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Can ICT Diffusion Reduce Income Inequality for a Better Life? Evidence from Indonesian Provinces

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Abstract

This study examines the potential of ICT development to impact income inequality and economic development. While enhancing ICT infrastructure can broaden economic opportunities, it also has the potential to exacerbate wealth disparities among individuals with limited access. Utilizing panel data from 34 Indonesian provinces between 2012 and 2022, the study employs fixed effect and system GMM estimation methods to assess the relationship between ICT development and income inequality. The findings suggest that while ICT readiness tends to increase income inequality, the use of ICT and associated skills can mitigate it. Additionally, control variables such as wages and small/micro-enterprises show promise in reducing income inequality, whereas factors like life expectancy, population, and density tend to exacerbate it. The study concludes with implications for policymakers and stakeholders, emphasizing the importance of incorporating the social and economic benefits of ICT development into strategies aimed at reducing income inequality in Indonesia.

Keywords: ICT readiness; ICT use; ICT skill; income inequality
JEL Classification: D63; I24; O10

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1. Introduction

The UN ratified the incredibly ambitious 2030 plan for sustainable development on September 25, 2015, focusing on the promise to "end poverty, protect the planet, and ensure prosperity for all," and divided it into 17 sustainable development goals (SDGs) (United Nations, 2015). Reducing income inequality is policy goal 10 of the SDGs. Income inequality is a critical factor in assessing a country's socioeconomic performance in a modern economy (Shah & Krishnan, 2024). This discrepancy illustrates the allocation of wealth across people or families within a community. Income inequality has garnered significant global attention, encompassing both established and developing nations, and has emerged as a prominent topic in national policy deliberations (Njangang et al., 2021).

The progress in information and communication technology (ICT) has the capability to address income inequality and enhance economic development. The idea that ICT is the engine that can drive change unites all the goals of the SDGs, despite their differences (ITU, 2021). However, incremental changes in the most critical areas will bring about the most change—sweeping metaphors about technology's advantages notwithstanding (Rath & Hermawan, 2019). ICT proliferates and plays a vital role in economic activities (Haseeb et al., 2019; Ihm & Hsieh, 2015). The development of ICT has created a digital market that has brought together service providers and users in almost all areas of life, such as transportation, trade, finance, education, and health (Albach et al., 2015; Kinuthia, 2009). Digital technology helps increase information and communication speed, reach, and efficiency (Jurriëns & Tapsell, 2017). All levels of society benefit from digital technology because the various conveniences created by digital platforms and applications enable wider use of technology (Dahlman et al., 2016). The development of the internet has dramatically shaped the domain of human activity, disseminated information throughout the world faster than ever before, and is easily accessible at low cost (Fuchs, 2009; Uy-Tioco, 2019).

Qiu et al. (2021) observed a continuous rise in the number of people using digital platforms. One of the main factors contributing to this phenomenon is the presence of digital infrastructure, which facilitates the connection to the internet network and enables the collection and exchange of data. According to the ASEAN-6 Digital Population 2019 dataset, there is evidence of significant growth in the digital economy sector, as indicated by the substantial increase in the number of internet users (ASEAN Up, 2019). Indonesia has about 210 million internet users, making it the fourth country with the biggest number of Internet users globally, following China, India, and the United States (Nurhayati-Wolff, 2024). The country's expanding online population has been significantly influenced by the enhancement of its internet infrastructure.

Nevertheless, it is imperative to exercise caution and consider any unintended consequences while seizing exceptional opportunities (Volti & Croissant, 2024). Indonesia, being classified as a developing nation, has a range of macroeconomic challenges that necessitate careful consideration due to their potential long-term detrimental effects on the economy, including those pertaining to inequality (Rath & Hermawan, 2019).

While the impact of ICT adoption in Indonesia on socioeconomic well-being is generally good, there still needs to be more clarity and ongoing controversy regarding its distributional implications (Patria & Erumban, 2020).

Indonesia boasts a highly engaged populace and a vibrant startup ecosystem, positioning it as one of the most active nations worldwide (The Coordinating Ministry for Economic Affairs, 2023). Nevertheless, with regard to its execution, the digitization process is still in its nascent phase and, on the whole, has yet to realize the benefits offered by contemporary technology (Erwin et al., 2020; Widyanto & Haryanto, 2021). The Information and Communication Technology-Development Index (ICT-DI) is a metric for assessing Indonesia's digital capabilities (Statistics Indonesia, 2023). To advance ICT-DI in accordance with the International Telecommunication Union's (ITU) guidelines, Statistics Indonesia established the ICT-DI scores as a benchmark. It calculates the ICT-DI score by considering factors like access and infrastructure, user characteristics, and user experience. A positive correlation exists between more excellent ICT-DI scores and a higher degree of development (Dewi et al., 2022). The purpose of this index is to assess and evaluate the level of ICT development in different regions, with the goal of identifying the potential for a digital gap.

In 2022, the ICT-DI score in 34 Indonesian provinces will remain concentrated in Western Indonesia, whereas its effect is still lagging in Eastern Indonesia (Statistics Indonesia, 2023). The highest ICT-DI scores were in the provinces of Jakarta (7.64), Yogyakarta (7.25), and Riau Islands (6.69), while the lowest were in the regions of Papua (3.22), East Nusa Tenggara (5.13), and North Moluccas (5.27) (Statistics Indonesia, 2023). Digital inequality between Indonesian provinces is still high, and the difference in ICT-DI scores between provinces in Indonesia has necessitated that technology be more optimal. The community, particularly in Eastern Indonesia, still needs to fully appreciate the equitable progress of ICT development in their regions (Dewi et al., 2022).

According to the World Inequality Report 2022, the top 10% wealthiest individuals in the world today possess 52% of the total global income, while the bottom 50% of the population only receives 8.5% of that money (Chancel et al., 2022). The COVID-19 pandemic has exacerbated this phenomenon. Furthermore, the COVID-19 pandemic has brought about substantial alterations in the economic sphere, in addition to its impact on public health (Rachmat et al., 2022). The Indonesian people and government must together confront the economic downturn, characterized by a decrease in economic activity and an increase in unemployment (Sparrow et al., 2020). Notwithstanding these limitations, a nation's economic activity persists, primarily through the extensive use of ICT. Nevertheless, Indonesia's economic development frequently coincides with the emergence of widening disparities (Hill et al., 2008).

There is a correlation between regions characterized by high levels of economic inequality and relatively low scores on the ICT-DI (Dewi et al., 2022). Hence, the causal relationship between the two variables becomes a subject of uncertainty. The relationship between high inequality and impediments to ICT adoption leading to low ICT-DI, or conversely, the impact of ICT adoption on income inequality, is a subject of inquiry. This research aims to investigate the role of ICT-DI as a determining factor in income inequality. The objective of this study is

to present empirical findings that establish a substantial relationship between the ICT-DI score, which serves as a measure of ICT adoption, and the Gini ratio, which serves as an indicator of income inequality, across several provinces.

The paper will be presented as follows: In Section 2, a literature review is utilized to discuss the impact of ICT adoption on income inequality. Descriptive illustrations are provided regarding the influence of ICT and the Gini ratio across 34 provinces in Indonesia. Additionally, an examination is conducted on the influence of factors such as GDRP per capita, poverty, labor, unemployment, wages, mean years of schooling, foreign direct investment, micro-manufacturing industries, small-manufacturing industries, life expectancy, population growth, population density, and civil liberties, political rights, institutions of democracy on income inequality. The data and research methodology are discussed in Section 3. The results of the estimation and economic analysis are explained in Section 4, along with a discussion section on how ICT influences income inequality. Conclusions, policy recommendations, and suggestions for future research are presented in Section 5.

2. Literature Review

The impact of ICT on income inequality has been a subject of scholarly investigation (Adams & Akobeng, 2021; Asongu & Le Roux, 2017; Richmond & Triplett, 2018; Tchamyou et al., 2019; Tong & Dall'erba, 2008). Numerous literary works assert that ICT has a significant role in fostering economic progress (Borés et al., 2003; Remenyi et al., 2007). ICT presents a comprehensive strategy for mitigating poverty, fostering economic growth, and influencing social and human capital (Gruber & Koutroumpis, 2011; Lum, 2011; Matalqah & Warad, 2017; Roller & Waverman, 2001). It is anticipated that the wider adoption and integration of digital technology will lead to a reduction in economic inequality. Salahuddin & Alam (2016) claim that the advancement of information and communication technology has considerable promise within the framework of macroeconomics.

According to Jahanshahi et al. (2011) and Khurana et al. (2019), the utilization of digital technology presents a potential avenue for generating novel avenues of productivity, hence fostering social inclusion among Micro, Small, and Medium Enterprises (MSMEs). According to (Zhuang et al., 2009), it is widely believed that the implementation of some measures can contribute to economic growth, enhance the functioning of market players, and have an indirect effect of reducing income disparity. This issue is recognized as a significant concern at both national and global levels.

Kuznets' theory on economic growth and income inequality explores the impact of technology on the distribution of income (Kuznets, 1955). Kuznets demonstrates the relationship between income inequality and the stage of industrialization, indicating that such disparity tends to rise initially and, after that, decline after reaching a specific income threshold, referred to as the inverted U-curve. According to Krugman (1991), the advent of technological advancements has resulted in economies of scale, which have disproportionately benefited the industrial sector in urban regions as compared to the agricultural industry in rural areas. The advent of industrialization has resulted in a notable rise in economic disparity.

The development of ICT can exhibit both exogenous and endogenous attributes, leading to its transformation into a public good or service in due course. According to Romer (1990), many benefits can be experienced by countries with different variations as a result of technical spillovers that occur between nations. Hence, the advancement of ICT has the potential to result in disparities in economic growth and human capital among nations (Verspagen, 1993). According to Rosenberg (1972), there is a belief that new technologies serve essential productive functions that play a crucial role in fostering economic progress. Hence, the outcomes of technology advancements can be effectively employed for the purpose of promoting inclusive development. ICT has emerged as a significant factor influencing the achievement of sustainable and inclusive economic growth, as viewed from both national and commercial standpoints (Farouq & Sulong, 2020; Miśkiewicz, 2018). Various features influence the evolution of ICT. Therefore, the primary determinant for the progress of ICT is the human capital, encompassing individual knowledge, competencies, and capabilities that influence the growth of the economy (Coleman, 2009).

Income inequality can be measured by examining the impact of ICT breakthroughs on the labor market. Bound & Johnson (1988) found that the presence of technology with characteristics that favor specific abilities is the primary factor driving changes in the wage structure. The advancement of ICT has been crucial in facilitating more engagement among individuals with high levels of talent as opposed to those with lower levels of skill (Autor et al., 1998).

Acemoglu & Autor (2011) posit that individuals who possess the ability to adapt to emerging technologies swiftly may see an augmentation in their salaries. In contrast, individuals with limited abilities whose occupations are vulnerable to automation may witness a decline in their pay. According to Michaels et al. (2010), there has been a notable transition in the labor market, namely within the ICT sector, in the United States, Japan, and Europe between the years 1980 and 2004. A change in demand from middle-skilled people to high-skilled professionals characterizes this shift.

The rise of ICT signifies a shift in the emphasis on technical skills, resulting in advantages that need to be distributed proportionally among the workforce capable of capitalizing on these opportunities (Goldin & Katz, 2008). According to (Galbraith, 2001), there exists a notable relationship between the demand for labor-intensive consumer products and the suppression of wage distribution. Additionally, the demand for capital-intensive investment goods, as well as the skills possessed by the workforce, might contribute to the augmentation of income inequality (Oryoie, 2023). On the contrary, Grossmann (2001) presents a contrasting perspective, suggesting that the evolution of ICT closely aligns with the production function. This alignment consequently triggers a restructuring of labor, diverting resources towards non-productive endeavors ultimately diminishing the productivity of individuals with lower skill levels (Mazyaki & Ashtari, 2023).

In a study conducted by Downes (2009), it was shown that there is potential for enhanced and equitable distribution of ICT development among nations. However, the evidence of this phenomenon can be observed through the progressive transformations in social, economic, and legal structures. When coupled with

disparities in access and availability of infrastructure (Agahari, 2018), the advancement of ICT has the potential to reinforce existing economic stratification trends and exacerbate inequality (Falck et al., 2016). According to a study conducted in Sri Lanka by Carte et al. (2011), it is observed that the implementation of an effective e-learning program requires addressing the need for more pertinent skills, prevalent illiteracy rates, and insufficient information and technology infrastructure.

The study conducted by Samoilenko & Osei-Br (2011) yielded a significant discovery about investment in ICT among 18 transition economies. Notably, the researchers also examined the correlation between the strength of the economy and the availability of infrastructure, which were found to exert an influence on the impact of ICT development. According to a study conducted by Dell'Anno & Solomon (2014), it was shown that ICT has a favorable effect on income inequality. This effect is influenced by factors such as education and the quality of institutions.

In a recent study, Mendonça et al. (2015), made a distinction between access to ICT and the skills and capacities associated with it in the context of Portugal. The findings of this study indicate that the mean access index is twice as high as the mean talent index, and those with lower incomes exhibit a significant concentration within both indices. This discovery provides more support to the notion that advancements in ICT have the potential to exacerbate disparities in wealth distribution.

Low-income community groups are synonymous with small businesses. The definition of small businesses in Indonesia is known as micro, small, and medium enterprises (MSMEs). Based on Law Number 20 of 2008 concerning MSMEs, there are 4 categories of the business world, namely micro-businesses, small businesses, medium businesses, and large businesses that carry out economic activities and are domiciled in Indonesia. The criteria that differentiate the four business worlds are ownership, net worth, and annual sales. Internet users have enabled SMEs to participate in the digital economy, increasing labor productivity and exports, according to a study by Falentina et al. (2021) in Yogyakarta. Research results by Adviento et al. (2022) and Priyono et al. (2019), say that SMEs have a negative and significant impact on income inequality. The same thing was also found in Beck et al. (2007), where high credit distribution can accelerate the reduction in inequality levels. Meyer (1998) also stated that the source of capital for small businesses will be very dependent on credit distribution from banks.

The diverse empirical research pertaining to the influence of ICT on income disparity yields inconclusive findings. The inclusion of multiple countries in the study poses a challenge in formulating comparison findings. This study makes a scholarly contribution by employing a cross-province analysis to examine the effects of ICT advancements on the level of income inequality.

3. Methods and Data

3.1 Data description

The study aims to examine the influence of ICT on income inequality across 34 provinces of Indonesia from 2012 to 2022. Quantitative data in the form of secondary data from Statistics Indonesia publications is

utilized. The analysis focuses on the Gini ratio as the primary measure of income inequality, derived from the Lorenz curve, which compares the distribution of a specific variable (e.g., income) with a uniform distribution representing the cumulative percentage of the population.

This research investigates the impact of ICT on income inequality, utilizing the Gini ratio as the metric for income inequality. The independent variable is represented by ICT-DI scores, indicating the level of ICT development. Control variables encompass GDRP per capita, poverty, labor, unemployment, wages, mean years of schooling, foreign direct investment, micro-manufacturing industries, small-manufacturing industries, life expectancy, population growth, population density, civil liberties, political rights, and democratic institutions.

GDRP per capita is utilized to understand how a province's wealth level affects income inequalities between different population components. It is assumed that GRDP per capita will negatively impact the overall income disparity. Poverty and income inequality are two interrelated issues with significant social, economic, and political implications. Working labor has the potential to reduce income inequalities. Enhancing access to and quality of education and training, which prepares the labor force for the labor market, is assumed to reduce income inequalities and enhance employment opportunities. Unemployment is a significant issue in developing countries. High unemployment rates prevent individuals from receiving income, leading to an increase in income inequality. Trained workers are better equipped to perform their jobs and have a higher chance of earning a higher salary, thus reducing income inequality. Mean years of schooling can influence income inequality in a society because education significantly impacts an individual's ability to earn a high income. Foreign investment can have a varied impact on income inequality in a country. There is potential for FDI to help reduce income inequalities, but its impact depends heavily on contextual factors such as government policies, industrial structures, and global economic conditions. Micro and small business operators can have a significant impact on reducing income disparities through job creation, empowerment of local economies, market access, education and training, and innovation and creativity. There is a positive correlation between an increase in average life expectancy and an improvement in a society's overall health. Population growth and population density can significantly impact a country's income inequality. The democracy index, which includes civil liberties, political rights, and democratic institutions in developing countries, is an effective mechanism to mitigate the impact of ICT on income inequality.

Table 1A outlines the definitions of variables, while Table 2A provides summary statistics (refer to the appendices). The data from 2012 to 2022 for the panel data collection of 34 Indonesian provinces are summarized in Table 1A, detailing both dependent and independent variables. However, it's important to note that the available macroeconomic data is limited to these 34 provinces. The ITU's methodology resulted in the release of new ICT-DI data at provincial and national levels in 2016, covering the period from 2012 to 2022.

In Indonesia, the Gini ratio fluctuated during the period 2012–2022, with several influential factors including economic conditions, government policies, and events such as the COVID-19 pandemic. During this period, Gini ratios in Indonesia tended to be stable with slight fluctuations. Governments are making various

efforts to reduce income inequalities, such as through social assistance programs and improved access to education and health services. The COVID-19 pandemic has affected Indonesia's economy significantly. The socially restrictive measures implemented to control the spread of the virus have led to economic decline, job losses, and income losses for many people. Equal economic impacts do not occur, with specific sectors and vulnerable groups hitting hardest. It potentially exacerbates income inequality in the country. Despite the government's implementation of economic stimulus and social assistance programs to alleviate the pandemic's impact, distributing aid evenly to those in need remains a challenge, and the negative economic impact may not adequately protect some community groups.

Indonesia's ICT development continues to improve, as evidenced by an increase in the ICT readiness index by 5.14 in 2012 and 5.80 in 2022. ICT use increased by 2.24 in 2012 and 5.66 in 2022. However, in ICT skills, the index value decreased by 6.47 in 2012, compared to 6.00 in 2022. Overall, ICT developments in Indonesia show positive trends with increased access, use, and expertise in ICT across society. However, there are still challenges, such as cross-regional access gaps and the need for continuous efforts to improve digital literacy and ICT skills so that people can enjoy the full benefits of ICT.

3.2 Empirical specification

This paper examines the impact of ICT on income inequality across 34 provinces in Indonesia. To achieve this, the following basic econometric specification is utilized:

$$GINI_{it} = \beta_0 + \beta_1 READINESS_{it} + \beta_2 USE_{it} + \beta_3 SKILL_{it} + \beta_4 X_{it} + \varepsilon_{it} \quad (1)$$

Where i indicates different provinces $(i = 1, \dots N)$ and t indicates periods of time $t = 1, \dots T)$. The dependent variable, $GINI_{it}$, represents income inequality in province i during the period t. The Gini ratio indicator measures income inequality in this study. $READINESS_{it}$ is the ICT access and infrastructure. USE_{it} is ICT intensity as measured by the use. $SKILL_{it}$ refers to the necessary skill or expertise. X_{it} is a vector of other control variables, such as per capita GRDP, poverty, labor, unemployment, wages, mean years of schooling, foreign direct investment, micro-manufacturing industries, small-manufacturing industries, life expectancy, population growth, population density, civil liberty, political rights, and institutions of democracy. $\beta_0, \beta_1, \beta_2, \beta_3$ are the parameters and vectors of the parameters to be estimated. ε_{it} is an error term. We expect strong standard errors to enable the correction of heteroskedastisity. In addition, $READINESS_{it}; USE_{it}$, and $SKILL_{it}$ are the main interesting variables in the equation. We are attracted to the mark of coefficients $\beta_1; \beta_2,$ and β_3. The positive (or negative) mark of $\beta_1; \beta_2$ and β_3 indicates that the increase (or decrease) of income inequality is spreading as ICTs strengthen, respectively.

3.3 Estimation technique

The Gini ratio is adopted as a measure of income inequality, as recommended by (Adams & Akobeng, 2021). This paper aims to investigate the impact of interactions between ICT readiness, ICT use, and ICT skills on income inequality in 34 Indonesian provinces. To achieve that goal, the use of panel data, compared to

cross-sectional data, allows for important provincial-specific impact controls when considering a large number of heterogeneous provinces (Ali et al., 2018). For this type of data, the commonly used estimation methods are the Fixed Effect Model (FEM), the Random Effect Model (REM), and the Generalized Method of Moments (GMM).

The GMM method has many advantages over the other two methods: unbiased dynamic modeling, endogeneity correction, and greater efficiency with high data persistence (Ali et al., 2018; Chauvet et al., 2016; Soto, 2009). A two-step GMM estimation technique is employed, based on (Roodman, 2009), which builds upon Arellano and Bover (1995). In this investigation, GMM is selected as the empirical technique based on three factors: Firstly, the panel data structure in this study aligns with GMM, thereby excluding cross-country variations. Secondly, this study has more cross sections (N) than time series (T), with N = 34 and T = 11, satisfying the GMM condition. The empirical model is estimated in 34 provinces in Indonesia from 2012 to 2022. Thirdly, GMM is a powerful technique that controls endogeneity through instrumentation and accounts for the eliminated time-invariant variables. This method also restricts excessive identification and allows for control of cross-part dependency (Baltagi, 2013).

4. Results and Discussion

4.1 Indonesia's provinces Gini ratio and ICT development index

Regional development conditions will be successful if prosperity is not only felt by the middle- to upper-class population but also by residents who have low incomes. Efforts made at the national level are contained in the National Long-Term Development Plan (RPJPN) 2005–2025. One of the missions of implementing the RPJPN is to realize equitable and just development. The rise and fall of the Gini index in Indonesia can hinder the fulfillment of national development targets, and equitable development in various provinces has not been fully realized. In measuring the level of inequality in Indonesia, Statistics Indonesia-BPS uses expenditure data as a proxy for income sourced from the National Socioeconomic Survey (SUSENAS). Between 2012 and 2022, income inequality in Indonesia showed a fluctuating pattern, but overall, there were efforts towards reduction. Indonesia's Gini ratio, which measures income inequality, exhibited some variation during this period. While there was progress in reducing poverty, the income distribution among the population remained an area of concern.

Figure 1 illustrates the correlation between the Gini ratio and ICT readiness in 2012 dan 2022. There are provinces with the highest Gini ratio in 2012, namely Yogyakarta (0.449), Papua (0.446), and Jakarta (0.437), while the lowest are North Moluccas (0.306), Bangka Belitung Islands (0.311), and North Sumatra (0.331). In 2022, the provinces with the highest Gini ratios will still be Yogyakarta (0.459), Gorontalo (0.423), and Jakarta (0.412), while the lowest are Bangka Belitung Islands (0.255), North Kalimantan (0.270), and Aceh (0.292). Most provinces did not experience changes in their positions as provinces with the highest and lowest income inequality. This is because income inequality tends to be constant.

This is not the first time that the Gini ratio in Yogyakarta has become the highest in Indonesia. Statistics Indonesia data shows that since March 2017, Yogyakarta's Gini ratio has always been the highest compared to other provinces in Indonesia. So far, Yogyakarta's economy has depended on the tourism and education sectors. These two sectors can provide a multiplier effect for many parties. One example is that the arrival of domestic and foreign tourists benefits not only tourist attraction managers but also restaurant owners, hotels, souvenir shops, and so on. However, Yogyakarta's tourism and education sectors suffered in 2020 due to the COVID-19 pandemic. This is because the number of tourists coming to Yogyakarta has decreased drastically. Simultaneously, some Yogyakarta students opt to return to their hometowns due to the shift in the lecture process to online learning.

In 2022, the Bangka Belitung Islands will be the province with the lowest income inequality in Indonesia. If you look at development in the Bangka Belitung Islands at a glance, it appears to be more evenly distributed compared to other areas. Almost all areas in the Bangka Belitung Islands have affordable access to transportation. Even in the island areas, the roads are generally well-maintained and paved. The facilities and infrastructure in villages and cities are similar, and they also benefit from a relatively small area; the terrain is relatively flat, and there are no high mountains or extremely up-and-down roads, making management easier.

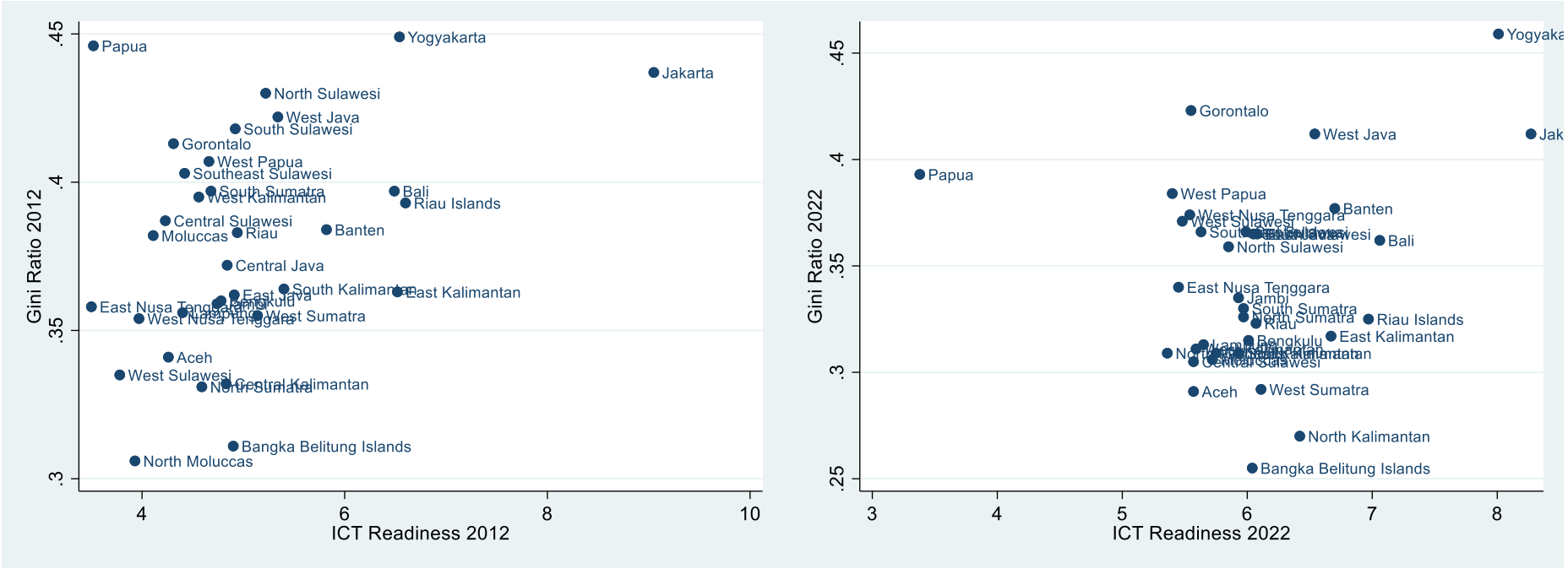

Figure 1: Development of Gini Ratio and ICT Readiness in 34 Indonesian Provinces, 2012 and 2022

ICT developments in each region of Indonesia have different access and infrastructure, giving rise to a digital divide. In terms of access and infrastructure, many areas, particularly provinces outside Java and Bali, still require the provision of distributor network services. The island of Java, especially the areas around Jakarta, Bandung, and Surabaya, has become the center of ICT development in Indonesia. In this region, ICT infrastructure such as fast internet, data centers, and access to the latest technology is more available and developing rapidly. Many technology companies and startups are also developing in this region. Because of its advanced tourism, the island of Bali has quite good ICT development. This digital gap is visible in Papua, West Papua, and West Sulawesi, which have the lowest ICT access and infrastructure in Indonesia. Papua is one of the regions with the most significant digital divide in Indonesia. The region has limited ICT infrastructure, and many areas still lack adequate internet access.

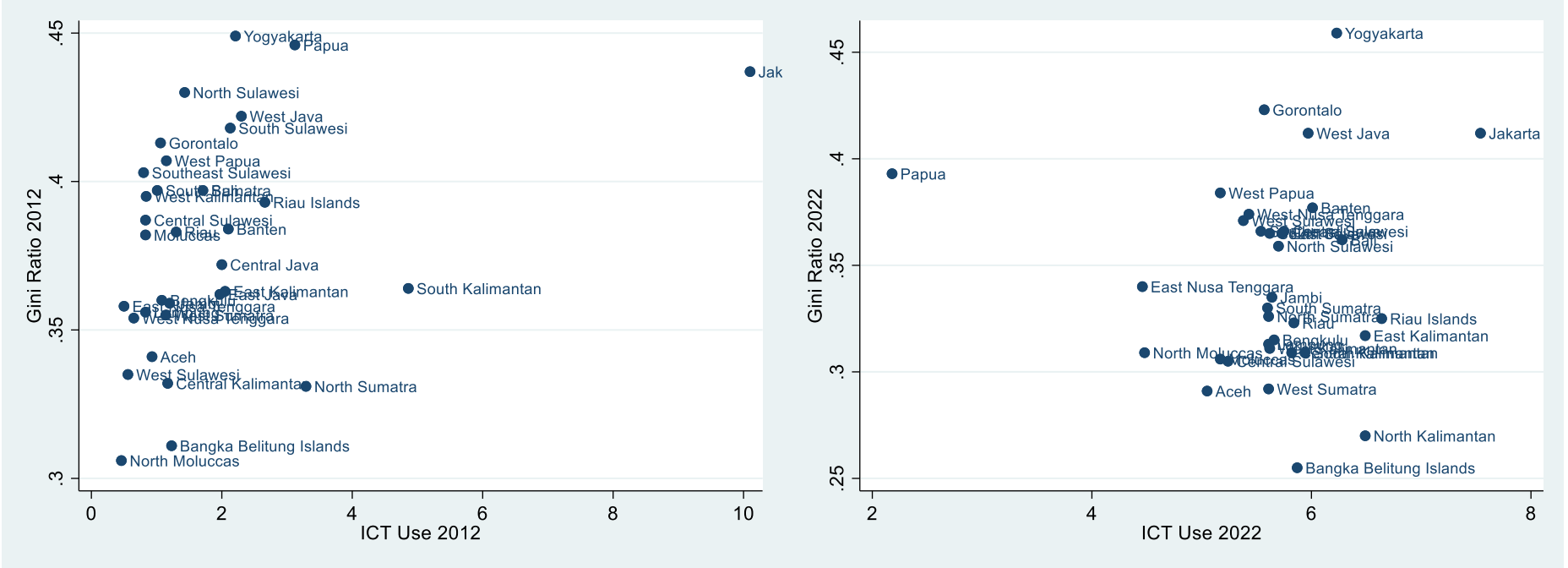

Figure 2: Development of Gini Ratio and ICT Use in 34 Indonesian Provinces, 2012 and 2022

ICT use remains concentrated in Jakarta, the Riau Islands, and East Kalimantan due to the digital divide in ICT access and infrastructure (see Figure 2). Jakarta is Indonesia's capital and the center of government, business, and finance. The Riau Islands and East Kalimantan also have rapidly developing economies, mainly due to the shipping sector and natural resources. These centers' presence supports ICT development in the region. These regions have better ICT infrastructure compared to other regions. This includes faster internet connectivity and access to more modern technology services. Jakarta, the Riau Islands, and East Kalimantan also have educational institutions and human resources that support ICT development. Many universities, colleges, and ICT training centers are located in these areas. These regions attract technology companies and startups that invest in ICT development and implementation. The existence of these companies encourages the growth of the ICT ecosystem. However, we still need to solve the digital divide between regions. To overcome this, the Indonesian government needs to make further efforts to expand ICT access to

underdeveloped regions. This involves improving ICT infrastructure, ICT training for residents, and incentives for technology companies to invest more in less developed regions. Reducing the digital divide will help create more equitable economic growth throughout Indonesia.

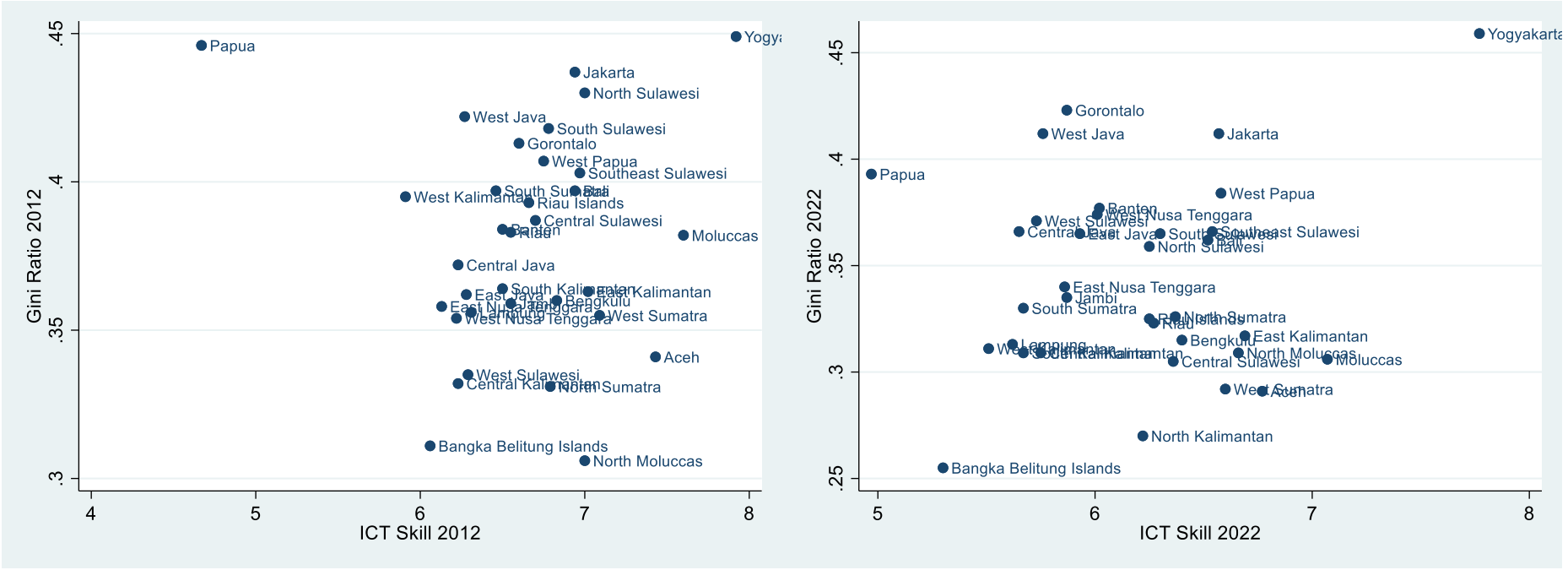

Figure 3: Development of Gini Ratio and ICT Skill in 34 Indonesian Provinces, 2012 and 2022

Figure 3 shows a visualization of the development of ICT skills during 2012 and 2022. This information indicates that the provinces that have the highest ICT skills are Yogyakarta, Moluccas, and Aceh. This is a positive indication of ICT development in these regions. High ICT capabilities can increase productivity in various economic sectors, including industry, education, and health services. This can encourage sustainable economic growth. High ICT skills can open up job opportunities in ICT-related sectors such as software development, data analysis, and information technology. This can reduce the unemployment rate in the region. Quality education in the ICT field can help create human resources who are more skilled and ready to face the challenges of the digital world. This will have a positive impact on the level of education in the

region. High ICT capabilities can encourage innovation and entrepreneurship in the region. This could result in more tech companies and startups thriving. The use of ICT in public services such as health and electronic government can improve residents' quality of life.

Meanwhile, the provinces that have the lowest ICT capabilities and expertise are Papua, Bangka Belitung Islands, and West Kalimantan. This is an indication of Indonesia's digital divide. Low ICT capability and expertise may indicate limitations in access to ICT education and training available in the region. This can hamper the ability of residents to utilize modern technology. Residents of these regions may require assistance to compete in an increasingly technology-driven job market due to their limited ICT capabilities. This can impact unemployment rates and lower income levels. People who are less skilled in ICT may need assistance accessing digital public services such as e-government and online health care, which can improve their quality of life. Low ICT capabilities can hinder the region's economic potential, including in terms of business growth and innovation.

4.2 Income inequality: the role of ICT readiness, use, and skill

This study uses two estimators, namely FEM and system GMM, to estimate equation (1). The FEM estimator serves as a useful benchmark, while the system GMM estimator is more robust and reliable. To address the issues of heteroscedasticity and autocorrelation in standard errors, we have included a 'robust' option in the Stata commands when implementing both estimators. Table 1 and Table 2 present the empirical results and test statistics related to equation (1) for FEM and system GMM, respectively. Specification (1) examines individual impacts on ICT readiness, use, and skills. Specifications (2) through (16) enter control variables step-by-step, whereas the specification (17) includes all significant variables. In this study, we conducted two types of tests after estimating the GMM system. First, the results of the Sargan test demonstrate that the instruments used in the study were good enough to produce accurate specifications. We found significant p-values for all specifications, exemplifying this. Second, the Arellano-Bover/Blundell-Bond test results do not show any signs of second-order serial correlation in the residuals (AR2) for any of the specifications.
The results of this study show that ICT readiness has an effect on increasing income inequality (Adams & Akobeng, 2021; Asongu & Le Roux, 2017; Richmond & Triplett, 2018; Tchamyou et al., 2019; Tong & Dall'erba, 2008). Indonesia is an archipelago with diverse geographical and demographic characteristics. Urban areas tend to have better ICT infrastructure and higher internet penetration rates compared to rural and remote regions (Dewi et al., 2022). This urban-rural divide contributes to disparities in access to technology and digital services. Individuals and communities with limited access to ICT face challenges in accessing educational resources, job opportunities, and online markets, which can perpetuate income inequality (Celbis & De Crombrugghe, 2014; Kartiasih et al., 2023).

The use of ICT has an effect on reducing income inequality (Faizah et al., 2021). The adoption of ICT opens up new job opportunities (Dewi et al., 2022; Kartiasih et al., 2023), particularly in sectors related to technology such as software development, digital marketing, data analysis, and IT services. Indonesia has seen a growing digital economy, with startups emerging in various fields, leading to increased demand for skilled workers (The Coordinating Ministry for Economic Affairs, 2023). This expansion of the technology sector creates diverse employment opportunities, contributing to a reduction in unemployment rates (Kustanto, 2020b).

Indonesians with ICT skills have the potential to significantly contribute to reducing income inequality by accessing employment opportunities, participating in the digital economy, empowering themselves through education, contributing to economic growth, and creating spillover effects that benefit their communities (Faizah et al., 2021). By investing in the development of ICT skills among its populace, Indonesia can foster a more inclusive and equitable society where everyone has the opportunity to thrive in the digital age (Kartiasih et al., 2023).

The provincial minimum wage has an effect on reducing income inequality. Minimum wage policies can lead to improved wage distribution within a province (Rohmah & Sastiono, 2021). By setting a floor on wages, minimum wage laws prevent employers from paying excessively low wages to workers, particularly those in low-skilled or vulnerable occupations (Rani et al., 2013). This can help narrow the wage gap between different segments of the workforce and reduce income inequality (Setyadi et al., 2023).

ICT can provide small businesses and microbusinesses with access to larger markets beyond their immediate vicinity (Bhattacharya, 2019). Through e-commerce platforms and digital marketplaces, these businesses can reach customers across Indonesia and even internationally, thereby increasing their revenue and contributing to economic growth (Kartiasih et al., 2023). In this study, small-enterprises and micro-enterprises have an influence on reducing income inequality and improving the overall quality of life for all citizens. Small and micro-enterprises are significant employment providers in Indonesia (Tambunan, 2019). They create job opportunities for a wide range of the population, including low-skilled workers, women, and rural residents. These enterprises help raise income levels and reduce poverty by providing employment, which is a direct way to mitigate income disparities (Falentina et al., 2021).

The findings of this study are also consistent with previous study from (Faizah et al., 2021), which found that the number of populations and population density have a positive and significant effect on income inequality. Population growth will result in rapid urbanization (Kustanto, 2022). Urbanization has historically been associated with significant increases in total factor productivity. In this case, economic productivity in a country increases substantially when economic centers grow (Gilpin, 2001). The population increase will undoubtedly have both positive and negative effects. Uncontrolled population growth will cause various problems and obstacles to efforts to be made because high population growth will cause a rapid increase in the number of

workers (Kustanto, 2020a). At the same time, the regional ability to create new job opportunities will be minimal (Todaro & Smith, 2012).

Income inequality is often associated with disparities in access to healthcare, nutrition, and other determinants of health (Kustanto, 2021). Individuals with higher incomes tend to have better access to quality healthcare services, leading to improved health outcomes and higher life expectancies (Setyadi et al., 2023). Conversely, lower-income individuals may face barriers to accessing healthcare, leading to poorer health outcomes and shorter life expectancies (Bayati et al., 2013). As a result, income inequality can contribute to differences in life expectancy between socioeconomic groups.

The results of this study show that the level of significance may differ from the development of ICT in Indonesia and other control variables, but it is still acceptable. Note that ICT readiness, use, and skills consistently exhibit both positive and negative coefficients on income inequality.

4.3 Robustness checks: result using Gini ratio as dependent variable

We use the Gini ratio as an indicator of income inequality to evaluate the robustness of the estimates in our study. Our estimates, as reported in Table 2, are in line with our previous findings. We found that ICT readiness has a significant effect on increasing income inequality. On the other hand, ICT use and skills have a significant impact on reducing income inequality. The provincial minimum wage also has a significant impact on reducing income inequality. Apart from that, life expectancy, population growth, and population density all contribute significantly to increasing income inequality. Overall, we find that the development of ICT in Indonesia has proven to be beneficial for people to get a better life, which is characterized by reduced income inequality.

4.4. Discussion

Enhanced ICT can boost economic activity and create jobs, potentially reducing income inequality (Faizah et al., 2021; Untari et al., 2019). However, it may also widen the gap as those with better access to technology and digital skills benefit more (Sujarwoto & Tampubolon, 2016). ICT can improve access to education resources, benefiting remote or underserved areas (Albach et al., 2015; Kinuthia, 2009). However, disparities in access to technology and internet connectivity can exacerbate educational inequalities. ICT investment and development may be more significant in urban areas, potentially widening the urban-rural divide, necessitating efforts to include rural areas. Improved ICT can promote social inclusion by connecting communities and fostering cultural exchange. However, excluding some groups from these developments can also lead to increased social inequality (Agu et al., 2023).

Promoting digital inclusivity must be a priority. According to Patria and Erumban (2020), at a certain level of adoption, the use of ICT can contribute to reducing income inequality. Strategies could include investing in digital infrastructure in remote and underserved areas, promoting digital literacy, and making digital services more affordable and accessible. Unaddressed digital transformation can lead to unequal socioeconomic development, as it is crucial to ensure that no one falls behind (Wang et al., 2021). This way, the benefits of ICT, such as improved access to information, education, and economic opportunities, can be more evenly distributed, helping to reduce income inequality and promote inclusive growth in Indonesia.

Resistance to technology and a lack of digital literacy are significant barriers to ICT adoption (Kocsis, 2020), so user acceptance is the most critical factor in using technology. Addressing these factors requires a multifaceted approach from policymakers, educators, and technology developers. Programs that emphasize the importance and relevance of ICT in personal and professional realms can facilitate greater acceptance and integration of technology across various segments of society, which in turn reduces inequality through activities that generate income and provide benefits to consumers (Mushtaq & Bruneau, 2019).

Various stakeholders are making concerted efforts to harness the potential of small enterprises and microenterprises to reduce income inequality through the adoption of ICT (Kartiasih et al., 2023). The government must play a crucial role in facilitating this integration through supportive policies, infrastructure development, and targeted programs that address the digital divide. Simultaneously, educational institutions and private sector partnerships are essential in providing the necessary training and resources. By addressing these challenges, Indonesia can enhance the contribution of small and micro-enterprises to economic equity and national development (Tambunan, 2019).

Population challenges and high population density can have significant effects on the readiness, use, and skill level of ICT, which in turn may influence income inequality (Faizah et al., 2021). By addressing these areas, policymakers and stakeholders can mitigate some of the adverse effects of population and high population density on ICT readiness, use, and skill, thus potentially reducing income inequality. Life expectancy can indeed influence income inequality, with varying impacts depending on several socioeconomic factors (Setyadi et al., 2023). To ensure that improvements in life expectancy contribute to reducing inequality (Bayati et al., 2013), it is critical to implement comprehensive social policies that provide support across the lifespan, such as access to affordable healthcare, robust pension schemes, and lifelong learning opportunities, which together can create a more equitable distribution of the economic benefits associated with longer lives.

A variety of factors, including economic growth, technological change, globalization, labor market policies, and the provision of social safety nets, can influence the interdependent effects of the provincial minimum wage on income inequality (Rani et al., 2013; Rohmah & Sastiono, 2021). Ensuring that minimum wage policies are well-designed and responsive to economic conditions can help minimize potential negative impacts on employment while maximizing the benefits in terms of reducing income inequality.

Table 1: Results on the effects of ICT readiness, use, and skill on income inequality (fixed effect model)

Dependent Variable	Income inequality							
Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ICT readiness	0.007	0.007	0.008	0.007	0.007	0.009	0.007	0.006
	(0.004)***	(0.003)**	(0.003)*	(0.003)**	(0.004)**	(0.004)*	0.004**	(0.004)**
ICT use	-0.008	-0.008	-0.007	-0.008	-0.008	-0.003	-0.008	-0.008
	(0.001)***	(0.001)***	(0.002)***	(0.001)***	(0.001)***	(0.001)**	(0.001)***	(0.001)***
ICT skill	-0.005	-0.005	-0.005	-0.006	-0.006	-0.0008	-0.004	-0.006
	(0 .003)**	(0.003)**	(0.003)**	(0.003)*	(0.004)**	(0.002)***	(0.002)***	(0.003)**
GDRP per capita		0.00005						
		(0.0002)						
Poverty			0.002					
			(0.001)					
Labor				0.001				
				(0.0009)				
Unemployment					-0.001			
					(0.001)			
Wages						-2.06e-08		
						(3.48e-09)**		
FDI							-2.702e-06	
							(1.17e-06)*	
Micro-enterprises								-2.05e-08
								(4.24e-08)**
Constant	0.313	0.313	0.278	0.202	0.314	0.369***	0.322	0.311
	(0.036)***	(0.036)***	(0.04)***	(0.107)	(0.036)***	(0.032)***	(0.032)***	(0.036)***
Obs.	374	374	374	374	374	374	374	374

Dependent Variable	Income inequality							
Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Group	34	34	34	34	34	34	34	34
R-squared	0.8433	0.8433	0.8448	0.8442	0.8448	0.8701	0.8468	0.8435

Table 1: (Continued)

Dependent Variable	Income inequality							
Independent Variable	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
ICT readiness	0.006	0.009	0.006	0.007	0.007	0.007	0.007	0.007
	(0.004)**	(0.004)**	(0.004)**	(0.004)*	(0.004)**	(0.004)**	(0.004)**	(0.004)**
ICT use	-0.008	-0.004	-0.008	-0.008	-0.009	-(0.008)	-0.006	-0.008
	(0.001)***	(0.002)*	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.002)***	(0.001)***
ICT skill	-0.005	-0.003	-0.005	-0.005	-0.003	-0.005	-0.007	-0.006
	(0.004)***	(0.002)*	(0.003)***	(0.003)***	(0.002)**	(0.003)**	(0.003)**	(0.004)**
Small-enterprises	-1.31e-08							
	(6.03e-08)**							
MYS		-0.021						
		(0.006)**						
Life expectancy			5.73e-07					
			(2.93e-07)					
Population				1.39e-08				
				(6.41e-09)*				
Density					-0.00004			
					(4.51e-06)***			
Civil						-0.0001		
						(0.0001)		

Dependent Variable	Income inequality							
Independent Variable	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Political							-0.0003	
							(0.0001)	
Institutions								0.00007
								(0.0001)
Constant	0.314	0.478	0.314	0.312	0.361	0.325	0.313	0.304
	(0.037)***	(0.069)***	(0.036)***	(0.036)***	(0.035)***	(0.036)***	(0.033)***	(0.041)***
Obs.	374	374	374	374	374	374	374	374
Groups	34	34	34	34	34	34	34	34
R-squared	0.8433	0.8522	0.8433	0.8434	0.8482	0.8439	0.8489	0.8436

Table 1: (Continued)

Dependent Variable	Income inequality
Independent Variable	(17)
ICT readiness	0.010
	(0.003)***
ICT use	-0.0002
	(0.001)**
ICT skill	-0.001
	(0.002)**
GDRP per capita	-0.0005
	(0.0002)*
Poverty	0.002
	(0.001)
Labor	-0.0004

Dependent Variable	Income inequality
Independent Variable	(17)
	(0.001)
Unemployment	-0.002
	(0.001)
Wages	-3.22e-08
	(4.79e-09)***
FDI	-1.06e-06
	(9.77e-07)
Micro-enterprises	-2.19e-08
	(4.53e-08)**
Small-enterprises	-5.65e-08
	(8.26e-08)**
MYS	0.013
	(0.006)
Life expectancy	2.36e-06
	(5.23e-07)***
Population	4.06e-08
	(8.80e-09)***
Density	0.00003
	(9.78e-06)***
Civil liberties	-0.0001
	(0.0001)
Political rights	0.0001
	(0.0001)
Institutions of democracy	0.00001
	(0.0001)

Dependent Variable	Income inequality
Independent Variable	(17)
Constant	0.278
	(0.162)**
Obs.	374
Groups	34
R-squared	0.8791

Notes: In all estimated models, the dependent variable is the Gini ratio, as a measure of income inequality. We use the ICT-DI scores as an independent variable to gauge a country's level of ICT development, encompassing ICT readiness, use, and skill. Control variables include GDRP per capita, poverty, labor, unemployment, wages, mean years of schooling, foreign direct investment, micro-manufacturing industries, small-manufacturing industries, enterprises, life expectancy, population growth, population density, civil liberties, political rights, and institutions of democracy. Robust standard errors are shown in parentheses. *p<0.05, **p<0.01, and ****p<0.001

Table 2: Results on the effects of ICT readiness, use, and skill on income inequality (System GMM)

Dependent Variable	Income inequality							
Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LGini	0.409	0.411	0.401	0.411	0.409	0.347	0.399	0.339
	(0.102)***	(0.101)***	(0.104)***	(0.104)***	(0.101)***	(0.110)**	(0.100)***	(0.098)***
ICT readiness	0.015	0.0155461	0.016	0.015	0.015	0.018	0.013	0.010
	(0.005)**	(0.005)**	(0.004)***	(0.005)**	(0.005)**	(0.005)***	(0.005)**	(0.004)*
ICT use	-0.009	-0.009	-0.009	-0.009	-0.009	-0.006	-0.009	-0.009
	(0.002)***	(0.002)***	(0.002)***	(0.002)***	(0.002)***	(0.002)**	(0.002)***	(0.002)***
ICT skill	-0.002	-0.002	-0.001	-0.003	-0.002	-0.00004	-0.002	-0.003
	(0.003)***	(0.003)***	(0.001)**	(0.003)**	(0.003)**	(0.002)**	(0.003)**	(0.004)**
GDRP per capita		-0.0001						
		(0.0002)						
Poverty			0.002					
			(0.003)					
Labor				0.0008				
				(0.001)				
Unemployment					-0.0003			
					(0.001)			
Wages						-1.29e-08		
						(4.35e-09)**		
FDI							1.78e-06	
							(1.18e-06)	
Micro-enterprises								-6.67e-08
								(4.26e-08)**
Constant	0.143	0.143	0.126	0.054	0.143	0.184	0.155	0.185

Dependent Variable	Income inequality							
Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	(0.048)**	(0.048)**	(0.058)*	(0.171)	(0.048)**	(0.050)***	(0.048)**	(0.059)**
No of Obs.	340	340	340	340	340	340	340	340
Group	34	34	34	34	34	34	34	34
Instruments	58	59	59	59	59	59	59	59
AR(2)	0.2332	0.2301	0.2086	0.3201	0.2903	0.0992	0.2355	0.4308
Sargan test	0.1248	0.1369	0.1276	0.1449	0.1418	0.1310	0.1413	0.1466

Table 2. (Continued)

Dependent Variable	Income inequality							
Independent Variable	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
LGini	0.385	0.409	0.409	0.369	0.273	0.412	0.405	0.411
	(0.101)***	(0.103)***	(0.103)***	(0.098)***	(0.107)*	(0.101)***	(0.103)***	(0.104)***
ICT readiness	0.013	0.015	0.015	0.013	0.007	0.015	0.015	0.0157
	(0.005)**	(0.004)**	(0.005)**	(0.005)**	(0.005)	(0.005)**	(0.005)**	(0.005)**
ICT use	-0.009	-0.009	-0.009	-0.009	-0.010	-0.009	-0.009	-0.009
	(0.002)***	(0.003)**	(0.002)***	(0.002)***	(0.002)***	(0.002)***	(0.002)**	(0.002)***
ICT skill	-0.002	-0.002	-0.002	-0.002	-0.0005	-0.002	-0.003	-0.002
	(0.003)**	(0.003)**	(0.003)**	(0.003)**	(0.002)**	(0.003)**	(0.003)**	(0.004)**
Small-enterprises	-3.09e-07							
	(1.58e-07)**							
MYS		0.0001						
		(0.006)						
Life expectancy			-8.61e-07					
			(1.23e-06)***					

Dependent Variable	Income inequality							
Independent Variable	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Population				7.02e-08				
				(4.16e-08)***				
Density					8.56e-06			
					(5.05e-06)***			
Civil						0.0001		
						(0.0001)		
Political							-0.0001	
							(0.0001)	
Institutions								-0.00002
								(0.0001)
Constant	0.158	0.142	0.143	0.166	0.254	0.131	0.144	0.146
	(0.048)**	(0.064)*	(0.048)**	(0.051)**	(0.043)***	(0.053)*	(0.047)**	(0.050)**
No of Obs.	340	340	340	340	340	340	340	340
Group	34	34	34	34	34	34	34	34
Instruments	58	59	59	59	59	59	59	59
AR(2)	0.3105	0.2356	0.2493	0.3367	0.3100	0.2345	0.1891	0.2116
Sargan test	0.1214	0.1318	0.1356	0.1214	0.1114	0.1310	0.1410	0.1138

Table 2: (Continued)

Dependent Variable	Income inequality
Independent Variable	(17)
LGini	0.211
	(0.097)*
ICT readiness	0.008

Dependent Variable	Income inequality
Independent Variable	(17)
	(0.003)*
ICT use	-0.007
	(0.002)**
ICT skill	-0.002
	(0.002)**
GDRP per capita	-0.0003
	(0.0002)
Poverty	0.0001
	(0.002)
Labor	0.001
	(0.002)
Unemployment	-0.0001
	(0.002)
Wages	-1.32e-08
	(5.49e-09)*
FDI	1.27e-06
	(1.35e-06)
Micro-enterprises	-2.17e-08
	(4.29e-08)**
Small-enterprises	-1.38e-07
	(1.23e-07)**
MYS	-0.001
	(0.008)
Life expectancy	2.26e-06
	(2.00e-06)***

Dependent Variable	Income inequality
Independent Variable	(17)
Population	1.25e-08
	(2.71e-08)***
Density	6.29e-06
	(4.79e-06)***
Civil	0.00007
	(0.0001)
Political	0.0001
	(0.0001)
Institutions	-0.00005
	(0.0001)
Constant	0.145
	(0.235)**
No of Obs.	340
Group	34
Instruments	73
AR(2)	0.3540
Sargan test	0.1458

Notes: Same as Table 1, except LGini (dependent variable lag) is include.

Several limitations need to be considered when interpreting the results of this research regarding the influence of ICT developments on income inequality. First, the findings are based on macroeconomic data covering 34 provinces, which may need to be more representative at the district or city level. Because the differences in ICT infrastructure conditions, users, capabilities, and expertise in each province in Indonesia are significant and can be a factor that influences the level of ICT adoption and its impact on income inequality, provinces that have better ICT infrastructure, users, capabilities, and expertise tend to have a more remarkable ability to integrate

technology in various aspects of economic and social life. This creates opportunities for more inclusive and sustainable economic development. Therefore, it is crucial to continue research on the influence of ICT developments on income inequality in Indonesia.

In this study the FEM and system GMM estimates were used to control for possible bias when unobserved and persistent provincial characteristics that influence income inequality variables are correlated with independent variables. For this reason, we recommend that future research adopt instrumental variable (IV) estimation techniques by constructing a series of exogenous instruments that are fully convincing in this panel data structure.

Policymakers and stakeholders who are interested in encouraging economic development and reducing income inequality through the use of ICT can read the findings of this research, which provide a valuable contribution to the development of knowledge regarding the impact of ICT on income inequality in Indonesia. However, the practical implications or specific policies will depend on the context and circumstances in the area being considered for building infrastructure, preparing human resources, and creating an ecosystem that can become an incubator for the information industry.

6. Conclusion

This study examines the influence of ICT readiness, use, and skills on income inequality in 34 provinces in Indonesia during the 2012-2022 period. The study employed fixed effect and system GMM tests for empirical analysis. The results of this research show that ICT readiness has a significant effect on increasing income inequality. Meanwhile, ICT use and skill have a significant impact on reducing income inequality. Additionally, the results of this study show that control variables such as wages, small enterprises, and micro-enterprises have an effect on reducing income inequality. Life expectancy, population growth, and population density have a significant effect on increasing income inequality. The results of this study's analysis can contribute to the development of valuable knowledge and further strengthen previous research on the influence of ICT developments on income inequality.

The development and expansion of ICT across Indonesian provinces have had a significant impact on economic activities and opportunities. In several ways, ICT penetration can influence income inequality. In regions where there's greater access to ICT, there tend to be improved economic opportunities, potentially leading to reduced inequality. However, in provinces where ICT infrastructure is lacking or where the adaptation to digital economies is slower, the gap may widen because they might not benefit equally from the economic growth driven by technological advancements.

The role of ICT in influencing inequality in Indonesia, as in many other countries, is multifaceted. As policymakers grapple with the challenges and opportunities presented by the proliferation of ICT, several vital areas emerge where its development could have a significant impact on inequality. First, ensuring that internet connectivity is widespread and affordable is essential to avoiding a digital divide. Investment in rural and remote

areas is particularly crucial. Second, we can ensure a more equitable distribution of ICT benefits by implementing programs to improve digital literacy across the population. Third, establishing regulations that promote fair competition and consumer protection can help ensure that ICT development benefits a broader segment of the population. Fourth, collaboration between the government and the private sector can help accelerate ICT development and make it more inclusive. Fifth, we must intentionally design policies to be inclusive, taking into account the needs of marginalized groups such as women, the poor, and those residing in remote areas. By carefully analyzing the role of ICT development on inequality, Indonesian policymakers and stakeholders can craft strategies that not only embrace the economic and social benefits of ICT but also mitigate the risks of increasing inequality.

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Appendices

Table 1A. Definitions and sources of variables

Variables	Signs	Definitions	Sources
Income Inequality	Gini ratio	The Gini coefficient is used to measure the overall level of income inequality with a value between zero (perfect equality) to one (perfect inequality)	Statistics Indonesia
ICT diffusion	ICT readiness	ICT access and infrastructure reflect ICT readiness in terms of access and availability of infrastructure	Statistics Indonesia
	ICT use	ICT use describes the level of ICT use by society	Statistics Indonesia
	ICT skill	Ability or expertise plays an important role in ICT development in a country or region	Statistics Indonesia
Income	GDRP per capita	Growth rate of GDRP per capita at 2010 constant market prices	Statistics Indonesia
	Poverty	Percentage of poor population	Statistics Indonesia
Employment	Labor	Percentage of working to economically active	Statistics Indonesia
	Unemployment	Unemployment rate	Statistics Indonesia
	Wages	Provincial minimum wages per month	Statistics Indonesia
Human capital	MYS	Mean years school of population aged 15 years and over	Statistics Indonesia
Investment	FDI	Foreign direct investment realization by projects	Statistics Indonesia

Variables	Signs	Definitions	Sources
Manufacturing	Micro-enterprises	Number of establishments of micro-enterprises	Statistics Indonesia
	Small-enterprises	Number of establishments of small-enterprise	Statistics Indonesia
Population	Population	Annual population growth rate	Statistics Indonesia
	Density	Annual population density rate	Statistics Indonesia
Democracy	Civil	The Indonesian democracy index based on civil liberties aspect	Statistics Indonesia
	Political	The Indonesian democracy index based on the political rights aspect	Statistics Indonesia
	Institutions	The Indonesian democracy index based on the institutional aspects of democracy	Statistics Indonesia

Table 2A. Summary statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Gini	374	0.359	0.041	0.247	0.459
ICT readiness	374	5.52	0.99	3.38	9.28
ICT use	374	3.73	1.79	0.46	10.34
ICT skill	374	6.39	0.66	4.65	8.21
GDRP per capita	374	3.30	3.75	-20.13	21.18
Poverty	374	11.09	5.82	3.42	31.53
Labor	374	94.69	1.91	89.05	98.63
Unemployment	374	5.29	1.92	1.4	10.95
Wages	374	2035340	711975	181000	4641854
FDI	374	698	1662	3	16787
Micro-enterprises	374	107113	185134	1180	934814
Small-enterprises	374	9397	22630	39	160148
MYS	374	8.27	1.00	5.73	11.31
Life expectancy	374	89.11	378.44	38.61	73.88
Population	374	78444	117649	5725	992643
Density	374	724	2620	8	16158
Civil	374	82.32	10.30	47.21	100
Political	374	65.13	12.64	28.95	88.76
Institutions	374	72.35	9.94	47.25	93.98