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-RESEARCH ARTICLE-

HOW MOBILE INTERNET AND E-COMMERCE DRIVE ECONOMIC GROWTH: DISTRICT-LEVEL INSIGHTS FROM INDONESIA

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─Abstract─

Understanding the economic implications of digitalisation is essential for emerging economies undergoing rapid technological advancement. This study examines the influence of digitalisation on economic growth in Indonesia, utilising panel data drawn from 514 districts and cities spanning the years 2019 to 2023. Digitalisation is represented through indicators such as mobile internet usage and e-commerce activity, while investment levels and the dependency ratio serve as control variables. The empirical analysis employs both fixed effects (FE) and random effects (RE) panel regression models to address region-specific, time-invariant characteristics. Results from the preferred FE model indicate that increased mobile internet penetration and e-commerce engagement significantly contribute to improvements in gross regional domestic product (GRDP) per capita. These outcomes highlight the pivotal role of digitalisation in enhancing market connectivity, promoting economic efficiency, and facilitating broader participation in the digital economy. Conversely, investment does not exhibit a statistically significant effect, which may reflect inefficiencies or misdirected allocation of resources. Additionally, a higher dependency ratio is found to impede economic growth, revealing demographic constraints that hinder productive potential in several regions. The study's findings underscore the necessity of strengthening digital infrastructure, fostering widespread technological adoption, and ensuring coherence between investment and labour market policies to achieve inclusive and sustainable economic development across Indonesia. The insights provided may also offer valuable guidance for digital transformation initiatives in other emerging contexts.

Keywords: Digitalisation, Mobile Internet, E-Commerce, Economic Growth, Dependency Ratio.

INTRODUCTION

The COVID-19 pandemic presented considerable obstacles to global economies, leading to stagnation in growth, major disruptions to international trade, and a marked reduction in foreign direct investment (FDI) (OECD, 2022). In response, many sectors accelerated their digital transformation as a strategic means to absorb economic shocks and preserve macroeconomic stability (Mohamed, 2023). As various economic functions shifted to online platforms, digitalisation gained prominence as a central driver of global economic recovery, offering productivity gains, fostering innovation, and broadening access to financial services, e-commerce, and other technology-enabled economic interactions (Du & Jian, 2025; Ye et al., 2025).

In developing nations, digital technologies have opened new avenues for inclusive economic advancement by lowering transaction costs, improving financial inclusion, and supporting entrepreneurial ventures (Afjal, 2023; Wen et al., 2024). However, the spread of such technologies has also highlighted significant structural disparities, particularly with regard to infrastructure provision and regional capabilities (Abbas & Zaman, 2024; Kartiasih et al., 2023). These inequities risk deepening the digital divide, potentially hindering the capacity of digitalisation to generate widespread development gains (Kartiasih et al., 2023; Liu et al., 2024). For countries characterised by significant geographic and socioeconomic diversity, such as Indonesia, understanding the impact of digitalisation on economic performance at a disaggregated level is thus of critical importance.

Indonesia, the largest economy in Southeast Asia and an archipelagic nation comprising over 17,000 islands, has integrated digitalisation as a core element of its national strategy through initiatives such as the “Making Indonesia 4.0” roadmap, which seeks to enhance industrial competitiveness via technological adoption (Ministry of Industry, 2018). Considerable progress has been made in expanding digital infrastructure and services, particularly mobile connectivity. By 2024, internet penetration in the country had reached 77.02%, accompanied by consistent monthly growth in mobile usage, internet banking, and e-commerce activity, averaging 2% (Indonesia, 2024). These developments reflect the increasing embedding of digital tools within daily economic transactions, most notably through mobile internet access and digital marketplaces.

Nevertheless, the pace of digital progress remains inconsistent across the country. Substantial disparities persist in infrastructure availability, affordability, and digital literacy, particularly between urban centres and rural or remote areas (BPS, 2023). Many underdeveloped regions lack sufficient broadband coverage or mobile connectivity, limiting their capacity to engage in the digital economy. As a result, the advantages of digitalisation tend to accrue to metropolitan zones, exacerbating spatial

inequalities. This situation raises a pressing policy concern: to what extent does digitalisation support inclusive economic growth at the subnational level in Indonesia? This issue is particularly relevant considering Indonesia's ongoing demographic transition. The country is currently positioned to benefit from a demographic dividend, driven by a substantial working-age population (Bloom & Canning, 2003). However, realising this potential depends heavily on the productive absorption of this labour force into the economy. Elevated dependency ratios—where the share of non-working-age individuals exceeds that of working-age residents—can burden fiscal systems and suppress income growth. In areas with limited digital access, the challenge of generating sufficient employment is exacerbated, placing additional strain on regional economies and limiting growth potential (Amornkitvikai et al., 2023; Rhee et al., 2022).

Despite considerable policy dialogue and macroeconomic research, limited empirical analysis exists on how digitalisation—measured through mobile internet penetration and e-commerce participation—influences regional economic performance in Indonesia. Most prior studies have focused either on aggregate national indicators or firm-level metrics, providing little insight into the district-level implications of digital transformation. Furthermore, scholarly consensus remains divided on the direction and strength of the relationship between digitalisation and growth, which may vary depending on local context, absorptive capacities, and the presence of complementary investments (Korherr et al., 2022; Maiti et al., 2019).

To fill this empirical void, the present study uses panel data from 514 districts and cities in Indonesia, covering the period from 2019 to 2023, to assess the effects of digitalisation on regional economic growth, measured by GRDP per capita. Digitalisation is represented by two key indicators—mobile internet access and e-commerce transactions—capturing both availability and active utilisation of digital technologies. To mitigate omitted variable bias, the model also incorporates investment levels and the dependency ratio as control variables. This study advances existing research in several important ways. Firstly, it sheds light on how distinct aspects of digitalisation influence economic performance at the subnational level in a developing economy. Secondly, it addresses the need for nuanced, evidence-based policy recommendations that extend beyond national averages, focusing instead on equitable and region-specific digital strategies. Thirdly, it explores the mediating effects of investment quality and demographic structure in shaping the returns from digital infrastructure.

Moreover, the findings emphasise the strategic role of digital infrastructure investment in underdeveloped areas. Targeted diffusion of digital technologies in these regions can help narrow development disparities, enhance labour absorption, reduce transaction costs, and improve institutional effectiveness. Empirical evidence suggests that such investments, particularly when integrated with skills development and digital public services, can significantly bolster regional innovation and economic resilience (Chen &

Xu, 2024; Liu et al., 2024). Accordingly, the primary aim of this study is to empirically evaluate the impact of digitalisation on district-level economic growth in Indonesia. It seeks to quantify the relative contributions of mobile internet and e-commerce to GRDP per capita, while accounting for variations in investment and demographic structure. In doing so, the study aspires to produce actionable insights that can guide targeted infrastructure planning, labour market reforms, and more inclusive digital development across the country.

The remainder of this paper is organised as follows. Section 2 offers an extensive review of the relevant literature on digitalisation and economic growth. Section 3 details the data sources, variables, and econometric methodology. Section 4 presents and interprets the empirical findings, while Section 5 concludes with a summary of key outcomes, policy implications, and directions for future research.

LITERATURE REVIEW

Economic Impacts of Digitalisation

The significance of digital technologies in facilitating economic transformation is well established. Prior research has shown that digital adoption, particularly the use of mobile internet, has played a central role in improving firm productivity and supporting broader regional economic growth (Ahmad et al., 2021; Khera et al., 2021). Nevertheless, much of the empirical literature remains confined to case-specific analyses, offering limited insights applicable to broader geographical settings, thereby raising concerns about the generalisability of these findings. In the Indonesian context, mobile internet access and e-commerce uptake have been recognised as key drivers of inclusive development. Studies by Elfaki and Ahmed (2024) and Xia et al. (2024) illustrated how enhanced mobile connectivity has contributed to greater financial inclusion in rural areas and improved access to markets. Despite these positive outcomes, existing literature has primarily centred on urban environments. For instance, while Simamora and Ningsih (2020) and Wang et al. (2024) acknowledged the contributions of e-commerce to employment creation and skills development within micro, small, and medium enterprises (MSMEs), their focus remained largely on metropolitan settings. This presents a critical research gap, as it remains unclear whether the economic benefits of digitalisation are equally realised in less developed and underserved districts.

Proxies of Digital Capability and Measurement Frameworks

The measurement of digitalisation in a durable and theoretically grounded manner has also become a focal point in scholarly discourse. Initial frameworks, such as those proposed by Brown (1997), Sambamurthy and Zmud (2000), and Bharadwaj (2000), concentrated primarily on internal IT governance mechanisms. Subsequent research expanded this scope, with contributions from Aral and Weill (2007) and Wamba-

Taguimdje et al. (2020), who incorporated performance-based dimensions into their assessments. However, critiques by Korherr et al. (2022) and Warner and Wäger (2019) highlighted that many of these models failed to adequately reflect the evolving dynamics associated with Industry 4.0 transformations. More recent developments have introduced conceptual improvements. Benitez et al. (2022) and Herhausen et al. (2020) integrated dimensions such as organisational agility and platform-based capabilities into digital capability assessments. Despite these advances, Maycotte et al. (2025) noted a persistent gap in the literature, pointing out the limited application of second-order constructs capable of capturing the multidimensional nature of digital capabilities. In empirical macroeconomic analyses, simplified indicators—most notably mobile internet penetration and e-commerce usage—remain frequently employed, although these proxies are often utilised without strong theoretical foundations.

Digital Infrastructure, Underdevelopment, and Resilience

Empirical studies indicate that the development of digital infrastructure in economically disadvantaged regions holds the potential to mitigate structural disparities. Research by Chen (2024) and Liu et al. (2024) demonstrated that the expansion of broadband and mobile technologies in underdeveloped sub-national areas contributed to enhanced entrepreneurial activity, increased economic resilience, and the strengthening of human capital. Comparable outcomes were observed in studies by Ji and Huang (2024) focusing on Chinese provinces, and by Osei (2024) within African settings. Although these investigations identified positive associations between digital infrastructure and regional development, they often lacked in-depth analysis of the underlying causal pathways and the sustainability of long-term outcomes. This gap highlights the need for more robust methodological approaches, such as panel data estimation techniques, to more effectively address potential endogeneity and provide stronger empirical validation.

Dependency Ratio: Demographics and Growth

The demographic composition of a population, commonly measured through the dependency ratio, has become an important focus within the economic growth literature. Bloom and Canning (2003) theorised that a demographic transition characterised by a declining proportion of dependants and an expanding working-age population could generate a "demographic dividend." Empirical studies in Asia, including analyses centred on Indonesia, have shown that regions with lower dependency ratios tend to experience higher savings rates and increased labour productivity (Amornkitvikai et al., 2023). Despite these findings, limited research has explored the intersection of demographic dynamics and digitalisation. As a result, it remains unclear whether demographic pressures serve to reinforce or constrain the potential of the digital economy to stimulate economic growth.

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MATERIALS AND METHOD

Research Data

This study utilised a panel data regression methodology to assess the influence of digitalisation on regional economic growth within Indonesia. The panel structure combined both cross-sectional and temporal dimensions, enabling the analysis of spatial and time-based variations across 514 districts and municipalities over the period 2019 to 2023. In contrast to conventional cross-sectional methods, panel data offer a greater volume of observations and facilitate the tracking of dynamic changes, akin to time series analysis. Critically, panel data techniques allow for the construction of more reliable econometric models by addressing the potential biases introduced by unobserved variables that may otherwise distort outcomes (Deng et al., 2025). This method improves estimation accuracy, accounts for latent heterogeneity, and alleviates multicollinearity concerns (Baltagi, 2005; Gujarati & Porter, 2012). The core dataset was sourced from the Indonesian Central Bureau of Statistics (BPS, 2023), with additional digital infrastructure metrics obtained from the International Telecommunication Union (Afjal, 2023), and macroeconomic indicators drawn from (Bank, 2023). The dependent variable, regional economic performance, was captured using the natural logarithm of GRDP per capita (lnGRDP). The independent variables used to proxy digital transformation are summarised in Table 1.

Table 1: Operational Definition and Data Sources

Variable	Definition	Source	Symbol
lnGRDP	Regional economic output per capita (log scale).	BPS	$lnGRDP_{it}$
Mobile Internet	Measured by the number of individuals owning mobile phones and using internet services (representing access and adoption of mobile device, as well as digital connectivity) (Simamora & Ningsih, 2020; Xia et al., 2024)	BPS, ITU	$Mobileinternet_{it}$
E-Commerce	Captured by the number of internet-based sellers in each region (digital commerce adoption) (Kilay et al., 2022)	BPS	$ecommerce_{it}$
Investment	Investment as a percentage of GRDP. Measured as the ratio of investment to GRDP, reflecting capital accumulation (Elfaki & Ahmed, 2024)	BPS	$Investment_{it}$
Dependency Ratio	Ratio of non-productive (under 15 and over 65) to the productive-age (15-64) populations, indicating labour market pressures (Zhao et al., 2022)	BPS	$Dependency_{it}$

To evaluate the association between digitalisation and regional economic growth, the study employed the following panel data regression model:

$$lnGRDP_{it} = \alpha + \beta_1 Mobileinternet_{it} + \beta_2 ecommerce_{it} + \gamma_1 Investment_{it} + \gamma_2 Dependency_{it} + \varepsilon_{it}$$

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Where:

$lnGRDP_{it}$: Log of GRDP per capita in district i and year t
$Mobileinternet_{it}$: Access to mobile and internet services
$ecommerce_{it}$: Number of online sellers
$Investment_{it}$: Investment share of GRDP
$Dependency_{it}$: Demographic dependency ratio
i : Region
t : Year
ε_{it} : Error term

Model Selection and Estimation

To thoroughly examine the relationship between digital infrastructure investment and economic growth across Indonesian provinces, multiple regression techniques were applied. The analysis began with the ordinary least squares (OLS) method as a baseline estimator. However, due to the likelihood of unobserved heterogeneity—where region-specific factors may influence the association between explanatory variables and economic outcomes—the study progressed to panel data approaches. Both FE and RE models were employed to account for spatial and temporal variation at the district level. Accordingly, three regression models—OLS, FE, and RE—were used to provide a comprehensive assessment of the influence of mobile internet access and e-commerce activity on regional economic performance.

The FE model was utilised to account for unobserved, time-invariant district-level characteristics that could potentially bias the coefficient estimates. Conversely, the RE model operated under the assumption that district-specific effects were uncorrelated with the explanatory variables, thereby providing more efficient estimations if this assumption held true (Gunasekara et al., 2014). To determine the appropriate panel model specification, the Hausman test was employed as a standard diagnostic tool (Hamaker & Muthén, 2020). This test evaluates whether the individual effects are correlated with the regressors, thus informing the selection between FE and RE models. A statistically significant outcome (p-value < 0.05) supports the rejection of the RE model in favour of FE. The econometric strategy was adapted from the framework proposed by (Habibi & Zabardast, 2020), with contextual adjustments to align with the Indonesian setting and available data. All estimations and diagnostic procedures were carried out using STATA software.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 2 presents a summary of the key variables employed in the empirical analysis. The dataset comprises 2,470 observations, reflecting substantial variation across

regions. The mean value of lnGRDP is 16.12, suggesting a relatively balanced distribution of economic output, though disparities remain evident (minimum: 13.04, maximum: 20.04). The average score for mobile internet access is 12.76, indicating generally high digital connectivity, yet also revealing the presence of regional digital divides. E-commerce participation, proxied by the proportion of online sellers, remains low (mean = 0.02), highlighting considerable untapped potential for digital commerce expansion in many districts. Broader uptake of e-commerce may accelerate local digital transformation and enhance operational efficiency (Suroso et al., 2022). Investment, as a share of GRDP, averages 32.01%, but displays wide variation (minimum: 3.91%, maximum: 109.71%), pointing to unequal capital allocation across districts. Increasing strategic investment in digital infrastructure may serve to reduce these disparities and promote a more inclusive economy (Kartiasih et al., 2023). The dependency ratio shows that around 50% of the population falls outside the working-age group, which could impede long-term economic growth if not addressed through investments in human capital. The availability of a skilled workforce is a critical determinant in the success of digital transformation efforts (Wu & Yu, 2022).

Table 2: Descriptive Statistics of Key Variables (Indonesia, 2019–2023)

Variable	Observer	Mean	Std. Dev.	Min	Max
GRDP	2,470	16.12	1.21	13.04	20.04
Mobile Internet	2,470	12.76	1.11	9.13	15.95
E-Commerce	2,470	0.02	0.02	0.00	0.12
Investment	2,470	32.01	11.11	3.91	109.71
Dependency Ratio	2,470	49.38	7.46	32.39	83.71

Over the past several decades, rapid advancements in ICT have fundamentally reshaped the way societies function, particularly in the economic domain. The integration of digital technologies into core economic, social, and cultural systems—referred to as digitalisation—has become a pivotal engine of global economic expansion, a trend clearly visible in Indonesia's evolving development trajectory. Indonesia's status as a vast archipelagic nation, with a population exceeding 270 million, brings forth both structural challenges and considerable opportunities for fostering growth. In this context, the expansion and modernisation of digital infrastructure have emerged as critical, yet complex, components of national development. The Indonesian government has prioritised digitalisation as a cornerstone of its long-term economic vision, aiming to transition towards a more innovation-oriented and knowledge-driven economy. This ambition is operationalised through a range of policy measures and strategic investments, including the rollout of the Palapa Ring Project to deliver high-speed broadband access, the acceleration of 4G and 5G service coverage, and the cultivation of a digitally enabled economic landscape characterised by expanding e-commerce, fintech platforms, and app-based services. To empirically capture the distribution and evolution of digital infrastructure within this study, several key indicators are employed.

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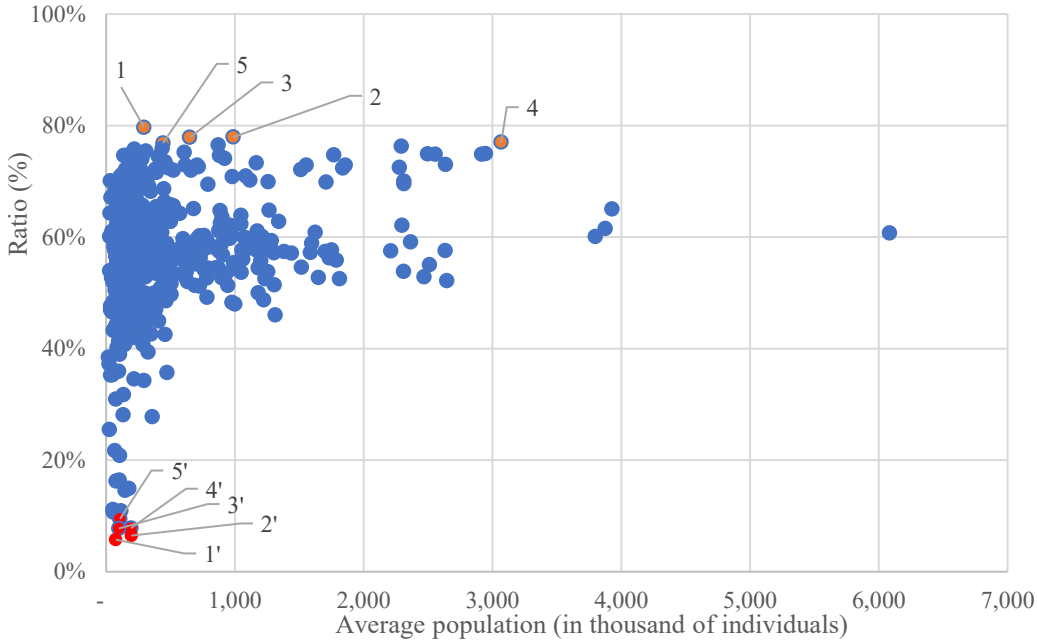
These include the ratios of mobile phone ownership, internet connectivity, online seller presence, and e-commerce participation, each measured relative to the total population.

Mobile Phone Ownership

Figure 1 presents the distribution of mobile phone ownership across 514 districts and cities in Indonesia. Over recent decades, ownership levels have expanded markedly, signalling a transformation in how technology is adopted and utilised by the population. As one of the world's most populous nations, Indonesia's mobile user base encompasses a broad demographic, spanning both urban centres and remote rural areas. Between 2019 and 2023, mobile phone ownership grew by an average of 14%, reflecting sustained national momentum in digital accessibility. According to Figure 1, the mean ownership ratio across all districts and cities is 56.88%, measured against the total population. Considerable variation is evident across regions. Palangkaraya recorded the highest level of mobile phone penetration at 79.71%, while Deiya District in Papua registered the lowest, at just 5.74%, underscoring persistent infrastructural and technological gaps between more and less developed areas.



- 1 : Palangka Raya (294; 79.71%)
- 2 : Denpasar (988; 77.95%)
- 3 : Balikpapan (650; 77.88%)
- 4 : Bekasi (3,069; 77.02%)
- 5 : Yogyakarta (442; 76.89%)
- 1' : Deiyai – Papua (76; 5.74%)
- 2' : Yahukimo – Papua (195; 6.48%)
- 3' : Dogiyai -Papua (99;7.75%)
- 4' : Lanny Jaya – Papua (193; 7.80%)
- 5' : Nduga - Papua (108; 9.47%)

Figure 1: Distribution of the Mobile Phone Ownership Ratio Relative to the Average Population From 2019-2023

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The expansion of mobile phone ownership across Indonesia has been propelled by a combination of structural and socioeconomic factors. Key among these are the decreasing cost of mobile devices, rising disposable incomes among households, and the progressive enhancement of telecommunication infrastructure. Mobile phones have evolved beyond mere communication tools, emerging as essential instruments of modern living and development. Their proliferation reflects not only increasing digital inclusion but also the population's growing reliance on mobile technologies for daily functions. Presently, mobile phones serve a diverse array of purposes, ranging from everyday communication to more complex economic functions such as conducting online transactions, facilitating digital payments, and enabling access to financial services. In the realm of education, mobile devices have proven especially valuable, acting as primary learning tools during the COVID-19 pandemic, when remote instruction became the dominant mode of educational delivery.

Internet Access

Figure 2 illustrates the distribution of internet access across 514 districts and cities in Indonesia. Internet connectivity has become a fundamental component of the country's digital development agenda, experiencing substantial growth between 2019 and 2023. During this period, access rates increased by 186%, signalling a rapid shift toward greater digital inclusion nationwide.

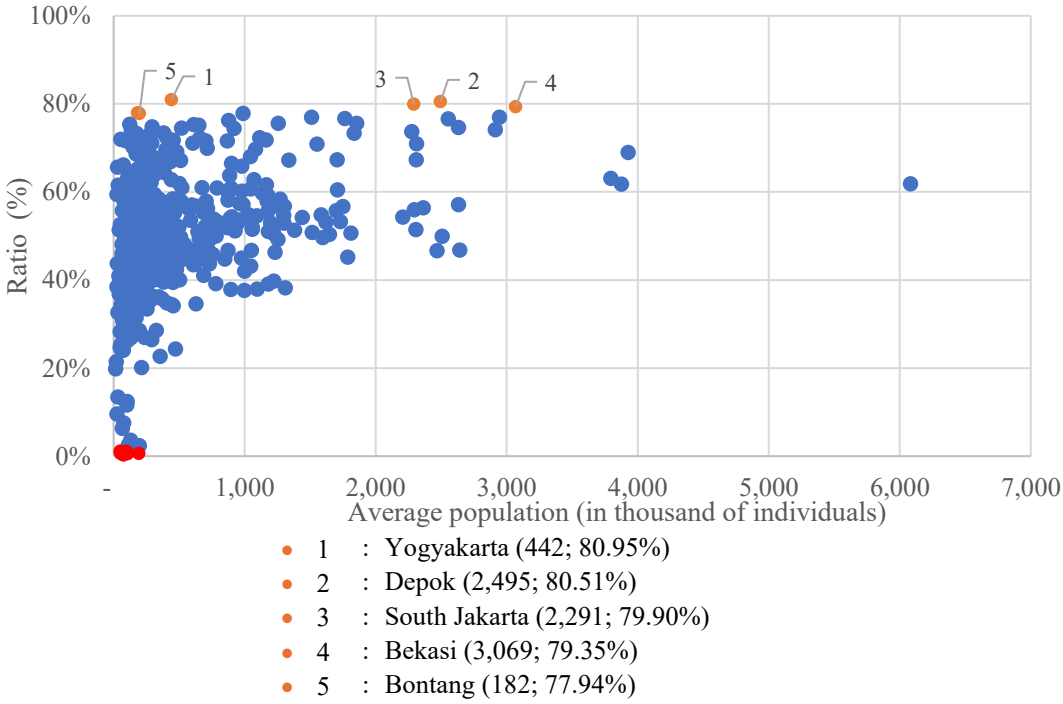

Figure 2: Distribution of the Internet Access Ratio Relative to the Average Population From 2019-2023

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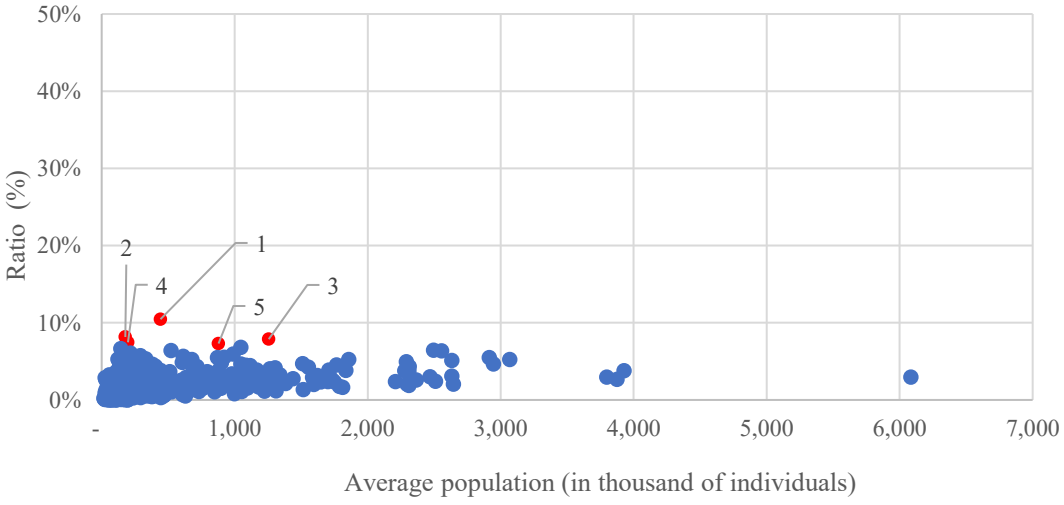
As of the most recent data, internet penetration across the sampled districts and cities averages 49.65% of the total population. Urban areas exhibit significantly higher levels of access, as previously shown in Figure 1. Among all regions, Depok City recorded the highest internet penetration rate at 80.51%, while Nduga District in Papua had the lowest, with just 0.54%, highlighting persistent regional disparities in digital infrastructure. Paralleling the role of mobile phones, internet connectivity now supports a wide spectrum of activities. These range from educational engagement and entertainment consumption to social communication and participation in digital economic activities, including online trade and service access.

Sale and Purchase of Goods and Services via the Internet

Figure 3 depicts the distribution of internet-based sellers across 514 districts and cities in Indonesia. The simultaneous expansion of mobile phone ownership and internet connectivity has played a catalytic role in fostering the growth of e-commerce activity. This technological integration has created favourable conditions for digital entrepreneurship, resulting in a substantial rise in the number of online sellers. Between 2019 and 2023, the volume of internet-based commercial actors increased by approximately 226%, reflecting a broadening participation in the digital economy. As shown in Figure 4, Yogyakarta City reported the highest concentration of online sellers, with 10.46% of its population engaged in e-commerce activity. This trend highlights the increasing relevance of digital platforms as avenues for economic participation and local business development.



- 1 : Yogyakarta (442; 10.46%)
- 2 : Madiun (178; 8.16%)
- 3 : Sleman (1,256; 7.88%)
- 4 : Salatiga (197; 7.47%)
- 5 : Malang (879; 7.31%)

Figure 3: Distribution of the Internet-Based Sales Ratio Relative to the Average Population From 2019-2023

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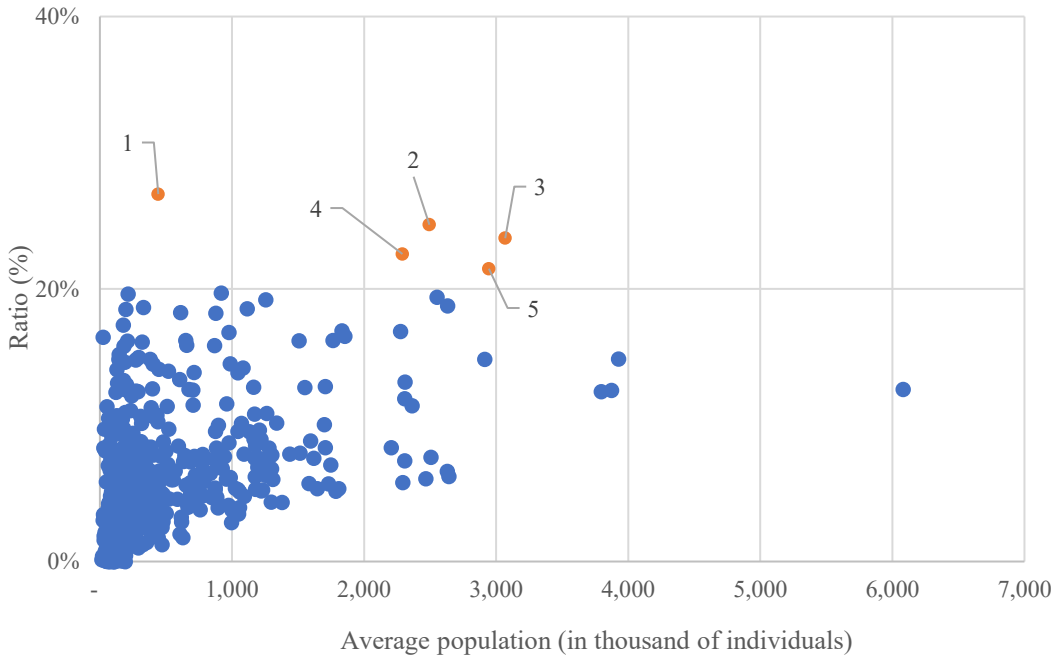
A parallel trend is evident in the rise of internet-based buyers, which grew markedly by approximately 300% between 2019 and 2023. This surge underscores the expanding integration of digital platforms into consumer behaviour across the country. As illustrated in Figure 4, Yogyakarta City recorded the highest proportion of online buyers, with 26.97% of its population participating in e-commerce. This was followed by Depok City at 24.72%, Bekasi City at 23.73%, South Jakarta City at 22.57%, and East Jakarta City at 21.49%. In contrast, the lowest levels of online purchasing activity continue to be concentrated in districts within Papua, highlighting persistent regional disparities in digital adoption. Figure 4 provides a comprehensive overview of the distribution of internet-based buyers across the 514 districts and cities included in the study.



- 1 : Yogyakarta (442; 26.97%)
- 2 : Depok (2,495; 24.72%)
- 3 : Bekasi (3,069; 23.73%)
- 4 : South Jakarta (2,291; 22.57%)
- 5 : East Jakarta (2,945; 21.49%)

Figure 4: Distribution of the Internet-Based Buyer Ratio Relative to the Average Population From 2019 to 2023

Figure 5 presents the trajectory of economic growth alongside key digitalisation indicators in Indonesia from 2019 to 2023. The visual representation demonstrates a clear upward trend in digital adoption, proxied by the mobile phone ownership rate (MobileOwn), internet usage rate (InternetUsers), and the prevalence of internet-based sellers (ecommerce). Each of these variables shows consistent growth over the period, signalling the expanding digital footprint across the country. Between 2019 and 2023,

the average rate of mobile phone ownership rose from 0.36% to nearly 0.6%, indicating growing access to essential digital infrastructure. Mobile devices have increasingly become the foundation for a wide range of technology-enabled activities, including participation in e-commerce platforms and utilisation of digital financial services. As noted by Ward and Zheng (2016), rising mobile adoption enhances economic performance by improving communication within the business sector, broadening financial inclusion, and strengthening community-level digital engagement. Moreover, the analysis by Suroso et al. (2023) confirms that mobile internet access contributes not only to business transformation but also directly improves productivity in specific economic sectors. This effect is particularly evident in rural areas, where digital tools have been shown to support agricultural development, including food crop and horticulture production. In the Indonesian context, where many remote regions remain underdeveloped, such technological integration plays a pivotal role in promoting local economic advancement.

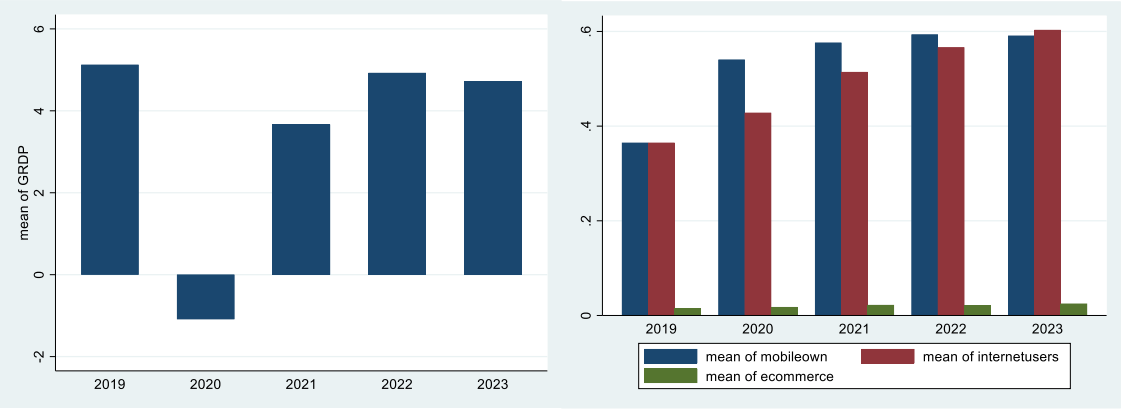


Figure 5: Economic Growth in Indonesia and the Growth of Digitalisation Variables Over the Period From 2019 to 2023

The surge in internet usage during 2020 and 2021 underscores the profound influence of the COVID-19 pandemic in accelerating digital transformation. As health-related restrictions forced the migration of numerous economic and social activities onto digital platforms, both individuals and enterprises rapidly adopted internet technologies at a pace exceeding prior projections. According to Mohamed (2023), the pandemic acted as a global catalyst for digitalisation, unlocking new economic prospects, particularly within technology-intensive industries. Within the Indonesian context, the expansion of internet access has significantly empowered MSMEs by facilitating their integration into broader digital marketplaces through e-commerce channels. The work of Rapih and Wahyono (2023) supports this observation, highlighting that internet connectivity functions as a central enabler of MSME engagement in the digital economy, thereby broadening their reach and enhancing their competitiveness.

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Digitalisation and Economic Growth (GRDP) in Indonesia

This section examines the influence of the independent variables—mobile internet penetration, e-commerce activity, investment levels, and the dependency ratio—on lnGRDP across Indonesia's districts and cities. The analysis was conducted using three econometric approaches: OLS, FE, and RE models. The findings, summarised in Table 3, indicate that the majority of these explanatory variables have a statistically significant impact on lnGRDP, underscoring their relevance in shaping regional economic outcomes.

Table 3: Impact of Mobile Internet, E-Commerce, Investment, and the Dependency Ratio on Economic Growth (GRDP) in Indonesia

Variable	Model 1	Model 2	Model 3
	OLS	Fixed Effect	Random Effect
Mobile Internet	0.881***	0.291***	0.384***
	(0.012)	(0.018)	(0.017)
E-Commerce	2.714***	0.358**	0.015
	(0.839)	(0.168)	(0.161)
Investment	0.005***	0.002	0.001
	(0.001)	(0.002)	(0.001)
Dependency Ratio	-0.016***	-0.002***	-0.004***
	(0.002)	(0.000)	(0.000)
Cons	5.772***	12.344***	11.051***
	(0.207)	(0.279)	(0.253)
R-Squared	0,795	0,477	0,769
No. of Cities/Districts	494	494	494
No. of Observations	2.470	2.470	2.470

Standard errors are presented in parentheses. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

To determine the most appropriate estimation method within the panel data framework, the study utilised the Hausman test to evaluate the suitability of the FE and RE models. The test produced a statistically significant outcome (p-value = 0.000), signifying that the explanatory variables were correlated with unobserved individual-specific effects. Consequently, the RE model was rejected in favour of the FE model, which was judged to provide more reliable and unbiased estimates under these conditions. This model selection was further validated through diagnostic measures, the results of which are presented in Table 4.

Table 4: Hausman Test Result

	Chi-Square	Prob
Hausman Test	686.24	0.000

The proliferation of mobile internet has emerged as a transformative force in the

economic evolution of developing nations, with Indonesia offering a particularly illustrative case. The results derived from the FE model in this study affirm its substantial influence on regional economic performance. Specifically, a 1% rise in mobile internet penetration is associated with a 29.1% increase in lnGRDP, a result statistically significant at the 1% level. This underscores the profound impact of mobile connectivity in facilitating efficient communication, reducing transaction costs, and broadening access to critical information, particularly in rural areas where physical infrastructure remains underdeveloped. The expansion of mobile internet infrastructure in Indonesia has been instrumental in integrating previously marginalised communities into the digital economy. These findings are consistent with the work of (Wu & Yu, 2022), who emphasise that mobile internet enhances automation, stimulates innovation, and strengthens competitiveness in sectors such as e-commerce and digital finance. Broader macroeconomic evidence supports this relationship; for example, Farhadi et al. (2012) and Gruber and Koutroumpis (2011) demonstrated that returns on mobile internet are especially pronounced in contexts with high existing mobile penetration and robust supporting infrastructure.

Beyond economic productivity, mobile internet also contributes to broader developmental goals, including improved access to education and healthcare, enhanced social inclusion, and the narrowing of gender disparities—particularly in disadvantaged regions (Rotondi et al., 2020). Rhee et al. (2022) further note that, within Southeast Asia, mobile internet serves as a key driver of total factor productivity and a strategic enabler of inclusive, sustainable development. Alongside mobile connectivity, e-commerce has become a vital pillar of Indonesia's digital economy. Empirical findings from this study reveal that e-commerce significantly improves lnGRDP, with a coefficient of 0.358, significant at the 5% level. This supports the notion that digital platforms have redefined business operations, especially for MSMEs, by expanding market access, increasing transaction efficiency, and fostering process innovation. Abu Alfoul et al. (2024) underscore the competitive edge derived from digitalised trade, while Kilay et al. (2022) and Shanmugalingam et al. (2023) highlight the capacity of e-commerce to reinforce supply chains and improve trade outcomes for MSMEs.

Moreover, Gao et al. (2023) found that digital services provided economic stability during crises such as the COVID-19 pandemic, affirming their role in resilience building. Technological enablers such as cloud computing and artificial intelligence (Wang et al., 2023), along with emergent business models like the sharing economy (Łobejko & Bartczak, 2021), continue to reshape the digital landscape while supporting the attainment of sustainable development goals. However, the transition towards digitalisation among Indonesian MSMEs remains uneven. By 2023, only 22% of MSMEs had adopted e-commerce platforms (Bening et al., 2023), signalling a persistent digital adoption gap. This disparity is attributed to several barriers, including limited digital literacy, constrained technical capacity, and insufficient infrastructure investment. Bridging this gap requires coordinated interventions such as digital skills

training, expanded internet coverage, and incentives for technology uptake, aimed at unlocking the full potential of e-commerce and promoting broader participation in the digital economy.

In contrast to the promising results associated with mobile internet and e-commerce, the findings show that investment has a negligible effect on lnGRDP, with a coefficient of only 0.002, lacking statistical significance. This implies that investment volume alone is insufficient in catalysing growth unless accompanied by strategic allocation. Niebel (2018) argues that the qualitative dimensions of investment—particularly in digital infrastructure, research and development, and education—are more critical than quantitative inputs. Supporting this, Behera et al. (2024) observed that ICT-driven investment significantly promotes growth in developed countries, especially when combined with strong financial systems. In Indonesia's case, the limited effectiveness of investment highlights the importance of institutional quality and prioritised allocation towards sectors with high growth multipliers, such as digital infrastructure and human capital development.

Digital technology holds considerable promise for enhancing regional innovation, consumption, and productivity (Yu et al., 2022). However, such benefits tend to be concentrated in more developed regions. Bridging this gap demands targeted investment strategies that explicitly address structural disparities, reduce digital divides, and advance inclusive growth (Chen, 2024; Stanley et al., 2018). Demographic structure also emerges as a key determinant of regional economic outcomes. The study finds that the dependency ratio—representing the proportion of the non-working-age population—has a statistically significant negative effect on lnGRDP, with a coefficient of –0.002 at the 1% level. This outcome reflects the demographic strain faced by Indonesia, where a growing economically inactive population may constrain output and place pressure on public resources. This aligns with findings from Aninditya et al. (2024) and Yang and Qi (2024), who document similar demographic constraints across various national contexts. A comparable dynamic has been observed in India, where shifts in labour force composition significantly influence sector-specific growth (Ro & Park, 2024).

Globally, demographic transitions have critical implications for growth trajectories and income distribution. While regions such as South Asia and Africa may benefit from demographic dividends due to expanding working-age populations, ageing economies face heightened vulnerabilities (Brakman et al., 2025). In Indonesia, the window to harness demographic potential remains open but requires proactive policy measures. Strategic investments in human capital—including access to quality education, vocational training, and healthcare—are essential to enhance labour productivity, strengthen economic resilience, and mitigate the adverse effects of a rising dependency burden (Long et al., 2024; Yang & Qi, 2024; Yu et al., 2024).

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CONCLUSION AND POLICY RECOMMENDATIONS

This study has empirically assessed the relationship between digitalisation and regional economic performance in Indonesia over the period 2019–2023, using mobile internet penetration and e-commerce activity as proxies for digital transformation. These indicators were evaluated alongside investment levels and the dependency ratio through a fixed-effects panel data model applied across 514 districts and cities. The findings demonstrate that both mobile internet access and e-commerce engagement exert a statistically significant and positive impact on lnGRDP. Enhanced mobile connectivity facilitates information dissemination and market integration, while digital marketplaces improve business scalability and efficiency, particularly for MSMEs, by lowering operational costs and broadening customer reach. Despite notable growth in digital adoption nationally, the study reveals persistent disparities in infrastructure and technological uptake across regions. This uneven distribution poses a challenge to the inclusive potential of digitalisation, as lagging areas risk exclusion from its economic benefits. The observed insignificance of investment on lnGRDP suggests inefficiencies in capital allocation, potentially due to limited targeting of strategic sectors such as ICT and digital entrepreneurship. Meanwhile, the dependency ratio exerts a significant negative influence on economic output, highlighting demographic challenges that demand long-term commitments to workforce development and productive integration.

Drawing from these insights, several policy measures are warranted. First, the government should prioritise digital infrastructure expansion in rural and underdeveloped areas to bridge the digital divide and facilitate equal participation in the digital economy. Second, digital literacy initiatives and capacity-building programmes must be broadened to support MSME engagement in e-commerce and digital platforms. Third, both public and private investment should be strategically redirected toward sectors with high developmental multipliers, particularly ICT, human capital, and innovation ecosystems. Finally, addressing demographic pressures requires an integrated policy approach that strengthens education systems, vocational training, and healthcare services to bolster labour productivity and economic resilience.

Although this study contributes valuable empirical evidence, it is subject to certain limitations. Its reliance on secondary macro-level data may obscure granular dynamics at the firm or household level, while informal digital activity remains unaccounted for. Moreover, the five-year timeframe may be insufficient to capture the full structural impacts of digitalisation, particularly those with longer gestation periods. Future research should consider utilising micro-level datasets to explore digital behaviour among households and enterprises, while also examining institutional and governance factors that mediate digital outcomes. Incorporating spatial econometric techniques could further uncover geographic spillover effects associated with digital adoption. Extending the temporal scope beyond 2023 would also provide a more comprehensive

understanding of the long-term implications of digital transformation on regional development trajectories.

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