through their contribution to technology-based economic activities. Digital infrastructure encompasses various physical facilities and software systems that enable the digital distribution of goods and services. The development of information technology–based infrastructure aims to improve ease of access, operational effectiveness, and time efficiency in carrying out economic activities (Febrianty, 2020). In many developing countries, government investment in infrastructure development constitutes a substantial portion of total public expenditure, reflecting the government's important role in providing adequate digital facilities. The growth of digital infrastructure has progressed rapidly because it facilitates a wide range of economic activities without requiring face-to-face interaction.

THEORETICAL REVIEW

Economic Growth Theory

Neoclassical economic growth theory explains the development of a country's economy by considering factors such as labor, capital, and technology. According to the Harrod–Domar model, stable economic growth (steady growth) can be achieved through the formation of investment and savings. This framework serves as an important foundation for understanding economic growth, particularly for developing countries that require substantial investment to accelerate development. Nevertheless, this theory needs to be complemented by other factors, such as technological change, government policies, and the dynamics of continuously evolving global conditions (Mankiw, 2003).

Investment Theory

Investment can be understood as an effort to allocate resources primarily funds at the present time with the expectation of obtaining benefits in the future (Gunardi, Alghifari, & Suteja, 2022). Investment activities include expenditures on the acquisition of capital goods to enhance the production capacity of goods and services, which are expected to stimulate economic growth in subsequent periods. In general, investment activities require substantial costs and involve a high degree of uncertainty.

Research and Development (R&D)

Based on Law No. 25 of 2007 on Investment, investment is defined as "investment activities, both domestic and foreign, carried out in Indonesia, including lawful business activities." R&D is understood as a process undertaken by companies to develop new products and/or improve existing products (Judianto et al., 2024). R&D activities play a crucial role in innovation, as they enable the creation of new technologies, products, services, or systems that can be utilized or commercialized to increase corporate profitability.

E-commerce

According to the OECD (2009), Electronic Commerce (e-commerce) is "the process of buying and selling goods or services conducted through computer networks, using methods specifically designed to receive or place orders. However, payment and delivery of goods and services do not necessarily have to be carried out online." E-commerce transactions may involve various parties, including households, companies, individuals, and government entities, both public and private. Musnaini (2020) explains that several types of e-commerce have developed in Indonesia, including Consumer to Business (C2B), Business to Consumer (B2C), Business to Business (B2B), Consumer to Consumer (C2C), Business to Administration (B2A), and Online to Offline (O2O).

Digital Infrastructure as a Foundation for Growth

Digital infrastructure is a crucial factor in supporting the transformation toward a knowledge-based economy, as explained in endogenous economic growth theory. This infrastructure includes broadband internet networks, data centers, digital communication systems, cloud computing technologies, and electronic payment systems that serve as the backbone of the modern digital economy. Within the framework of endogenous growth, digital infrastructure functions as public capital that can enhance productivity and broadly stimulate innovation. It enables the diffusion of knowledge and technology across all economic sectors, strengthens collaboration among business actors, and supports continuous learning and innovation through increasingly extensive connectivity.

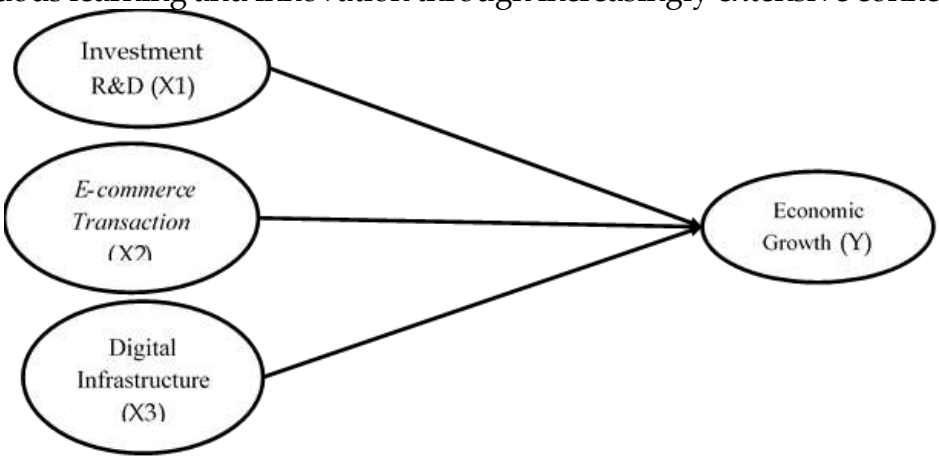


Figure 1. Conceptual Framework

METHODOLOGY

Study employs a quantitative research approach using secondary time-series data to analyze the effect of digital economy variables on Indonesia's economic growth. The data were obtained from official and publicly accessible sources, including the Central Bureau of Statistics (BPS), Statista, and the World Bank, covering the period from 2015 to 2024. Economic growth, measured by the growth rate of real Gross Domestic Product (GDP), is used as the dependent variable, while research and development (R&D) investment, e-commerce transactions, and digital infrastructure serve as the independent variables, proxied respectively by R&D expenditure as a percentage of GDP, total e-commerce transaction value, and internet penetration rate. Data were collected through documentation and literature review of statistical reports and previous studies and analyzed using multiple linear regression with the Ordinary Least Square (OLS) method. Classical assumption testing, as an essential aspect of multiple linear regression analysis, was conducted to ensure that the model fulfills the Best Linear Unbiased Estimator (BLUE) criteria, including normality tests using Kolmogorov–Smirnov and Shapiro–Wilk tests, multicollinearity test using Variance Inflation Factor (VIF), heteroskedasticity test using the Glejser method, and autocorrelation test using the Lagrange Multiplier (LM) test. Hypothesis testing was performed using the coefficient of determination (R^2), partial t-test, and simultaneous F-test to examine both partial and joint effects of the independent variables on economic growth.

RESULTS

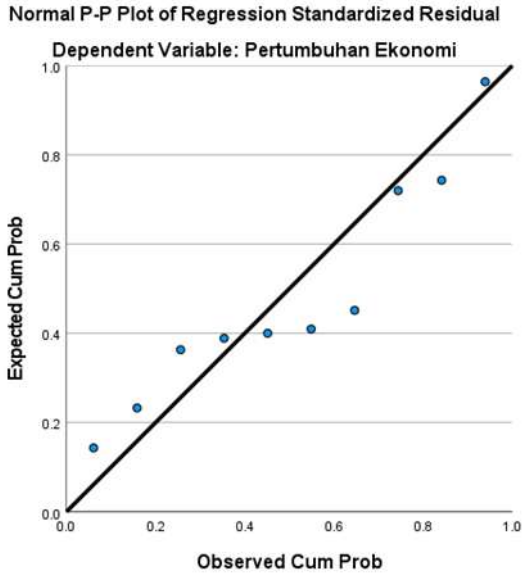
Analysis and Hypothesis Test

Normality Test

Table 1. Result Normality Test

Kolmogorov-Smirnov			***Shapiro-Wilk***		
Statistic	*df*	*Sig.*	*Statistic*	*df*	*Sig.*
0,259	10	0,055	0,896	10	0,197

Source: Processed Data (2025)



Source: Processed Data (2025)

Figure 2. Result Normality Test Jarque-Bera

Based on the normality test using the P–P Plot as well as formal tests such as the Kolmogorov–Smirnov and Shapiro–Wilk tests, it is concluded that the residuals are normally distributed. The P–P Plot shows that the observed data points lie close to the regression line, and the probability values of the Kolmogorov–Smirnov test (0.055) and the Shapiro–Wilk test (0.197) are both greater than 0.05. This indicates acceptance of the null hypothesis, meaning that the residuals in the model can be considered to be normally distributed.

Multicollinearity Test

Table 2. Result Test Multikolinearitas (VIF)

Variabel	***Tolerance***	***Centered VIF***
Investment R&D	0,207	4,827236
Transaction E-Com	0,195	5,136975
Infrastruktur Digital	0,343	2,919292

Source: Processed Data (2025)

a. R&D Investment Variable: The centered VIF value is 4.827236. Since this centered VIF value is below the threshold of 10, it indicates that multicollinearity among the independent variables is not significant.
b. E-commerce Transaction Variable: The centered VIF value is 5.136975. A centered VIF value below 10 confirms that no serious multicollinearity is detected.
c. Digital Infrastructure Variable: The centered VIF value is 2.919292. This value is well below 10, indicating that there is no multicollinearity problem.

Based on the analysis of centered VIF values, which are relevant for detecting multicollinearity among independent variables, all VIF values are below the threshold of 10. Therefore, it can be concluded that the model is free from serious multicollinearity issues in the regression model. High uncentered VIF values are often caused by correlations between independent variables and the constant term (intercept) and do not necessarily indicate multicollinearity among the explanatory variables.

Heteroscedasticity Test

Table 3. Result Test Heterokedastisitas (Glejser)

Variabel	t-statistik	Prob.
C	0,628	0,553
Investment R&D	-0,752	0,481
Transactions E-Com	1,012	0,350
Infrastruktur Digital	0,388	0,711
F-statistic	0,822	0,528

Source: Processed Data (2025)

Based on the results of the Glejser heteroskedasticity test, it can be concluded that there is no heteroskedasticity problem in the regression model. This conclusion is based on the probability (p-value) of all test statistics being greater than the 0.05 significance level.

The null hypothesis (H_0) in this test states that the variance of the residuals is constant (homoskedasticity). Since the probability value of the F-statistic (0.528) is greater than 0.05, we fail to reject the null hypothesis. This indicates that the variation of the residuals is constant across the range of the independent variables. Therefore, the homoskedasticity assumption in the regression model is satisfied, ensuring that the estimated coefficients are efficient and reliable.

Autocorrelation Test

According to the explanation by Gujarati and Porter (2008), conclusions drawn from the Durbin–Watson value are based on the dU and dL values referring to the Durbin–Watson table above, so the following conclusions can be derived:

Table 4. Result Test Durbin-Watson

Parameter	**Score**	**Conclusion**
Number of observations (n)	10	Inconclusive (indecision region) for positive autocorrelation.
Number of independent variables (k)	3	
Durbin-Watson (dW)	1,856	
Lower Bound (dL)	0,565	
Upper Bound (dua)	2,016	

Source: Processed Data (2025)

Based on the calculation results, the Durbin–Watson (DW) value of 1.856 falls within the range dL ≤ DW ≤ dU (0.565 ≤ 1.856 ≤ 2.016), placing it in the inconclusive region. This indicates that the Durbin–Watson test cannot provide a definitive decision regarding the presence or absence of positive autocorrelation. To obtain further confirmation, it is recommended to conduct an additional test such as the Breusch–Godfrey test (LM test). The LM test is used to detect autocorrelation in the residuals of a regression model, including both first-order and higher-order autocorrelation. The procedure involves first estimating the main regression model and obtaining its residuals, after which the residuals are regressed on the original independent variables along with several lags of the residuals themselves (Gujarati & Porter, 2008).

Table 5. Result Test Breusch–Godfrey (LM Serial Correlation)

Lag Resid	n (Obs)	R^2	LM = $n \times R^2$	χ^2tabel (α=0.05)	Prob. Chi-Square	Prob. F	Conclusion
1	10	0.001	0.010	3.84	0.919	1.000	No autocorrelation
2	10	0.186	1.860	5.99	0.395	0.955	No autocorrelation

Source: Processed Data (2025)

Based on the results of the Breusch–Godfrey autocorrelation test, it can be concluded that there is no autocorrelation problem in the regression model. This conclusion is based on the probability (p-value) of both test statistics being greater than the 0.05 significance level. The null hypothesis (H_0) in this test states that there is no serial correlation in the residuals.

Since the probability values of the F-statistic (0.6633) and Obs*R-squared (0.3954) are both greater than 0.05, we fail to reject the null hypothesis. This indicates that there is no significant correlation between the residuals in one time period and those in the previous period. Therefore, the classical regression assumptions are satisfied, and the estimated coefficients can be considered valid and efficient.

Regression Analysis
Multiple Linear Regression Results

Table 6. Multiple Linear Regression Results

Variabel	Koefisien	Std. Error	t-Statistik	Prob.
C	-2,588	2,292	-1,129	0,302
Investment *Research and Development*	159,762	22,913	6,973	0,000
Transaction *E-Commerce*	-0,010	0,003	-3,361	0,015
Infrastruktur Digital	-0,138	0,031	-4,404	0,005

Source: Processed Data (2025)

$$\text{PE} = -2{,}587641 + 159{,}7620\text{IRD} - 0{,}009702\text{TEC} - 0{,}138336\text{IDG} + \varepsilon_{it}$$

a) Constant
   If all independent variables—Research and Development Investment (IRD), E-commerce Transactions (TEC), and Digital Infrastructure (IDG)—are held constant, economic growth will decrease by −2.58%. However, the constant generally does not have strong economic significance.
b) Research and Development Investment (IRD)
   This variable has a positive coefficient of 159.762, meaning that a 1 percent increase in Research and Development Investment (IRD) will increase economic growth by 159.762 percent, assuming that the other variables—E-commerce Transactions (TEC) and Digital Infrastructure (IDG)—remain constant.
c) E-commerce Transactions (TEC)
   This variable has a negative coefficient of −0.010, indicating that a 1 trillion increase in e-commerce transactions will reduce economic growth by 0.010 percent, ceteris paribus.
d) Digital Infrastructure (IDG)
   Digital infrastructure has a coefficient of −0.138, meaning that a 1 percent increase in internet users will reduce economic growth by 0.138 percent, ceteris paribus.

Hypothesis Test
F-Test (Simultaneous Test)

Table 7. F-Test (Simultaneous Test)

F-statistic	**F-Tabel**	**Prob.**
18,43292	4,76	0,001975

Source: Processed Data (2025)

Based on the regression table calculations, the calculated F-statistic is 18.433 with a significance value of 0.001975. Meanwhile, the critical F-value at the 5% significance level with degrees of freedom $df_1 = k - 1 = 3$ and $df_2 = n - k = 6$ is approximately 4.76. These results indicate that the calculated F-statistic (18.433) is greater than the critical F-value (4.76) and the significance value (0.001975) is less than 0.05. Therefore, it can be concluded that, simultaneously, R&D investment, e-commerce transactions, and digital infrastructure have a significant effect on Indonesia's economic growth.

Partial Test (T-Test)

Table 8. Partial Test (T-Test)

Variabel	**t-Statistik**	**t-Tabel**	**Prob,**
C	-1,128888	2,447	0,3020
Investment *Research and Development*	6,972671	2,447	0,0004

Transactions *E-Commerce*	-3,361391	2,447	0,0152
Infrastruktur Digital	-4,403977	2,447	0,0045

Source: Processed Data (2025)

1. Research and Development Investment
   The t-statistic value is 6.972 with a significance level of 0.0004. The critical t-value at the 5% significance level (df = n − k = 10 − 4 = 6) is approximately 2.447. Since the t-statistic (6.972) is greater than the critical t-value (2.447) and the significance level of 0.0004 is less than 0.05, it can be concluded that, partially, Research and Development investment has a positive and significant effect on Indonesia's economic growth.
2. E-commerce Transactions
   The t-statistic value is −3.361 with a significance level of 0.0152. With a critical t-value of 2.447, it is evident that the t-statistic (−3.361) is less than −2.447 and the significance level of 0.0152 is less than 0.05. Therefore, it can be concluded that, partially, e-commerce transactions have a negative and significant effect on Indonesia's economic growth
3. Digital Infrastructure (IDG)
   Based on the regression results, the t-statistic value is −4.404 with a significance level of 0.0045. With a critical t-value of 2.447, it is evident that the t-statistic (−4.404) is less than −2.447 and the significance level of 0.0045 is less than 0.05. Thus, it can be concluded that, partially, digital infrastructure has a negative and significant effect on Indonesia's economic growth.

Koefisien Determinan

Table 9. Result Test Koefisien Determinan (R-Squared)

R-squared	**Adjusted R-squared**
0,902	0,853

Source: Processed Data (2025)

Based on the regression results, the R^2 value is 0.9021 and the adjusted R^2 is 0.853. This indicates that 90.2% of the variation in Indonesia's economic growth can be explained by R&D investment, e-commerce transactions, and digital infrastructure. The remaining 9.3% is explained by other factors outside the model. The high adjusted R^2 value suggests that the regression model has strong predictive power and is relevant for analyzing the effects of the three independent variables on economic growth.

DISCUSSION

The Effect of Research and Development (R&D) Investment on Indonesia's Economic Growth

Based on the data analysis results, Research and Development (R&D) investment has a coefficient value of 159.762 with a significance level of 0.0004, indicating a positive and significant effect on Indonesia's economic growth during the 2015–2024 period. This result suggests that a 1% increase in R&D investment will increase economic growth by 159.76%, assuming other variables remain constant. These findings emphasize the strategic role of R&D as a key driver of national economic growth.

The positive impact of R&D investment is consistent with endogenous growth theory, which posits that investment in R&D stimulates innovation and increases total factor productivity (TFP). Innovations generated through R&D enable improvements in production efficiency, the development of new products, and enhanced industrial competitiveness, thereby directly contributing to economic growth. According to Mankiw (2022), in Macroeconomics, Chapter 9.3, the return on research in technology and innovation reaches approximately 40%, which is substantially higher than the annual return on physical capital, which is around 6%. Thus, increased R&D investment benefits not only individual firms or specific sectors but also the overall economy.

These findings are in line with previous studies. Sumahir et al. (2022) found that R&D investment has a positive and significant effect on Indonesia's economic growth, supporting the results of the present study and reinforcing the argument that increased R&D investment promotes growth through innovation and productivity. In addition, a literature review conducted by Sholikhah et al. (2024) shows that, across 15 studies, R&D investment has a positive effect on economic growth in developing countries within the framework of endogenous growth theory. This evidence supports the findings of this study that R&D has a sustained effect on overall economic performance, suggesting that increasing R&D allocation in Indonesia can be an important strategy for achieving higher economic growth.

The Effect of E-commerce Transactions on Indonesia's Economic Growth

Based on the test results, E-commerce Transactions (TEC) have a coefficient value of −0.0097 with a significance level of 0.0152, indicating a negative and significant effect on Indonesia's economic growth during the 2015–2024 period. This implies that every increase of IDR 1 trillion in e-commerce transactions tends to reduce economic growth by 0.0097%, assuming other variables remain constant. These findings suggest the presence of specific dynamics in the contribution of e-commerce to economic growth in Indonesia.

This negative effect can be explained by several factors, particularly the uneven integration of the digital economy. Although e-commerce transactions have increased, the domestic production sector and goods distribution systems are not yet fully prepared to optimally leverage this growth. The World Bank (2016) emphasizes the importance of "analog complements," which include sound regulations, adequate skills, and accountable institutions. The report also highlights the need for sufficient infrastructure so that the benefits of

digitalization can be fully realized. In addition, labor availability and the quality of human resources are critical. According to modern growth theory, technological innovation and digitalization can promote economic growth only when accompanied by sufficient production capacity and labor absorption (human capital). Without adequate infrastructure, digital literacy, and appropriate policies, the positive effects of digital transactions on economic growth may be constrained (Blanchard, 2021).

Research by Rusdraryanti et al. (2024) finds that although e-commerce influences economic growth, its impact can be uneven due to variations in the readiness of economic sectors to respond to high levels of digital transactions. These findings are consistent with the results of the present study, which show that E-commerce Transactions have a negative partial effect on Indonesia's economic growth.

The Effect of Digital Infrastructure on Indonesia's Economic Growth

Based on the regression analysis results, the Digital Infrastructure (IDG) variable shows a coefficient of −0.1383 with a significance level of 0.0045, indicating a negative and significant partial effect on Indonesia's economic growth during the 2015–2024 period. This suggests that a 1% increase in internet users tends to reduce economic growth by 0.138%, assuming other variables remain constant. These findings indicate the presence of specific dynamics in the contribution of internet penetration to national economic growth.

This result can be linked to a similar phenomenon observed in the United States during the 1970s–1980s, when productivity declined despite significant advances in information technology. This phenomenon is known as the "Productivity Paradox of IT," a term introduced by Erik Brynjolfsson.

The negative effect can be explained by the level of economic readiness to utilize digital infrastructure. Although the number of internet users continues to increase, the ability of business sectors to integrate digital technology into production and distribution processes remains uneven. According to modern growth theory and the digital economy literature, digital infrastructure can promote economic growth only when accompanied by effective technology adoption, adequate digital literacy, and sufficient capacity among business sectors to utilize digital innovations. Findings by Narayan (2025) emphasize that supporting facilities and e-commerce enablers for business actors in Indonesia are still underdeveloped, causing cross-border activities to disrupt supply chains and ultimately affect the economy. As a result, even though public consumption through digital platforms has increased, its contribution to GDP remains relatively small because it does not generate significant domestic value added.

Research by Irwandi et al. (2025) finds that although digital infrastructure influences the economy, its effectiveness depends on the readiness of industries and society to utilize digital technologies. This is consistent with the results of the present study, which show that digital infrastructure has a negative partial effect on Indonesia's economic growth. This highlights the importance of a more comprehensive digital integration strategy so that internet penetration can have a tangible positive impact. In addition, a study by Suparta et al. (2024) also

indicates that telecommunications and internet infrastructure (BTS) has a negative effect on growth, which may occur because it is not accompanied by investment in digital literacy, technological innovation, and the strengthening of business sector capacity. Therefore, to make digital infrastructure a driver of economic growth, synergy among the government, industry, and society is required to build an inclusive and productive digital ecosystem.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the analysis, this study concludes that R&D investment has a positive and significant effect on Indonesia's economic growth during the 2015–2024 period, reflecting its important role in enhancing productivity, innovation, and industrial competitiveness. Conversely, e-commerce transactions and digital infrastructure exhibit negative and significant effects on economic growth, which may be explained by uneven integration with domestic production sectors, disparities in digital literacy and human capital, regional inequality, and the presence of adjustment lags known as the productivity paradox of information technology. Despite these individual effects, R&D investment, e-commerce transactions, and digital infrastructure simultaneously have a significant impact on economic growth, with the model explaining 90.21% of the variation in economic growth.

Based on these findings, this study recommends that the government intensify investment in R&D through increased public funding, tax incentives, and stronger collaboration among government, industry, and academia to support long-term economic growth. Furthermore, the development of e-commerce should be aligned with domestic production by strengthening local enterprises, enhancing digital literacy, and implementing policies that support domestic products. In addition, the expansion of digital infrastructure should be accompanied by improvements in human capital, equitable regional development, and institutional support to ensure effective technology adoption and to maximize the contribution of digital transformation to sustainable economic growth.

FURTHER STUDY

Future studies are encouraged to expand the data coverage beyond the 2015–2024 period and incorporate additional relevant variables, such as digital literacy levels, logistics infrastructure quality, and government policies related to R&D subsidies and e-commerce regulation, to provide a more comprehensive analysis of the digital economy. Further research should also examine the interactions among variables, particularly to assess whether the negative effects of e-commerce and digital infrastructure on economic growth may turn positive when accompanied by improvements in digital literacy or stronger integration with domestic production sectors. To capture these dynamics more effectively, advanced econometric approachessuch as interaction models, vector autoregression (VAR), autoregressive distributed lag (ARDL), or dynamic error correction model are recommended. In addition, combining quantitative analysis with qualitative methods, including in-depth interviews with business actors, policymakers, and economic experts, may offer deeper insights into non-

statistical factors such as regulatory constraints and cultural challenges in technology adoption.

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