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Digital Economy and Economic Growth in Indonesia: Insight and Challenges

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ABSTRACT

This study aims to analyze the relationship between the adoption of e-commerce (e-commerce) and regional economic growth in Indonesia. Using data from 34 provinces during the 2019–2021 period, the study applied panel data regression with a pooled OLS model, and included the index of education, real investment, and formal labour as control variables. The results of the study showed that the digital economy was positively and significantly related to economic growth. Real investment also showed a positive and significant relationship, while the labour force was positively associated with a weaker significance and an insignificant education index. These findings affirm the importance of strengthening the digital ecosystem through equitable distribution of infrastructure, capacity building of business actors, productive investment, and digital skills development. Given that the research period covered the COVID-19 pandemic, the estimated results reflect statistical relationships, not evidence of long-term causality.

Keywords: Digital Economy, E-commerce, Economic Growth, Panel Data, Indonesia

JEL Classification: O11; O32; O43

INTRODUCTION

Sustainable economic growth is now an inevitable integral element in the role of digital technology in various economies around the world. The digital economy offers new momentum and opens new paths towards sustainable economic expansion.

The development of the digital economy has become a key factor in the transformation of economic structures and activities across various nations. The utilization of information and communication technology (ICT) enables economic agents to enhance transaction efficiency, expand market access, accelerate information exchange, and foster innovation within production and distribution processes. From the perspective of economic growth theory, technological advancement is a crucial determinant of long-term productivity gains—a concept central to both neoclassical growth models and endogenous growth theory. Romer (1990) highlights the significance of knowledge accumulation and technological innovation in driving economic growth, while Habibi & Zabardast (2020) find a positive correlation between the development of information and communication technology and economic growth in Middle Eastern and OECD countries. Consequently, digitalization has the potential to serve as an instrument for supporting economic growth, though the realization of its benefits depends on the structural conditions, quality of human capital, and institutional capacity of each individual country.

In the context of Indonesia, the development of the digital economy is taking place in tandem with the increase in internet access and the use of digital technology in people's economic activities. Based on publications by the Central Statistics Agency (BPS, 2020, 2021a, 2022a), the percentage of the Indonesian population accessing the internet increased from 47.69% in 2019 to 53.73% in 2020 and 62.10% in 2021. These developments show a widening user base of digital technology that can support electronic commerce activities, financial services, business communication, and the provision of internet-based services. However, the increase in digital access does not automatically reflect an equal distribution of its utilization capacity. The World Bank (2021) shows that the development of Indonesia's digital economy still faces gaps in connectivity, digital skills, and the ability of households and business actors to obtain economic benefits from the use of technology. These conditions show that the expansion of internet access needs to be followed by an increase in productive capacity so that digital transformation can contribute to more inclusive economic growth.

The acceleration of Indonesia's digital transformation has been increasingly visible during the COVID-19 pandemic. Mobility restrictions and changes in economic interaction patterns have encouraged people and business actors to use internet-based services to support economic activity. At the same time, the pandemic has put great pressure on the national economy. BPS (2021b) noted that Indonesia's economy contracted by 2.07% in 2020, before growing again by 3.69% in 2021 (BPS, 2022c). These changes in economic conditions show the importance of business actors' ability to adapt to external shocks. The World Bank (2021) explained that the use of digital

technology during the pandemic provides opportunities for the sustainability of economic activities, although the benefits have not been evenly distributed. Therefore, the 2019–2021 period is a relevant context to examine the relationship between the adoption of digital technology by business actors and the dynamics of Indonesia's regional economic growth, without assuming that digitalization is the only cause of changes in economic growth during this period.

One form of digital transformation that is developing in Indonesia is electronic commerce (*e-commerce*), which allows business actors to carry out marketing, ordering, and selling goods and services through the internet. Based on *the 2022 eCommerce Statistics*, BPS (2022b) reported that the percentage of businesses conducting *e-commerce activities in the* listing *results* increased from 25.25% for the 2020 reference year to 32.23% for the 2021 reference year. However, BPS emphasized that this figure comes from business *listing activities* and is not a representative estimate at the national level. In addition, differences in the design and scope of surveys require caution in comparing results between years. This information indicates the development of online trading practices in the businesses covered in the data collection, as well as showing that there are still many business actors who have not yet taken advantage of this technology. Trinugroho, et al (2022), based on a survey of 2,222 micro and small enterprises in Indonesia, show that business characteristics, competitive conditions, and consumer preferences are related to business actors' decisions to adopt digital innovations. Thus, the development of the digital economy is not enough to be measured only through the number of internet users, but it is also necessary to pay attention to the level of participation of business actors in utilizing digital technology for productive economic activities.

International empirical literature has provided evidence on the relationship between digitalization and economic growth. Habibi & Zabardast (2020), using panel data on 10 Middle Eastern countries and 24 OECD countries during the period 2000–2017, found that the development of information and communication technology was positively associated with economic growth in both groups of countries. However, the size of the relationship differed according to technology indicators and the characteristics of country groups. These findings suggest that the contribution of digitalization to economic development needs to be understood by considering the level of development and technology utilization capacity of each region.

Furthermore, Gomes, et al (2022) found that the relationship between digital technology and economic performance in 36 OECD countries during the period 2000–2019 depends on the level of economic development and the type of technology indicators used, including the use of the internet, mobile phones, and broadband services. The results of the study confirm that the economic impact of digitalization is not always uniform between groups of countries and between technologies. Therefore, the positive coefficients found in this study need to be placed in the context of the characteristics of provinces in Indonesia that have different levels of infrastructure readiness, production capacity, and technology utilization.

In the context of regional economic development, Jiao & Sun (2021) provided relevant empirical evidence through a study of 173 cities in China during the period 2011–2018. The study shows that the development of the digital economy is positively related to urban economic growth, with the heterogeneity between cities, the role of employment opportunities as a mechanism, and the positive effects of spatial spillover. These findings provide a basis for considering that the benefits of the digital economy can go beyond the administrative boundaries of a region through market connectivity, production networks, and inter-regional trade activities. However, because this research model has not included spatial linkages between provinces, the existence of such spillover effects has not been directly proven.

Solomon & Klyton (2020), through research on 39 African countries during the period 2012–2016, showed that the relationship between digital technology and economic growth was not uniform by user category. Through an analysis of 39 African countries during the period 2012–2016, they found that the use of information and communication technologies by individuals had a positive relationship with economic growth, while the results for use by companies and governments did not show the same positive patterns. The findings provide an important perspective that the benefits of the digital economy are influenced by how technology is used, not just by the level of its availability or spread. The view on the importance of the digital economy for economic transformation was also discussed by Jurayevich & Bulturbayevich (2020) in the context of Uzbekistan's economic development. The study emphasized the importance of digital economy development, modernization of economic activities, and policies to support technological transformation. Although more conceptual and policy than providing comparable econometric estimates, the study strengthens the argument for the importance of integrating digital technology into economic development strategies.

Meanwhile, Coyle & Nguyen (2019) explain that the development of digital technology and data-driven business models pose challenges to conventional approaches in measuring economic activity. These findings confirm that different indicators of digitalization do not always represent the same economic mechanism. Therefore, the selection of digital economy indicators is important in explaining the contribution of technology to economic growth.

In the Indonesian context, research on digital transformation has developed at the business and regional levels. Trinugroho, et al (2022) focused more on the analysis of factors influencing the adoption of digital technology by micro and small enterprises. Meanwhile, Suhendra, et al (2025), using quarterly data from 34 provinces during the 2017–2022 period using the *dynamic panel Generalized Method of Moments* (GMM) approach, showed a positive relationship between a number of digital economy indicators and regional economic growth. The study used indicators that included the value of digital transactions, electronic business activities, and information and communication technology. While providing important evidence on the relationship between the digital economy and regional economic growth, the broader use of these

indicators differs from measurements that specifically emphasize the proportion of businesses participating in electronic commerce.

Based on the development of the literature, the *research gap* that is of concern in this study is the need for a more specific empirical understanding of the relationship between the level of *e-commerce adoption* by business actors and Indonesia's regional economic growth. Earlier research has elucidated the determinants of technology adoption at the business level and examined the relationship between various digital economy indicators and provincial economic growth. However, the use of different digital indicators can produce different economic interpretations. The value of digital transactions describes the amount of trading activity, while the percentage of businesses engaged in *e-commerce* shows the level of business participation in online trade. Therefore, this study focuses on the relationship between the proportion of businesses adopting *e-commerce* and provincial economic growth, considering the education index, investment realization, and the proportion of the formal workforce. This focus is intended to provide more targeted empirical evidence on the dimensions of digital technology adoption on the business actors' side, especially during the pre-pandemic period, economic contraction, and the beginning of Indonesia's economic recovery in 2019–2021.

The use of provincial panel data provides added value to the study because it allows the observation of differences in economic characteristics between regions and changes in economic variables over time. Indonesia has a diverse regional economic structure, including in connectivity levels, concentration of business activities, quality of human resources, and investment capacity. By using the provinces as the unit of analysis, this study can identify the statistical relationship between *e-commerce* adoption rates and GDP growth in a set of province-year observations, after taking into account the available control variables. This approach complements both company-level and national aggregate research as it provides a regional perspective on the relationship between digital transformation and economic performance. However, the use of the pooled *ordinary least squares model* does not automatically control for all of the characteristics of the province or the common influence each year, so the findings need to be interpreted as statistical associations and not as evidence of cause-and-effect relationships.

The contribution of this study to the literature can be explained through three dimensions. First, the contribution of measurement, namely the use of the percentage of businesses that do *e-commerce* as an indicator of digital adoption on the supply side, which is differentiated from the measure of internet penetration or the value of digital transactions. Second, the empirical-contextual contribution, namely the study of the relationship between *e-commerce* adoption and regional economic growth in the 2019–2021 period, when the Indonesian economy experienced sharp changes due to the COVID-19 pandemic. Third, the contribution of regional analysis, namely the use of provincial-year observations to link business participation in digital trade with economic growth after considering factors of education, investment, and employment

structure. This contribution is complementary to the research of Suhendra, et al (2025), not the claim that the use of provincial panel data or digital economy testing on economic growth is the first approach carried out in Indonesia.

Based on the background and gaps of the study, this study aims to analyze the relationship between the level of *e-commerce adoption* by business actors and provincial economic growth in Indonesia during the 2019–2021 period, taking into account the role of education indexes, investment realization, and the proportion of formal workers. The main question of the study is whether provinces with higher levels of business participation in *e-commerce* tend to show higher economic growth after considering these variables. Academically, this study is expected to enrich the understanding of the relationship between digital technology adoption on the business side and regional economic performance. In terms of policy, the results of the study are expected to be inputs for the development of digital connectivity, improving the capabilities of business actors, and expanding access to electronic commerce that is more in line with the characteristics of interprovincial economic development in Indonesia.

METHODS

This study uses a panel data regression approach to analyze the influence of the digital economy on economic growth in Indonesia. The analysis was conducted using data from 34 provinces during the 2019–2021 period, thus allowing the observation of interprovincial variations and changes in economic conditions over time. In addition to the digital economy as the main independent variables, this study included labour, investment, and human resources as control variables that theoretically contributed to economic growth.

Table 1. Variable Definitions

No.	Variables	Abbreviation	Measurement	Period
1	Economic Growth	EG	The value of economic growth, measured at constant prices	2019-2021
2	e-commerce businesses	ECB	Percentage of E-commerce businesses	2019-2021
3	Human Capital	HC	Education Index	2019-2021
4	Investment	IR	Investment realization	2019-2021
5	Labour	LBR	Ratio of labour employed in the formal sector to population	2019-2021

Source: E-commerce Statistic Year of 2019-2021 (BPS-Statistics Indonesia)

Furthermore, Model 1 was formulated to estimate the influence of the digital economy on economic growth by simultaneously considering the contribution of these control variables. Through this model specification, the research is expected to provide a more comprehensive empirical picture of the relationship between the development of the digital economy and economic growth at the provincial level in Indonesia.

$$EG_{i,t} = \alpha + \sum_{i}^{n} \beta_i DE_t + \sum_{i}^{n} \rho_i X_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

If the above equation is written in more detail, then the above equation can be rewritten in the form:

$$EG_{i,t} = \beta_1 + \beta_2 ECB_{i,t} + \beta_3 HC_{i,t} + \beta_4 IR_{i,t} + \beta_5 LBR_{i,t} + \varepsilon_{i,t} \quad \dots\dots\dots\dots . (2)$$

where EG is economic growth data that describes the amount of economic growth in each province in percentage units. ECB is the percentage of business data that conducts e-commerce in their buying and selling activities. IR is the realization of investment, which is the total realization of FDI and PMDN in each province in Indonesia in units of Billion Rupiah. LBR is the workforce, in this case, which is explained by the proportion of the population working in the formal sector in each province. HC is Human Capital that describes human capital in a region. The HC variable uses education index data in each province with an index unit. Additionally, i was in the province cross-section, and t was period (yearly).

The education index is calculated using a certain formula set by BPS with the following specifications:

$$I_{Education} = \frac{I_{HLS} + I_{RLS}}{2} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

$$I_{HLS} = \frac{HLS - HLS_{min}}{HLS_{maks} - HLS_{min}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots . . (4)$$

$$I_{RLS} = \frac{RLS - RLS_{min}}{RLS_{maks} - RLS_{min}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (5)$$

$I_{Education}$ = Education index

I_{HLS} = School length expectation index

I_{RLS} = Average index of school length

HLS = Long-standing expectations for schools

RLS = Average school time

The selection of the 2019–2021 observation period in this study is based on empirical and contextual considerations to analyze the relationship between the development of the digital economy and economic growth in Indonesia during a period of significant changes in economic conditions due to the COVID-19 pandemic. The period includes three different economic phases, namely pre-pandemic conditions in 2019, economic contraction due to the pandemic in 2020, and the initial phase of economic recovery in 2021.

These differences in macroeconomic conditions provide a relevant empirical context to examine the relationship between digital economy development and economic growth, especially when economic activity undergoes adjustments to mobility restrictions, changes in consumption patterns, and increased use of digital technology

in various economic activities. The use of panel data covering 34 provinces over three years allowed this study to identify variations in digital economy development and economic growth between regions and their changes over time, as well as to consider the heterogeneity of regional economic characteristics in the pre-pandemic period to the early phase of recovery. However, the observation period that only lasted three years limited the ability of the panel data regression model to capture long-term dynamics, structural changes, and possible digital economic influences that emerged through a gradual adjustment process.

RESULTS

The development of the digital economy in Indonesia shows that there are differences in the level of digital technology utilization in business activities between provinces. One of the indicators that can be used to describe this condition is the proportion of business actors who have utilized electronic commerce (*e-commerce*) in carrying out their business activities. This indicator reflects the level of digital trade adoption among business actors in each region, as well as providing a first overview of the heterogeneity of digital economic development in Indonesia. This difference is important to study because the use of *e-commerce* has the potential to expand market access, increase transaction efficiency, and create opportunities for the development of economic activities.

Based on E-Commerce Statistics data published by the Central Statistics Agency (BPS), Table 2 presents a comparison of the percentage of business actors who do and do not carry out *e-commerce* activities in the five provinces with the highest adoption rate and the five provinces with the lowest adoption rate based on the data used in the study.

Table 2. The average percentage of businesspeople who carry out e-commerce activities in each province

No	***Highest***			***Lowest***		
	Province	**Doing**	**Not Doing**	**Province**	**Do**	**Not Doing**
1	Jakarta	33.89%	66.11%	East Nusa Tenggara	11.79%	88.21%
2	DI Yogyakarta	31.77%	68,23%	Gorontalo	12.09%	87.91%
3	Lampung	29,08%	70.92%	West Sulawesi	12.90%	87.10%
4	West Java	28.52%	71.48%	Papua	13.32%	86.68%
5	Riau Islands	28.13%	71.87%	Southeast Sulawesi	13.95%	86.05%

Source: E-commerce Statistic Year of 2019-2021 (BPS-Statistics Indonesia)

Based on Table 2, the level of *e-commerce* utilization by business actors shows considerable variation between provinces in Indonesia. DKI Jakarta occupies the highest position with the percentage of business actors carrying out *e-commerce* activities of 33.89%, followed by DI Yogyakarta at 31.77%, Lampung at 29.08%, West Java at 28.52%, and Riau Islands at 28.13%. The descriptive findings show that in the five provinces, digital trade activities have been utilized by more than a quarter of the business actors covered in the observation. However, the majority of business actors

in each province still do not carry out *e-commerce* activities, as can be seen from the percentage of businesses that do not conduct electronic commerce which is still above 60%.

On the other hand, in the group of provinces with relatively low *e-commerce* adoption rates, East Nusa Tenggara recorded a percentage of 11.79%, followed by Gorontalo at 12.09%, Papua at 13.32%, and Southeast Sulawesi at 13.95%. The low proportion of business actors who use electronic commerce in this regional group indicates that there is a gap in digital technology adoption in economic activities between provinces. This gap can be related to differences in the availability and quality of digital infrastructure, technological literacy, business characteristics, and access to markets and services to support digital transactions. However, these factors are still possible explanations that require further empirical testing and cannot be directly concluded based on descriptive data alone.

The difference in the level of *e-commerce adoption* between provinces provides an early indication that the development of the digital economy in Indonesia has not taken place evenly. From the perspective of regional economic development, this condition becomes relevant because the use of digital technology has the potential to increase productivity, expand marketing reach, and reduce transaction barriers faced by business actors. However, the proportion of businesses engaged in *e-commerce* does not directly reflect the amount of added value of the digital economy or its contribution to the growth of the Gross Regional Domestic Product (GDP). Therefore, further econometric analysis is needed to test the relationship between the development of the digital economy and interprovincial economic growth, considering other factors such as labour, investment, and the quality of human resources.

In addition to showing the difference in the level of *e-commerce adoption* between provinces, the development of the digital economy can also be observed through the distribution of electronic commerce activities by business field. Figure 1 shows that the use of *e-commerce* in 2020 includes various economic sectors, especially wholesale and retail trade, motor vehicle and motorcycle repairs, the processing industry, and the provision of accommodation and food and beverages. The distribution shows that digital trade activities are not limited to the information technology sector but have also been used in conventional economic activities. The integration of digital technology in various business fields has the potential to expand market access, increase distribution efficiency, and strengthen interactions between producers and consumers. However, the large proportion of *e-commerce* businesses in a sector does not directly indicate the size of the sector's contribution to economic growth.

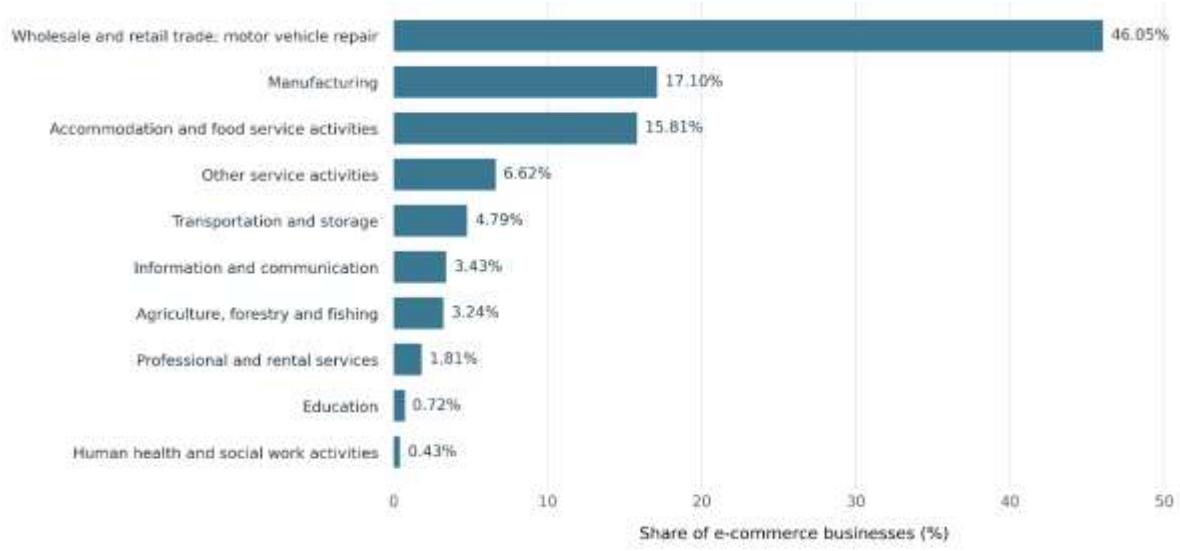


Figure 1. Distribution of E-commerce Business

Source: e-commerce Statistics in 2020 (BPS-Statistics Indonesia)

The difference in the level of *e-commerce* utilization between provinces and its distribution according to the business field provides an empirical basis to examine the relationship between the development of the digital economy and regional economic growth in Indonesia.

Table 3 presents the results of the panel data regression model estimation which was used to identify the direction, magnitude, and statistical significance of the relationship between *e-commerce activities* and provincial economic growth during the observation period.

Table 3. Results of E-commerce Estimates on RGDP growth

Dependent Variable: RGDP Growth				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Constant	5.360	0.796	6.729	0.0000*
Constant	5.360	0.7960	6.7336	0.0000*
Digital Economy	0.014	0.0057	2.4230	0.0172**
Educational Index	-0.257	0.9961	-0.258	0.7968
Investment realization	0.654	0.0393	16.6175	0.0000*
Labour	0.008	0.0041	1.9360	0.0557***
R-squared	0.863			
F-Statistic	153.3			
Prob(F-Statistic)	0.000			

Note. Symbols *** was Prob. < 10%, ** was Prob. < 5%, and * was Prob. < 1%.

Source: Author's Calculation Results, 2026

The results of the panel data regression estimation presented in Table 3 show a different relationship between the development of the digital economy, real investment, labour, and the quality of human resources with regional economic growth in Indonesia during the 2019–2021 period. In general, the estimation results show that the digital economy and real investment have a positive and statistically significant

coefficient, while labour shows a positive relationship with a weaker level of significance. Meanwhile, the education index has a negative coefficient, but it is not statistically significant. The findings indicate that there is a difference in the strength of the relationship between each explanatory variable and economic growth between provinces after controlling for other variables in the model.

The digital economy variable has a coefficient of 0.014 with a t-statistic value of 2.423 and a probability of 0.0172. A probability value smaller than 0.05 indicates that the positive relationship between the digital economy and economic growth is statistically significant at a confidence level of 95%. Real investment has a positive coefficient of 0.654 with a t-statistical value of 16.6175 and a reported probability of 0.0000. These results show that real investment is positively and significantly related to economic growth at a significance level of 1%.

The labour variable had a positive coefficient of 0.008, a t-statistical value of 1.936, and a probability of 0.0557. These results showed that labour had a significant positive relationship at the level of 10%, but not significantly at the level of 5%. Thus, the empirical evidence regarding the positive relationship between labour and economic growth is relatively weaker than the evidence obtained for the digital economy and real investment.

The variable of the education index produces a negative coefficient of -0.257, with a t-statistic of -0.258 and a probability of 0.7968. The value of this probability far exceeds the limit of conventional significance, so there is no sufficient statistical evidence to conclude that there is a relationship between the education index and economic growth in the specifications of the model used. Thus, the negative mark on the coefficient cannot be used as a basis for stating that an increase in education leads to a decrease in economic growth.

The estimated results show an R-squared value of 0.863. This value indicates that about 86.3% of the variation of economic growth variables observed in the sample can be explained statistically by the estimated model, while about 13.7% of the other variations are not explained by the model. This value indicates a relatively high fit of the model to the observational data, but it cannot be interpreted that the four independent variables causally determine 86.3% of economic growth.

Furthermore, the F-statistical value of 153.3 with a probability of 0.000 indicates that the model is simultaneously significant. In the interpretation of the conventional F-test, the results provide a basis for rejecting the null hypothesis that the entire slope coefficient of the explanatory variable is equal to zero. This means that the independent variables together can statistically explain the variation in economic growth in the model specifications used.

DISCUSSION

The main findings of this study show that the digital economy has a positive and statistically significant relationship with regional economic growth in Indonesia. These empirical results are consistent with Habibi & Zabardast, 2020; Solomon & Klyton, 2020; Jurayevich & Bulturbayevich, 2020; Jiao & Sun, 2021; Elgendy & Hanafy, 2022; Gomes, et al, 2022; and Suhendra, et al (2025), which provides empirical support for the argument that the development of economic activities based on digital technology is one of the factors related to increasing economic growth. In the context of development economics, these findings are relevant because digitalization can change the mechanisms of production, distribution, information exchange, and market interaction, thereby opening opportunities to increase economic efficiency and productivity.

The results of this study expand the empirical discussion on the relationship between the digital economy and economic growth in the Indonesian regional context. The similarity in the direction of the findings with several international studies shows the consistency of the positive relationship between digitalization and economic growth. However, differences in indicators, observation periods, estimation methods, and regional characteristics show that these relationships are contextual. The contribution of this study lies in the presentation of empirical evidence at the provincial level during the period 2019–2021, which includes changes in economic conditions before the pandemic, during economic contraction, and in the early phases of recovery.

Theoretically, these findings can be explained through the *endogenous growth theory* developed by Romer (1990). In this framework, technological change is not solely seen as an external factor, but can be produced through investment decisions, knowledge development, innovation, and human capital accumulation. The characteristics of knowledge as non-competitive inputs in its use (*non-rival*) allow innovation to provide economic benefits that go beyond the use by one business actor. In the context of the digital economy, information dissemination, the use of communication technology, and the development of data-based business models have the potential to increase the use of knowledge in production and trade activities.

Based on this perspective, the positive relationship between the digital economy and economic growth found in this study can be understood as results consistent with the predictions of endogenous growth theory. The use of digital technology has the potential to increase productivity through reducing the cost of information search, expanding transaction networks, and improving coordination between producers, suppliers, distributors, and consumers. However, the regression results have not directly proven the existence of *knowledge spillovers* or changes in total factor productivity, so the two mechanisms are placed as theoretical foundations to interpret the results, not as causal mechanisms that have been identified.

The 2019–2021 research period has special characteristics because it includes economic conditions before the COVID-19 pandemic, economic contraction in 2020,

and the first phase of recovery in 2021. These changes in economic conditions provide an important context in understanding the relationship between the development of the digital economy and regional economic growth in Indonesia. Restrictions on people's mobility, a decrease in direct trade activities, and changes in consumption patterns during the pandemic have the potential to encourage business model adjustments towards the use of digital platforms and electronic transactions.

In this context, the findings regarding the positive and significant relationship between the digital economy and economic growth can be understood as an indication that regions with higher development of digital activities tend to show better economic growth performance, after taking into account control variables in the model. This relationship is relevant to the argument that digital technology can provide alternative channels of economic transactions when conventional trade activities experience bottlenecks. However, since the study has not identified different influences between the period before the pandemic and during the pandemic, these results are not enough to conclude that digitalization causally increases the resilience of regional economies to the COVID-19 shock.

The World Bank (2021), through its *Indonesia Economic Prospects: A Green Horizon, Toward a High Growth and Low Carbon Economy*, emphasizes the importance of structural reforms in supporting Indonesia's economic recovery, including the development of the digital economy, the improvement of labour skills, and the strengthening of productive capacity. The report shows that the economic recovery in 2021 is still underway in a situation of uncertainty due to the pandemic, while consumption, investment, and labour market conditions have not fully returned to pre-pandemic conditions. Thus, the relationship between the digital economy and economic growth during the period needs to be understood in the context of structural adjustment and the recovery of economic activity more broadly.

Research by Trinugroho, et al (2022) shows that the use of digital technology by micro and small enterprises in Indonesia is related to business characteristics, consumer demand, and the condition of business activities during the pandemic. These results provide a basis for understanding that digital transformation can be a form of adjustment of business activities to changes in the economic environment. However, the study also shows the possibility of a selection process, when businesses with better capacity are better able to adopt digital technology. This is important because the positive relationship between digitalization and economic performance does not always indicate the direction of a single cause-and-effect relationship.

From a methodological perspective, Coyle & Nguyen's (2019) research provides an important foundation on the complexity of measuring the contribution of the digital economy in economic statistics. They explain that technological developments such as cloud computing, data use, and production process innovation can produce economic benefits that are not yet fully reflected in conventional economic measurement systems. Changes in the quality of digital services, declining technology costs, and

increasing use of intangible assets also pose challenges in calculating added value and productivity.

The implication of this argument is that the electronic commerce indicators used in this study need to be understood as a proxy for digital economy activities, not an overall measure of all the added value generated by the digital economy. Digital activities also include various other dimensions, such as digital financial services, information technology infrastructure, data processing, digital platforms, and the use of technology in the production process. Therefore, the positive coefficient of the digital economy in this study provides relevant evidence on the relationship between digitalization indicators observed and economic growth but does not yet describe the overall contribution of the digital economy to the formation of regional output.

Another limitation relates to the possibility of a two-way relationship between digital economic development and economic growth. On the one hand, increased use of digital technology has the potential to be related to increased productivity and economic activity. On the other hand, provinces with higher levels of income, infrastructure, investment capacity, and economic development may also have a greater ability to adopt digital technology. This condition raises the possibility of endogeny that needs to be considered in the interpretation of regression results.

In this regard, Suhendra, et al (2025) show that the choice of an estimation approach can affect conclusions about the relationship between the digital economy and economic growth in Indonesia. The study identified endogeneity problems in the panel model and used a dynamic panel approach to obtain alternative estimates. The findings confirm that the regression results in this study should not be directly interpreted as causal impacts before more testing is carried out on the possibility of simultaneity, regional heterogeneity, and other factors that have not been observed.

Thus, this study provides empirical evidence on the positive relationship between the digital economy and regional economic growth during periods of significant economic change. These findings are relevant in understanding the role of digitalization during the pandemic and the beginning of economic recovery, but it is not enough to identify the magnitude of the causal impact or long-term contribution of the digital economy. The development of research using a longer period and more comprehensive digitalization indicators is needed to obtain stronger conclusions.

Regarding other findings, specifically concerning investment, labour, and the quality of human resources in relation to economic growth during the observation period, the results indicate that real investment has a positive and significant association with economic growth, with a coefficient of 0.654 and a probability of less than 0.01. This finding aligns with the perspective that capital accumulation is a crucial element in expanding production capacity and enhancing economic productivity. Investment enables firms to increase their utilization of the machinery, equipment, infrastructure, and technology required to produce goods and services more efficiently. In the context of digital economic development, real investment has the potential to serve as a

supporting factor for technological transformation. The availability of telecommunications infrastructure, distribution facilities, payment systems, and logistics networks can enhance the ability of businesses to leverage e-commerce productively. Thus, the positive relationship between real investment and economic growth can be understood as an indication of the importance of capital formation in supporting economic activity in general, including digital-based economic activity. However, as the model does not estimate the interaction between investment and the digital economy, this study cannot definitively determine whether investment strengthens the link between the digital economy and economic growth.

Meanwhile, the labour coefficient of 0.008, with a probability of 0.0557, indicates a positive relationship that is significant at the 10% level. These findings suggest that labour remains linked to economic growth, though its level of significance is weaker compared to investment and the digital economy. This can be understood in the context of shifting labour requirements as digitalization advances—specifically, a transition toward economic activities that demand technological skills, information management capabilities, and the ability to adapt to digital-based business processes. In a study by Jiao & Sun (2021), employment was identified as a mechanism linking the development of the digital economy to urban economic growth. These results provide an empirical basis for considering the importance of evolving employment opportunities and labour productivity within the digital transformation process. However, in the present study, labour is treated as an independent control variable; therefore, its role as a transmission mechanism for the digital economy cannot be substantiated.

Furthermore, the estimation results for the education index show a negative coefficient of -0.257, which is not statistically significant. These findings warrant discussion because, theoretically, human capital is viewed as a fundamental factor in the development of productivity and economic growth. In Romer's (1990) endogenous growth theory, human capital plays a strategic role in the creation of knowledge, the development of technology, and innovation activities. Therefore, the lack of statistical significance for the education index in this study does not inherently contradict endogenous growth theory; rather, it may point to limitations in measurement, the observation period, or the empirical specification. There are several potential explanations for the insignificance of the education index in this study that merit further investigation. First, the 2019–2021 period is relatively short for capturing the outcomes of investments in education, which typically require time before they are reflected in increased economic productivity. Second, the education index tends to reflect formal educational attainment, which is not always synonymous with the mastery of digital skills or the alignment of competencies with the needs of the business sector. Third, changes in the education index over a three-year span may be quite limited, thereby reducing the model's ability to identify statistical relationships. Fourth, variations in labour market conditions across provinces during the pandemic may have influenced the capacity of human resources to contribute productively.

Thus, the relationship between the digital economy, investment, the labour force, and the quality of human resources should be understood within a framework of mutually reinforcing development. The digital economy has the potential to expand market opportunities and enhance efficiency; investment supports production capacity and infrastructure; while the labour force and education determine the economy's capacity to capitalize on these opportunities. However, the nature of this complementary relationship remains a theoretical interpretation, as it has not yet been tested through interaction models or mediation analysis in this study.

CONCLUSION

The results of the study provide three important messages academically. First, the digital economy is positively and significantly related to regional economic growth, so these findings are consistent with the arguments of endogenous growth theory and several empirical studies. Second, real investment is a statistically strong positive relationship factor, while labour shows evidence of a weaker relationship and the education index has not shown a significant relationship. Third, the COVID-19 pandemic period, variations in provincial characteristics, and endogeny limit causal interpretations of these results.

The results of this study provide several implications for the formulation of regional economic development policies in Indonesia. First, the positive and significant relationship between the digital economy and economic growth shows the importance of considering the development of the digital ecosystem as one of the components of the regional development strategy. The policy can be directed at expanding quality internet access, increasing the adoption of electronic commerce by business actors, developing digital payment systems, and strengthening connectivity between digital commerce platforms and regional distribution networks.

Second, the positive and significant relationship between real investment and economic growth provides a basis for encouraging productive investment that supports economic transformation, including the development of telecommunication infrastructure, increasing logistics capacity, and developing production technology. Digital economy development policies need to be integrated with investment policies so that the use of technology not only increases transaction activities but can also support the strengthening of production capacity and the competitiveness of business actors.

Third, the significant positive relationship between the workforce at the level of 10% and the insignificance of the education index show the need to pay attention to the quality of human resources and the suitability of skills with the needs of the digital economy. Education and training policies need to be directed at improving digital literacy, information technology competence, entrepreneurial skills, and the ability to use technology in production and trade activities. However, the results of this study

have not proven the effectiveness of these policies, so this recommendation is mainly based on theoretical interpretations and lessons from earlier empirical studies.

Fourth, the difference in the level of e-commerce utilization between provinces indicates the importance of a policy approach that considers regional characteristics. Provinces with limited access to digital technology require support in terms of connectivity, infrastructure, and capacity of business actors. On the other hand, regions with higher levels of digital adoption can be directed towards increased productivity, business model innovation, and integration of digital activities with regional economic value chains.

Academically, this study contributes by presenting empirical evidence on the relationship between the digital economy and economic growth at the provincial level in Indonesia during the period 2019–2021. This study also shows that the relationship between the digital economy and economic growth remains statistically significant when real investment, labour, and education index are included as control variables. However, this contribution needs to be limited to the identification of conditional relationships in the observation period, not as proof of long-term causal influences.

Overall, the study provides a basis for placing the digital economy as one of the key elements in the regional economic development agenda, along with productive investment and human resource development. A development approach that integrates these three dimensions has the potential to support economic growth that is more inclusive, productive, and adaptive to technological change. Further testing is needed to ensure the effectiveness of such strategies and find mechanisms that link digital transformation to economic growth.

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