Икономическа мисъл / Economic Thought 69 (3) 2024

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Как да се цитира тази статия / How to cite this article:

Kustanto, A. (2024). Bridging the Digital Gap: Analysing the Impact of ICT Diffusion on Income Inequality in Indonesia. *Economic Thought Journal*, 69 (3), 323-352. https://doi.org/10.56497/etj2469303

To link to this article / Връзка към статията:
https://etj.iki.bas.bg/macroeconomics-and-monetary-economics/2024/10/26/bridging-the-digital-gap-analysing-the-impact-of-ict-diffusion-on-income-inequality-in-indonesia

Published online / Публикувана онлайн: 28 October 2024

BRIDGING THE DIGITAL GAP: ANALYSING THE IMPACT OF ICT DIFFUSION ON INCOME INEQUALITY IN INDONESIA

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Abstract: The development of information and communication technology (ICT) has significantly transformed the socio-economic structure of society, particularly in terms of income distribution. This study aims to analyse the impact of ICT development on income inequality across 34 provinces in Indonesia from 2012 to 2020, employing econometric methods based on panel data through a fixed effects model. Empirical findings reveal that ICT readiness and ICT skills tend to exacerbate income inequality, while ICT use and its quadratic form contribute to reducing it. These results suggest that although ICT infrastructure and skills are crucial, their uneven distribution and utilisation can widen income disparities. Consequently, this study highlights the importance of ensuring equitable access to ICT across Indonesia to mitigate economic inequality. The study's recommendations stress the pivotal role of the government in expanding ICT infrastructure, fostering a research and innovation climate conducive to digital transformation, and formulating policies that enhance ICT skills nationwide. These measures would improve digital literacy, upgrade workforce capabilities, and promote inclusive digital economic growth. Ultimately, comprehensive and equitable ICT development can play a critical role in reducing income inequality across Indonesia.

Keywords: ICT Readiness; ICT Use; ICT Skills; Income Inequality; Indonesia

JEL codes: D63; I24; O10

DOI: https://doi.org/10.56497/etj2469303

Received 25 June 2024

Revised 13 September 2024

Accepted 15 October 2024

Introduction

The 2030 Agenda for Sustainable Development Goals (SDGs) is a global and national commitment to improving people's welfare. It encompasses 17 global goals and targets to be achieved by 2030, declared by both developed and developing countries on September 25, 2015 (United Nations, 2015). These SDGs share a common theme:

the diffusion of information and communication technology (ICT) serves as a powerful engine for driving economic change and transformation. The diffusion of ICT is crucial to people's economic activities (Haseeb et al., 2019; Ihm & Hsieh, 2015). The development of the digital economy has brought ICT service providers and users together in nearly all sectors, including finance, trade, transportation, education, and health (Albach et al., 2015; Kinuthia, 2009). Digital technology has significantly enhanced the speed and efficiency of communication and information-sharing within communities (Jurriëns & Tapsell, 2017). Communities benefit from digital technology due to the various conveniences offered by diverse platforms and applications, which are now more widely accessible (Dahlman et al., 2016). Daily activities have transformed dramatically, as information and communication are now delivered faster and at a lower cost than ever before (Uy-Tioco, 2019).

The continued growth of the digital population reflects a major shift in global society, particularly in how people interact, work, and conduct transactions (Qiu et al., 2021). ICT access and infrastructure are essential to supporting this growth, with components such as online networks, data centres, servers, cloud computing, and hardware enabling fast and efficient digital communication as well as data exchange. The 2019 ASEAN-6 Digital Population Dataset highlights significant growth in the digital economy, evidenced by a sharp rise in internet users (Hootsuite, 2019). According to these statistics, Indonesia, with a population of 270.6 million, has 150 million internet users, making it the leading country in internet usage within the ASEAN region (Nurhayati-Wolff, 2024).

Indonesia has a highly dynamic population, particularly with the growing number of internet users and increasing involvement in the digital economy (Kustanto, 2024). The country's startup ecosystem – spanning sectors such as e-commerce, fintech, edtech, and health-tech – shows immense potential, positioning Indonesia as one of the most active hubs in Southeast Asia (The Coordinating Ministry for Economic Affairs, 2023). However, the digitalisation process in Indonesia is still in its early stages, facing several challenges that could limit the full benefits of ICT development (Erwin et al., 2020; Widyanto & Haryanto, 2021). The ICT Development Index (IDI), established by Statistics Indonesia and aligned with International Telecommunication Union (ITU) guidelines, serves as a vital tool for measuring and assessing the extent of ICT diffusion across the country (Statistics Indonesia, 2023). A higher IDI score indicates better digital infrastructure, broader access, and greater user engagement. This index provides a comprehensive view of ICT development levels within regions and helps to identify digital divides between more advanced areas and those lagging in technology adoption. According to the 2020 IDI score, provinces in Eastern Indonesia – such as Papua (3.35), East Nusa Tenggara (4.49), and West Sulawesi

(4.73) – have lower scores, reflecting that residents in these regions have not yet fully benefited from ICT diffusion. In contrast, provinces in Western Indonesia – such as Jakarta (7.46), Yogyakarta (7.09), and Bali (6.57) – exhibit better infrastructure and higher levels of technology adoption, enabling their populations to leverage ICT for economic, educational, and social activities.

This study highlights the relationship between the ICT Development Index (IDI) and the Gini ratio, which measures income inequality and is crucial for understanding how ICT adoption affects regional income distribution. The relationship between income inequality and access to ICT is complex and influenced by a range of factors. There is a noticeable trend where regions with higher economic inequality often exhibit lower IDI scores. This suggests that limited access to ICT can exacerbate income inequality, as people in areas with restricted technology access tend to fall behind. A deeper investigation into the impact of ICT on income inequality in Indonesia could offer valuable insights into how ICT might serve as a catalyst for reducing income disparities and promoting more inclusive development across the country.

This study is organised into several sections: Section 2 reviews the existing literature on the impact of ICT adoption on income inequality; Section 3 explains the data sources and research methodology employed; Section 4 presents a descriptive analysis of the impact of ICT on income inequality across 34 provinces in Indonesia; Section 5 details the results of the estimation and economic analysis; Section 6 discusses how ICT influences income inequality; Section 7 offers policy recommendations and suggestions for future research.

Literature review: A deep dive into current studies and trends

Several researchers have examined the impact of ICT on income inequality (Adams & Akobeng, 2021; Asongu & Le Roux, 2017; Kustanto, 2024; Richmond & Triplett, 2018; Tchamyou et al., 2019; Tong & Dall'erba, 2008). These studies consistently highlight the crucial role ICT plays in driving economic development (Borés et al., 2003; Remenyi et al., 2007). When utilised effectively, ICT can provide a comprehensive strategy for reducing poverty, accelerating economic growth, enhancing human capital, and influencing social capital (Gruber et al., 2011; Lum, 2011; Matalqah & Warad, 2017; Roller & Waverman, 2011). Furthermore, the adoption and diffusion of ICT hold significant potential within the broader macroeconomic framework (Salahuddin & Alam, 2016).

Kuznets' theory of economic growth and income inequality (Kuznets, 1955) examines the effect of technological advancement on income distribution. Kuznets proposes that income inequality initially rises during the early stages of industrialisation but declines once a certain income threshold is reached, a concept commonly referred to as the 'inverted U-curve'. Krugman (1991) further argues that technological progress has fostered economies of scale that disproportionately benefit the industrial sector in urban areas, while the agricultural sector in rural regions lags behind, thereby contributing to increased income inequality. ICT diffusion can exhibit both exogenous and endogenous characteristics, potentially functioning as public goods or services. Romer (1990) suggests that technological spillovers between countries can stimulate economic growth while also widening gaps in human capital. Rosenberg (1972) emphasises that new technologies are critical for enhancing productivity and driving economic progress, contributing to more inclusive economic development.

The use of digital technology presents significant opportunities to enhance productivity and promote social inclusion among Micro, Small, and Medium Enterprises (MSMEs) (Jahanshahi et al., 2011; Khurana et al., 2019). Zhuang et al. (2009) emphasise that specific strategic initiatives can drive economic growth, increase market efficiency, and indirectly reduce income inequality. ICT has become essential for achieving sustainable and inclusive economic growth, both from national and commercial perspectives (Farouq & Sulong, 2020; Miśkiewicz, 2018). The quality of human capital – encompassing knowledge, competence, and skills – serves as a key factor in advancing ICT and plays a crucial role in fostering economic growth (Coleman, 2009).

Income inequality can be analysed through the labour market to better understand the impact of ICT advancements. Bound & Johnson (1988) argue that technology, particularly that which favours specific skills, has driven changes in wage structures. ICT advancements have enabled greater participation among individuals with high skill levels, while those with lower skills have often been left behind (Autor et al., 1998). Acemoglu & Autor (2011) suggest that individuals who can quickly adapt to new technologies tend to experience wage increases, whereas those with limited skills, especially those susceptible to automation, may face wage declines. Michaels et al. (2010) observed a shift in the labour market in the ICT sector, noting a transition from middle-skilled to high-skilled professionals in the United States, Japan, and Europe between 1980 and 2004.

The increasing use of ICTs indicates a shift toward technical skills, which generate benefits that should ideally be proportionally distributed among workers who can capitalise on these opportunities (Goldin & Katz, 2008). Galbraith (2001) highlights the connection between the demand for labour-intensive consumer products and the resulting depressed wage distribution. The rising demand for capital-intensive investment goods and specialised labour skills can further contribute to income inequality (Oryoie, 2023). Grossmann (2001) argues that the evolution of ICTs aligns with the function of production, restructuring labour and redirecting resources to less productive activities and thereby reducing productivity for low-skilled workers (Mazyaki & Ashtari, 2023).

Downes (2009) highlights the potential for a more equitable distribution of ICT development across countries. However, realising this potential depends on addressing gaps in ICT infrastructure access and availability (Agahari, 2018). While ICT advancements can drive progress, they also have the potential to reinforce existing economic stratification and exacerbate income inequality (Falck et al., 2016). In their study in Sri Lanka, Carte et al. (2011) emphasise that for e-learning programs to be effective, they must address skills gaps, illiteracy, and inadequate information and technology infrastructure.

Samoilenko & Osei-Bryson (2011) found in their study that significant investment in ICT across 18 transition economies was correlated with economic growth and the availability of infrastructure, both of which influenced the overall impact of ICT. Dell'Anno & Solomon (2014) have shown that ICT can positively influence income inequality, with the quality of education and institutions playing a key role in strengthening this effect. A study by Mendonça et al. (2015) in Portugal distinguished between ICT access and related skills, revealing that low-income groups were heavily concentrated in the access and skills index. This supports the hypothesis that ICT progress can exacerbate wealth distribution gaps, particularly for low-income groups often associated with small businesses, such as MSMEs in Indonesia. According to Law Number 20 of 2008 concerning MSMEs, there are four categories: micro, small, medium, and large businesses, differentiated based on ownership, net worth, and annual sales. Studies by Adviento et al. (2022) and Priyono et al. (2019) suggest that MSMEs play a significant role in reducing income inequality. Beck et al. (2007) has found that high levels of bank credit distribution can accelerate the reduction of inequality, while Meyer (1998) notes that small businesses often rely on bank credit as a crucial source of capital.

Empirical studies on the impact of ICT on income inequality have produced mixed results, largely due to differences in the contexts of previous case studies. This study adds to the existing literature by performing a cross-provincial analysis in Indonesia to assess the effects of ICT development on income inequality.

Data and methodology

The sample

This study aims to analyse the impact of ICT development on income inequality across 34 provinces in Indonesia from 2012 to 2020. The data employed in this research are quantitative and sourced from secondary data published by Statistics Indonesia. The

Gini ratio has been processed as the dependent variable, serving as one of the most widely used indicators of income inequality. The Gini scale measures the extent of inequality in a population's income distribution. It is derived from the Lorenz curve, a cumulative distribution curve that compares the actual distribution of income with an idealised uniform distribution, representing the cumulative percentage of income across the population.

Variables

The independent variables in this study are the IDI scores, which encompass ICT readiness, ICT use, and ICT skills. Control variables include factors such as poverty, education, population size, population density, life expectancy, Gross Regional Domestic Product (GRDP) per capita, the labour force participation rate, unemployment, foreign investment, wages, access to electricity, the prevalence of micro-enterprises and small businesses, ownership of decent housing, civil liberties, political rights, and the quality of democratic institutions. Our study hypothesises that ICT diffusion contributes to a reduction in income inequality.

Dataset – definitions and sources

This section outlines the datasets used, based on definitions and sources obtained from Statistics Indonesia. These datasets encompass key socioeconomic, demographic, and institutional quality indicators, all of which are publicly accessible through the official Statistics Indonesia portal. The datasets include the following:

1. Gini ratio: A coefficient used to measure the degree of income inequality within a population. It is derived from the Lorenz curve, which illustrates the cumulative distribution of income compared to a perfectly equal distribution.
2. ICT readiness: Refers to the availability of access to ICT and the infrastructure needed to support it.
3. ICT use: Describes the extent to which individuals, businesses, and institutions engage with and utilise ICT in their daily activities.
4. ICT use^2: The Square of ICT represents the four key dimensions or pillars of ICT that collectively support the digital transformation and innovation within societies, organisations, and economies.
5. ICT skill: Refers to the abilities or expertise possessed by individuals and communities that enable them to effectively engage with and utilise ICT.
6. Elementary school: The percentage of the population aged 15 years and over who have successfully completed primary school education.
7. Junior high school: The percentage of the population aged 15 years and over

who have successfully completed junior high school education.

8. Senior high school: The percentage of the population aged 15 years and over who have successfully completed senior high school education.

9. University: The percentage of the population aged 15 years and over who have attained a college-level education.

10. Population: The total number of individuals residing within a specified geographic area, measured at the provincial level.

11. Population density: The number of individuals living per unit of an area, typically expressed as people per square kilometre or mile.

12. Male life expectancy: An estimate of the average number of years a male born in a given year is expected to live, based on current mortality rates.

13. Female life expectancy: An estimate of the average number of years a female born in a given year is expected to live, based on current mortality rates.

14. Homeownership: The percentage of households that own and have access to adequate and affordable housing.

15. Electricity: The percentage of households that have access to electricity as their primary source for lighting and other domestic uses.

16. Poverty: The percentage of the population living below the poverty line, as defined by a specific income threshold.

17. GRDP per capita: Growth rate of per capita GRDP at the 2010 constant market price.

18. Labour: The percentage of the working-age population (typically aged 15 and over) that is either employed or actively seeking employment.

19. Foreign direct investment: Foreign Direct Investment (FDI) by project refers to the categorisation of FDI based on specific business initiatives or undertakings in the host country.

20. Wages: The legally mandated minimum amount of compensation that employers are required to pay workers within a specific region.

21. Unemployment: The percentage of the labour force that is actively seeking employment but is currently without a job.

22. Micro enterprises: Number of establishments of micro enterprises.

23. Small enterprises: Number of establishments of small enterprises.

24. Civil liberties: The civil liberties aspect of the Indonesian Democracy Index.

25. Political rights: The political rights aspect of the Indonesian Democracy Index.

26. Institutions: The democratic institutions aspect of the Indonesian Democracy Index.

Model specification

To analyse the effect of ICT diffusion on income inequality, we have adopted the model used by Faizah et al. (2021). Our study employs a panel data approach, combining cross-sectional and time-series data (Baltagi, 2015). The cross-sectional data includes 34 provinces in Indonesia, while the time-series data spans from 2012 to 2020. This period was selected based on data availability and its economic significance: in 2012, Indonesia was still grappling with global uncertainty and a domestic economic slowdown, while 2020 marked the onset of the COVID-19 pandemic, highlighting the critical role of ICT access and utilisation in economic resilience. This timeframe allows us to examine how ICT development and distribution during the pandemic may have impacted income inequality. While ICT has the potential to promote economic inclusion, the pandemic has demonstrated that unequal access can exacerbate inequality, especially in a country like Indonesia.

The approach employed to achieve the objectives of this study is panel data econometric analysis. The model specification process includes testing the reliability and efficiency of the fixed effects versus random effects models, using the Chow and Hausman specification tests. The empirical model in this study will be estimated as follows:

$$GINI_{it} = \beta_0 + \beta_1 READINESS_{it} + \beta_2 USE_{it} + \beta_3 USE^2{}_{it} + \beta_4 SKILL_{it} + \beta_5 X_{it} + \varepsilon_{it} \qquad (1)$$

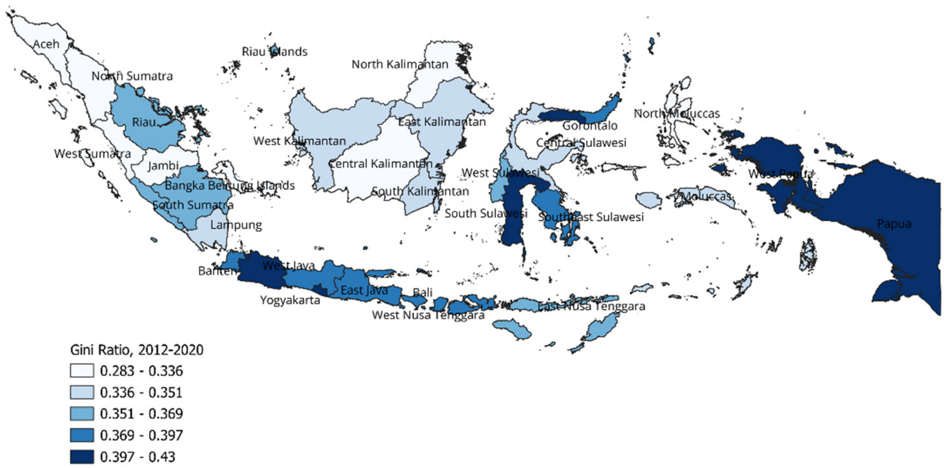
Where $GINI$ is the Gini ratio; $READINESS$ is the ICT access and infrastructure sub-index that describes ICT readiness as measured in terms of ICT access and infrastructure; USE is the ICT use sub-index that describes ICT intensity as measured by the use of ICT; $SKILL$ is the ICT skills sub-index that describes the skills or expertise needed in ICT skills; X is a vector of other control variables, including poverty, elementary school, junior high school, senior high school, university, population (in natural logarithm), population density, male life expectancy, female life expectancy, poverty, GRDP per capita, labour, unemployment, foreign direct investment (FDI), wages (in natural logarithm), electricity, micro enterprises (in natural logarithm), small enterprise (in natural logarithm), homeownership, civil liberties, political rights, and institutions of democracy; i = province, i = 1... 34; t = year; t = 2012, 2013... 2020.

Empirical findings

Overview of income inequality and ICT development in Indonesia

Statistics Indonesia uses expenditure data from the National Socioeconomic Survey (SUSENAS) as a proxy for income to measure income inequality in the country. The

Gini coefficient serves as the primary indicator of expenditure inequality, ranging from 0 to 1, with values closer to 1 signifying higher inequality. Between 2012 and 2020, the average Gini value for Indonesia stood at 0.363. Figure 1 highlights that provinces exceeding the national average in inequality include the Special Region of Yogyakarta (0.430), Gorontalo (0.418), and Papua (0.413). Regional development is considered successful when improvements in welfare are experienced by both the middle-to-upper class and low-income populations. Efforts to address inequality at the national level are outlined in the 2005-2025 National Long-Term Development Plan (RPJPN), which aims to achieve inclusive and equitable development. However, the persistently high Gini ratio reflects ongoing challenges to achieving this goal. Uneven development across provinces presents a significant obstacle, and failure to address this issue could undermine broader national development objectives.



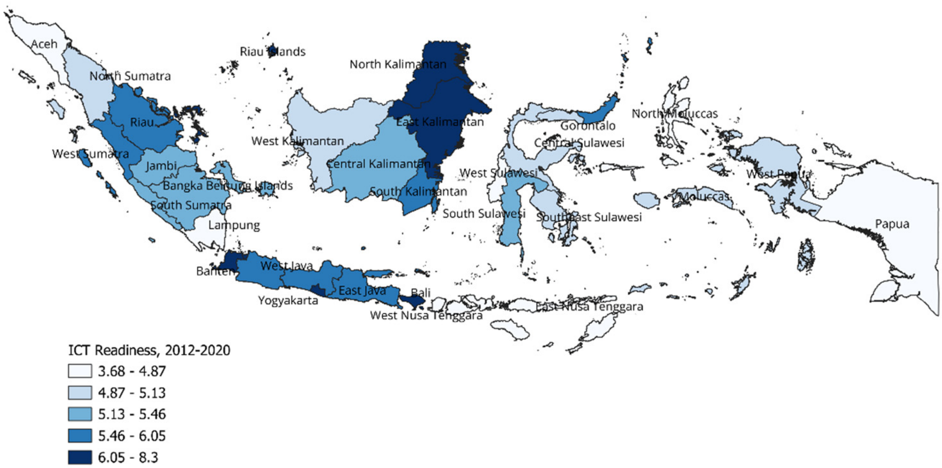
Source: Authors' calculations.

Figure 1. The average income inequality in 34 provinces in Indonesia, 2012-2020

Figure 1 illustrates the average income inequality in Indonesia during the study period, with Yogyakarta showing higher levels of inequality compared to the national average. This disparity is primarily due to economic dualism in the region, where the informal sector – characterised by low wages – dominates, while the formal sector offers significantly higher incomes. Consequently, there are noticeable income gaps between local residents and migrants. In 2020, Yogyakarta's economy was severely impacted by the COVID-19 pandemic. The sharp decline in domestic and international tourism, along with the shift to online learning, caused many students to leave the city.

This reduction in tourism and student presence worsened income inequality, as a significant portion of the population depends on the tourism and education sectors for their livelihoods.

In contrast, provinces with income inequality below the national average, such as the Bangka Belitung Islands (0.283), East Kalimantan (0.305), and North Maluku (0.312), reflect development progress that is still ongoing. The Bangka Belitung Islands, with the lowest income inequality in Indonesia, benefit from more balanced infrastructure development. Nearly all areas have access to affordable transportation, supported by well-maintained paved roads, even in the island regions. This suggests a more equitable distribution of infrastructure, facilitated by the province's small geographic size, flat topography, and lack of high mountains or steep roads, which simplifies development efforts. The local government's focus on rural development has further reduced inequality by ensuring equal access to essential services, such as education and healthcare, across the population. However, challenges remain in achieving sustainable and inclusive long-term growth.

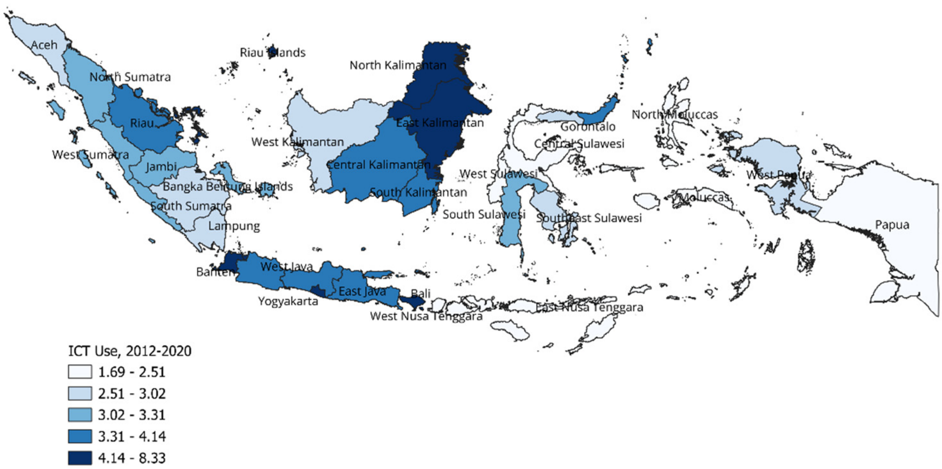


Source: Authors' calculations.

Figure 2. Development of ICT readiness in 34 provinces in Indonesia, 2012-2020

Figure 2 highlights the significant disparities in access to ICT services across Indonesia, showing substantial regional differences. Java, particularly in areas around Jakarta, Bandung, and Surabaya, has become the centre of ICT development, benefiting from well-established infrastructure that supports fast internet, data centres, and advanced technology. This has driven rapid growth in the local ICT sector, leading to the rise of numerous technology companies and startups. In contrast, regions outside Java and Bali face limited support in both infrastructure and ICT service access. Bali, however, is an exception due to its strong tourism sector, which has spurred improvements in ICT infrastructure to cater to international visitors and digital nomads. These developments have enhanced Bali's capacity to meet the demands of a globally connected workforce and tech-savvy tourists, further emphasising the uneven distribution of ICT resources across the country.

The situation is markedly different in provinces like Papua, West Papua, and West Sulawesi, which remain among the least connected in terms of ICT access and infrastructure. Large parts of these regions still lack reliable internet connectivity. In Papua, the digital divide is particularly severe, with geographical challenges and underdeveloped infrastructure limiting access to basic internet services. This disparity hampers economic development and restricts access to education, healthcare, and social services, which are increasingly reliant on digital platforms. The unequal distribution of ICT infrastructure across Indonesia underscores the urgent need for targeted policies and investments to bridge the digital divide, ensuring more equitable access to technology and its benefits for all provinces, especially in remote areas.



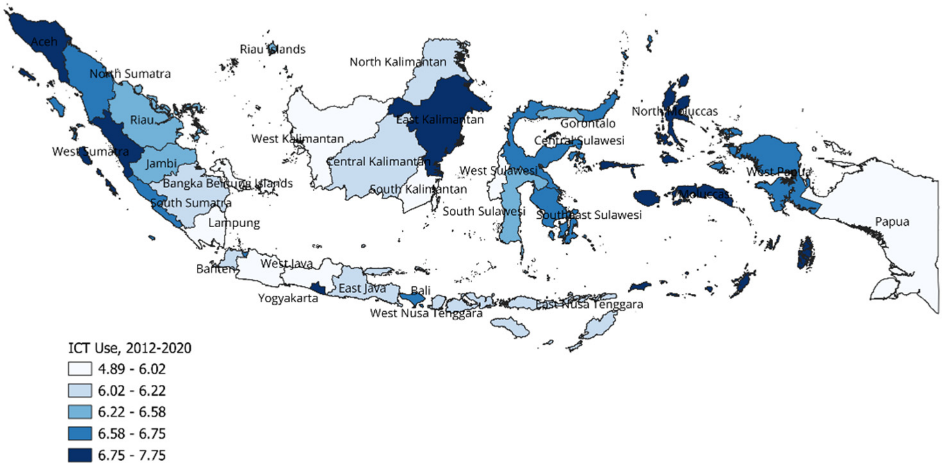
Source: Authors' calculations.

Figure 3. Development of ICT use in 34 provinces in Indonesia, 2012-2020

Figure 3 illustrates that the concentration of ICT uses in Jakarta, the Riau Islands, and East Kalimantan reflects the broader economic and infrastructure advantages these regions enjoy. As Indonesia's political, economic, and financial hub, Jakarta has naturally developed a robust ICT infrastructure, driven by the demands of its government, business, and financial sectors. Similarly, the Riau Islands and East Kalimantan, fuelled by their growing shipping industries and abundant natural resources, have made significant strides in ICT infrastructure, including faster internet and modern technology services. These regions also benefit from strong educational ecosystems, with numerous universities, colleges, and ICT training centres that produce a skilled workforce. The availability of skilled human resources fosters the growth of ICT-related industries, further driving technological development in these regions. The presence of such institutions has attracted technology companies and startups, creating a reinforcing cycle that supports continuous ICT development in these areas.

Despite these advancements, Indonesia's digital divide persists, particularly in provinces outside Java and Bali, such as Papua and West Sulawesi. Addressing this divide is essential for promoting more inclusive and balanced economic development. The Indonesian government must focus on expanding ICT access in underdeveloped regions by improving infrastructure, offering ICT education and training, and providing incentives for private sector investment. Bridging this digital gap will promote equity and unlock new opportunities for economic growth across the nation, enabling more regions to participate in the global digital economy.

Figure 4 shows that provinces such as Papua, the Bangka Belitung Islands, and West Kalimantan – which exhibit the lowest ICT capabilities and expertise in Indonesia – underscore the persistent digital divide within the country. The limited ICT skills in these regions are often a result of insufficient access to quality ICT education and training, which restricts residents' ability to use modern technology effectively. This digital gap places the local workforce at a significant disadvantage in an increasingly technology-driven job market, reducing competitiveness and contributing to higher unemployment rates and lower income levels. Moreover, the low ICT skill levels prevent residents from fully benefiting from digital public services, such as e-government platforms and online health services, which could otherwise enhance access to essential services and improve their overall quality of life. The inability to harness these technologies limits opportunities for streamlining administrative processes, accessing remote healthcare, and participating in the digital economy.



Source: Authors' calculation.

Figure 4. Development of ICT skill in 34 provinces in Indonesia, 2012-2020

From an economic perspective, regions with low ICT skills are less likely to realise their full potential in business growth and innovation. With a workforce skilled in ICT, however local businesses could adopt technological advances, enhancing productivity and innovation. Such disparities can lead to slower economic development and hinder efforts to attract investments or foster entrepreneurship, which are crucial for long-term growth. Addressing this gap requires targeted policies focused on improving ICT education, expanding access to infrastructure, and providing opportunities for skill development to promote more equitable economic progress across Indonesia.

This section presents empirical results on the diffusion of ICT and its relationship to income inequality in Indonesia. Table 1 provides descriptive statistics that offer key insights into the variables studied. The mean Gini ratio is 0.363, indicating income inequality within the population. Although income distribution is unequal, the inequality is moderate, meaning certain groups still hold a larger share of wealth, while some individuals experience severe disparities.

Table 1. Summary statistics

Variables	Obs.	Mean	Std. Dev.	Min	Max
Gini ratio	303	0.363	0.398	0.257	0.459
ICT readiness	302	5.391	1.009	3.5	9.28
ICT use	301	3.265	1.723	0.46	1.34
ICT use^2	301	13.667	14.946	0.21	106.92
ICT skill	301	6.430	0.666	4.65	8.21

Variables	Obs.	Mean	Std. Dev.	Min	Max
Elementary school	303	37.210	2.573	28.92	46.77
Junior high school	303	15.236	1.272	11.31	18.93
Senior high school	303	12.480	1.746	6.14	15.95
University	303	6.554	2.759	2.34	19.72
Population growth (ln)	303	8.364	1.005	6.47	10.82
Population density	306	719.346	2603.062	8	15907
Male life expectancy	305	67.514	2.639	61.18	73.22
Female life expectancy	305	71.354	2.627	65	76.83
Homeownership	303	79.172	8.493	45.04	91.47
Electricity	303	94.630	8.973	40.9	100
Poverty	303	11.317	6.017	3.42	31.13
GRDP per capita	304	3.214	3.793	-20.13	20.2
Labour	303	70.064	3.572	61.64	80.54
FDI	305	673.741	1647.041	3	16787
Wages (ln)	306	14.355	0.360	13.52	15.27
Unemployment	303	5.300	1.979	1.4	10.95
Micro enterprises (ln)	303	10.728	1.239	1.4	10.95
Small enterprises (ln)	303	7.733	1.671	3.66	11.98
Civil liberties	306	82.682	10.644	47.21	100
Political rights	306	62.202	11.918	28.95	86.52
Institutions	306	72.489	10.411	47.25	93.98

Source: Authors' calculations.

The mean ICT readiness score of 5.391 reflects fairly adequate levels of ICT access and infrastructure, although there remains room for improvement. This degree of readiness indicates that infrastructure is sufficient, access to technology is becoming more widespread, and most individuals or institutions can utilise ICT in various aspects, though not at its highest potential.

The mean ICT use score of 3.265 suggests that technology adoption is uneven across communities and institutions. While some sectors have embraced ICT, many others need full access or are not using it to its full potential, facing barriers to adoption. The mean square of ICT use (13.667) reflects the variation in ICT usage, highlighting the disparities in how different groups use technology. Some have integrated ICT effectively, while others need to catch up, creating an uneven distribution of technology use.

Lastly, the mean ICT skills value of 6.430 indicates that, on average, the community or group under analysis has fairly good digital and information technology skills.

However, further improvement in digital skills would bring about additional benefits, enhancing their ability to maximise ICT's potential.

Our empirical analysis has estimated panel regression models for all variables expected to influence income inequality based on theoretical predictions. The first model is a simple panel with a common constant, assuming that the provinces studied are relatively homogeneous. Table 2 presents the results of this initial set of regressions. The dependent variable in all regressions is the Gini ratio, so a positive coefficient indicates an increase in income inequality.

Table 2. Panel regression result: common constant

Dependent variable: Gini ratio				
Independent variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
ICT readiness	0.231*** (0.005)	0.266*** (0.005)	0.215*** (0.005)	0.024*** (0.005)
ICT use	-0.002* (0.005)	-0.010* (0.005)	-0.180*** (0.005)	-0.0005** (0.005)
ICT use^2	-0.001* (0.0005)	-0.0005* (0.0004)	0.001* (0.0004)	-0.0004* (0.0005)
ICT skill	0.016** (0.004)	0.001** (0.003)	0.001* (0.004)	0.005* (0.005)
Control variables				
Elementary school	-0.006*** (0.0009)			-0.004*** (0.0005)
Junior high school	-0.002 (0.001)			-0.001 (0.001)
Senior high school	-0.006*** (0.001)			-0.007*** (0.001)
University	0.0009 (0.0009)			0.001 (0.0009)
Population growth (ln)	0.007** (0.002)			0.007** (0.004)
Population density	2.22e-06 (1.36e-06)			-1.75e-07 (1.57e-06)
Male life expectancy	-0.037* (0.293)			-0.067* (0.029)
Female life expectancy	-0.037 (0.293)			-0.066 (0.029)
Homeownership	0.0006 (0.0003)			-0.0004 (0.0003)
Electricity	-0.002*** (0.0003)			-0.0004*** (0.0004)
Poverty		0.003*** (0.0003)		0.002*** (0.0004)
GRDP per capita		0.0007 (0.0005)		0.0003 (0.0005)
Labour		-0.001** (0.0006)		-0.001** (0.0006)

Control variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Foreign direct investment		3.76e-06 (1.52e-06)		2.75e-06 (1.74e-06)
Wages (ln)		-0.024* (0.007)		-0.009* (0.007)
Unemployment		0.002 (0.001)		0.003* (0.001)
Micro enterprises (ln)		0.003 (0.003)		0.006 (0.003)
Small enterprises (ln)		0.004 (0.002)		0.004 (0.002)
Civil liberties			-0.0003 (0.0002)	-0.00005 (0.0001)
Political rights			-0.0007*** (0.0002)	-0.0001*** (0.0001)
Institutions			-0.00008 (0.0002)	-0.0001 (0.201)
Constant	0.608*** (0.128)	0.642*** (0.140)	0.322*** (0.034)	0.648*** (0.201)
Number of obs.	301	301	301	301
Adjusted R-squared	0.3916	0.3803	0.1501	0.4970
SE of regression	0.03108	0.03137	0.03718	0.02826

Note: Robust standard errors are shown in parentheses: *p<0.05, **p<0.01, and ****p<0.001.

Source: Authors' calculations.

In Table 2, we begin by testing models 1 through 4. These models reveal that ICT readiness and ICT skills have a positive and significant effect on income inequality. ICT access and infrastructure can widen income inequality by creating a digital divide, where people in areas with better ICT infrastructure can leverage it to improve their economic, social, and educational outcomes. In contrast, those in regions lacking sufficient ICT access face disadvantages, further exacerbating inequality.

Additionally, individuals without ICT skills encounter limited job opportunities and economic mobility, intensifying the gap between highly skilled workers and those lagging in the digital economy, ultimately increasing income inequality. On the other hand, digital inclusion promotes social and economic mobility, contributing to a more equitable income distribution. This study demonstrates that ICT use and the square of ICT use have a significant impact on reducing income inequality. With ICT skills, individuals can access new opportunities, compete in more competitive labour markets, increase earnings, and reduce income inequality.

We have re-estimated all regression models under the assumption of fixed effects, with the results presented in Table 3. From model 1 to model 4, the results show that income inequality decreases as society becomes more skilled in ICT. Those proficient in ICT have the potential to reduce income inequality, as ICT skills provide access to education, job opportunities, and broader global markets. With ICT expertise, individuals from diverse economic backgrounds can increase productivity, engage in the digital economy, and create jobs.

However, ICT access, infrastructure, and skills also contribute to increasing income inequality by creating a digital divide, whereby individuals with access and skills are advantaged while those without them are left behind. We have consistently rejected the null hypothesis across all regressions when testing for redundant fixed effects. These results indicate that the fixed effects estimates are more appropriate than models assuming constant effects across all regions.

Table 3. Panel regression results: fixed effects

Dependent variable: Gini ratio				
Independent variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
ICT readiness	0.008* (0.005)	0.015** (0.004)	0.006* (0.004)	0.012* (0.005)
ICT use	-0.0002* (0.004)	-0.002 (0.003)	-0.008* (0.003)	-0.0008** (0.004)
ICT use^2	-0.0005 (0.0004)	-0.00002* (0.0003)	-0.0003* (0.0003)	-0.0002** (0.0005)
ICT skill	0.008* (0.004)	0.011** (0.004)	0.007* (0.003)	0.011* (0.005)
Control variables				
Elementary school	-0.00005* (0.0008)			-0.001* (0.0009)
Junior high school	0.0002 (0.001)			0.0006 (0.001)
Senior high school	-0.0002* (0.001)			-0.00008* (0.001)
University	-0.00006 (0.0006)			0.0002 (0.0006)
Population growth (ln)	0.023* (0.032)			0.019* (0.033)
Population density	0.00004 (0.0002)			0.00004 (0.00003)
Male life expectancy	-0.067* (0.032)			-0.057* (0.318)
Female life expectancy	-0.596 (0.322)			-0.061 (0.031)
Homeownership	-0.002** (0.0007)			-0.001* (0.0007)
Electricity	-0.0006* (0.0004)			-0.00004* (0.0004)
Poverty		0.001* (0.0006)		0.002* (0.001)
GRDP per capita		-0.0002* (0.0003)		-0.0003* (0.0003)
Labour		-0.001** (0.0006)		-0.0006 (0.0006)

Control variables	Model 1	Model 2	Model 3	Model 4
Foreign direct investment		7.36e-07 (1.19e-06)		1.67e-06 (1.68e-06)
Wages (ln)		-0.030*** (0.001)		-0.029*** (0.008)
Unemployment		0.003* (0.001)		0.003** (0.001)
Micro enterprises (ln)		0.002 (0.004)		0.002 (0.004)
Small enterprises (ln)		0.002 (0.001)		0.002 (0.002)
Civil liberties			-0.0001** (0.0001)	-0.0001** (0.0001)
Political rights			-0.0003** (0.0001)	-0.00002* (0.0001)
Institutions			0.0001 (0.0001)	0.00005 (0.0001)
Constant	1.061* (0.409)	0.585*** (0.114)	0.323*** (0.040)	0.099 (0.486)
Number of observations	301	301	301	301
Adjusted R-squared	0.3385	0.3616	0.2702	0.4001
SE of regression	0.016	0.016	0.017	0.016
Redundant FE test	22.05	24.10	32.67	17.58
Prob.	0.0000	0.0000	0.0000	0.0000

Note: Robust standard errors are shown in parentheses: *p<0.05, **p<0.01, and ****p<0.001.

Source: Authors' calculations.

The third static panel estimation model, based on random effects, has been applied next, with the results shown in Table 4. The regression outcomes from model 1 to model 4 yield similar findings to those of the fixed effects models, indicating that ICT readiness and ICT skills positively and significantly contribute to increasing income inequality. In contrast, ICT use shows a negative effect, helping to reduce income inequality. The results consistently indicate that the fixed effects specification is the preferred model when performing the Hausman test to compare fixed and random effects. Consequently, our analysis has focused on the fixed-effects approach.

Table 4. Panel regression results: random effects

Dependent variable: Gini ratio				
Independent variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
ICT readiness	0.011* (0.004)	0.017*** (0.004)	0.008* (0.004)	0.015*** (0.004)
ICT use	-0.005** (0.003)	-0.003* (0.003)	-0.009** (0.003)	-0.002** (0.003)
ICT use^2	-0.0002* (0.0003)	-0.0001* (0.0003)	-0.0003** (0.0003)	-0.00006** (0.004)
ICT skill	0.009* (0.004)	0.011** (0.003)	0.008* (0.003)	0.010* (0.004)

Control variables	Model 1	Model 2	Model 3	Model 4
Elementary school	-0.001* (0.0008)			-0.0003* (0.0006)
Junior high school	0.00009 (0.001)			0.0004 (0.001)
Senior high school	-0.0001* (0.001)			-0.0003* (0.001)
University	-0.001 (0.001)			0.0003 (0.0006)
Population growth (ln)	0.011* (0.005)			0.006* (0.007)
Population density	9.07e-07 (2.43e-06			1.28e-06 (2.61e-06)
Male life expectancy	-0.070* (0.279)			-0.055* (0.029)
Female life expectancy	-0.001* (0.0005)			-0.055 (0.029)
Homeownership	-0.001* (0.0004)			-0.001 (0.0005)
Electricity	-0.001** (0.0004)			-0.0001 (0.0004)
Poverty		0.002** (0.0007)		0.003** (0.0009)
GRDP per capita		-0.0001* (0.0003)		-0.0003* (0.0003)
Labour		-0.0006* (0.0006)		-0.0004* (0.0006)
Foreign direct investment		1.29e-06 (1.12e-06)		4.77e-07 (1.30e-06)
Wages (ln)		-0.029*** (0.005)		-0.026*** (0.006)
Unemployment		0.002* (0.001)		0.003** (0.001)
Micro enterprises (ln)		0.001 (0.003)		0.001 (0.004)
Smal enterprises (ln)		0.003 (0.001)		0.002 (0.002)
Civil liberties			-0.0001 (0.0001)	-0.00001 (0.0001)
Political rights			0.0001 (0.0001)	2.01e-07 (0.0001)
Institutions			0.0001 (0.0001)	0.00004 (0.0001)
Constant	0.405* (0.193)	0.563*** (0.105)	0.310*** (0.036)	0.371 (0.228)
Number of observations	301	301	301	301
Adjusted R-squared	0.3021	0.3565	0.2691	0.3874
SE of regression	0.016	0.016	0.017	0.016
Hausman test	99.261	100.142	54.184	98.124
Prob.	0.0000	0.0000	0.0000	0.0000

Note: Robust standard errors are shown in parentheses: *p<0.05, **p<0.01, and ****p<0.001.

Source: Authors' calculations.

ICT development – measured through access, infrastructure, uses, and skills – was selected as an independent variable in this study to examine its impact on income inequality. The robustness evaluation of the estimates, presented in Table 5 using a fixed effects model, shows that access to ICT and its infrastructure significantly affects income inequality (Adams & Akobeng, 2021; Asongu & Le Roux, 2017; Richmond & Triplett, 2018; Tchamyou et al., 2019; Tong & Dall'erba, 2008). Regions with limited ICT access and infrastructure, such as Papua and West Nusa Tenggara, face challenges in education, employment, and information access, perpetuating poverty and inequality cycles.

ICT skills also play a crucial role in developing ICT within a country or region (Kocsis, 2020). However, disparities in digital expertise and skills hinder Indonesia's ability to leverage the digital economy's benefits fully (Kustanto, 2024). The Indonesian population's low level of digital literacy is particularly evident in data and information literacy (The SMERU Research Institute, 2022). This is underscored by the poor performance of Indonesian students in the 2022 Programme for International Student Assessment (PISA), where Indonesia ranked 68th out of 81 participating countries in reading skills (OECD, 2023), which highlights the significant challenges in enhancing digital literacy across the country.

Other findings from the study suggest that the optimal and widespread use of ICT can help level the playing field in the digital economy, break down structural barriers, and reduce income inequality (Mendonça et al., 2015).

The control variables show that the life expectancy of both males and females influences the decline in income inequality. Better health conditions and longer working lives provide individuals with greater opportunities to earn income and improve their skills (Setyadi et al., 2023), which in turn helps reduce income inequality (Bayati et al., 2013; Kustanto, 2024). Factors such as ownership of decent housing, access to electricity, income levels, and regional minimum wages play a vital role in mitigating income disparities. Socioeconomic stability can be fostered through secure housing, enabling household members to concentrate on boosting productivity and enhancing skills (Carroll & Cohen-Kristiansen, 2021; Glaeser et al., 2002; Grinstein-Weiss et al., 2013; Paz-Pardo, 2021; Schuetz, 2020). Access to electricity further connects households to technology, education, and employment opportunities (Kustanto, 2020).

High per capita income indicates a more equitable distribution of wealth (Kustanto, 2022). At the same time, adequate regional minimum wages ensure that workers at the lowest income levels receive fair compensation, thus narrowing the gap between low- and high-income groups (Rani et al., 2013; Rohmah & Sastiono, 2021). Collectively, these economic conditions contribute to reducing income inequality and enhancing overall welfare (Kustanto, 2024).

Furthermore, a high democracy index – characterised by guaranteed civil liberties and political rights – supports the reduction of income inequality by expanding access to political participation and involving more people in public decision-making processes (Brady et al., 2020). In this way, strong democratic institutions promote fairer, more inclusive policies that help alleviate income inequality (Kustanto, 2024).

Table 5. Panel regression results: fixed effects; robustness checks

Dependent variable: Gini ratio				
Independent variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
ICT readiness	0.008* (0.005)	0.015* (0.006)	0.006* (0.004)	0.012* (0.006)
ICT use	-0.00002* (0.004)	-0.002* (0.003)	-0.008* (0.003)	-0.0008* (0.004)
ICT use^2	-0.0005* (0.0005)	-0.00002* (0.0003)	0.0003* (0.0005)	-0.0002* (0.0004)
ICT skill	0.008* (0.005)	0.011* (0.004)	0.007* (0.003)	0.011* (0.005)
Control variables				
Elementary school	-0.00005 (0.001)			0.001 (0.001)
Junior high school	0.0002 (0.001)			0.0006 (0.001)
Senior high school	-0.0002 (0.001)			0.00008 (0.001)
University	-0.00006 (0.0009)			0.0002 (0.0009)
Population growth (ln)	-0.023 (0.00002)			0.019 (0.049)
Population density	-0.00004 (0.00002)			-0.000004 (0.00002)
Male life expectancy	-0.067** (0.023)			-0.057* (0.027)
Female life expectancy	-0.059* (0.022)			-0.061* (0.023)
Homeownership	-0.0002* (0.0008)			-0.001* (0.0009)
Electricity	-0.0006* (0.0005)			-0.00004* (0.0005)
Poverty		0.001* (0.001)		0.002* (0.002)
GRDP per capita		-0.0002* (0.0002)		-0.003* (0.0003)
Labour		-0.001** (0.0005)		-0.0006** (0.0006)
Foreign direct investment		7.36e-06 (8.80e-07		1.67e-06 (1.11e-06)

Control variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Wages (ln)		-0.030*** (0.006)		-0.029** (0.009)
Unemployment		0.003* (0.001)		0.003* (0.001)
Micro enterprises (ln)		0.002 (0.005)		0.002 (0.005)
Small enterprises (ln)		0.002 (0.001)		0.002 (0.001)
Civil liberties			-0.0001* (0.0001)	-0.0001* (0.0001)
Political rights			-0.0003* (0.0001)	0.00002* (0.0001)
Institutions			0.0001 (0.001)	0.00005 (0.0001)
Constant	1.061* (0.515)	0.585*** (0.135)	0.323*** (0.050)	0.099** (0.653)
Number of observations	301	301	301	301
Adjusted R-squared	0.3385	0.3616	0.2702	0.4001
SE of regression	0.1038	0.1939	0.1555	0.1368

Note: Robust standard errors are shown in parentheses: *p<0.05, **p<0.01, and ****p<0.001.

Source: Authors' calculations.

Discussion

As outlined in the previous section, the conceptual framework on the theoretical and empirical relationship between ICT development and income inequality provides valuable insight for a coherent interpretation of findings from earlier studies. ICT development can stimulate economic activity and generate jobs, reducing income inequality (Faizah et al., 2021; Kustanto, 2024; Untari et al., 2019). However, challenges such as resistance to technology and low digital literacy in Indonesia are hindering ICT diffusion and exacerbating income inequality (Sujarwoto & Tampubolon, 2016). Factors like limited access to technology, inadequate infrastructure in remote areas, and low awareness of the benefits of ICT have contributed to the slow adoption of technology (Albach et al., 2015; Kinuthia, 2009).

Low digital literacy further restricts people's ability to use digital devices effectively, negatively impacting productivity and economic opportunities (Kocsis, 2020). Additionally, distrust of new technologies or the lack of technology education in various regions often fuels resistance to technological change. To overcome these barriers, efforts to enhance digital literacy through inclusive education and supportive policies are critical to achieving more equitable ICT adoption (Agu et al., 2023; Mushtaq & Bruneau, 2019).

Promoting digital inclusivity must be prioritised to ensure that all individuals, regardless of their socioeconomic background or geographic location, have equal access to digital technologies and opportunities (Patria & Erumban, 2020). Without inclusivity, the digital divide will continue to widen, worsening social and economic inequalities (Wang et al., 2021). By prioritising digital inclusivity, societies can empower marginalised groups, drive economic growth, and ensure more equitable participation in the digital economy (Kustanto, 2024).

Conclusion

This paper explores the relationship between ICT development and income inequality across 34 provinces in Indonesia from 2012 to 2020. The empirical findings suggest that while ICT readiness and ICT skills contribute to widening income inequality, ICT use and the squared term of ICT use help reduce it. These insights highlight the importance of optimising ICT use across Indonesia as a critical factor in addressing income inequality. As a result, the government should prioritise the development of robust ICT infrastructure nationwide, foster a research and development environment that supports digital transformation, and implement comprehensive policies to enhance ICT skills. By taking these steps, Indonesia can cultivate a digitally literate society with a skilled workforce, thus maximising opportunities within the digital economy and significantly reducing income inequality.

Acknowledgments

I would like to express my sincere gratitude to Statistics Indonesia for providing the essential data for this research. I would also like to extend my thanks to the editors and anonymous reviewers for their valuable feedback and suggestions. Additionally, I thank Monita Tahalea, Bayu Risa, TULUS, Yura Yunita, and Novo Amor for their support during the writing process. The usual disclaimer applies, and the views expressed are my sole responsibility.

Contribution of individual authors

Andi Kustanto: conceptualisation, formal analysis, writing the original draft, review, and editing.

Conflicts of Interest

The author has no conflicts of interest to declare.

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How to cite this article:

Kustanto, A. (2024). Bridging the Digital Gap: Analysing the Impact of ICT Diffusion on Income Inequality in Indonesia. *Economic Thought Journal*, 69 (3), 323-352. https://doi.org/10.56497/etj2469303