EKO-REGIONAL: JURNAL PEMBANGUNAN EKONOMI WILAYAH
Volume 18, Issue 1, March 2023, pp. 48–60
http://jp.feb.unsoed.ac.id/index.php/eko-regional/article/view/3371
DOI: https://doi.org/10.32424/1.erjpe.2023.18.1.3371

Digital Technology Development and Income Inequality in Indonesia: Using System GMM Model

By
Sugeng Setyadi[1*)], Lili Indriyani[2)], Rizal Syaifudin[3)]
Faculty of Economics and Business, Sultan Ageng Tirtayasa University
[*)]Email: sugeng.setyadi@untirta.ac.id

Submission: December 22, 2023; Accepted: February 20, 2023

ABSTRACT: This study aimed to analyze the importance of information and communication technology (ICT) for economic development. ICT development has been widely studied and well understood, but its impact on income inequality is less well documented. Therefore, this study used a panel data set in 34 provinces in Indonesia during 2013-2020 to examine the impact of ICT development on income inequality. The econometric Generalized Method of Moments (GMM) with the estimation model of the System GMM showed that higher ICT development (Information and Communication Technology Development Index) reduces income inequality (Gini Ratio). This implies that ICT development does not contribute to exacerbating income inequality. However, it could play a role in mitigating and reducing income inequality in Indonesia. Socio-economic and political factors are also important in reducing income inequality. Therefore, redistribution policies and government spending are crucial to reducing income inequality due to ICT development. These policies must be adapted to the needs of each region for ICT development.

Keywords: ICT Development, Income Inequality, Socio-Economic and Political Factors, GMM Model.

***ABSTRAK**: Penelitian ini bertujuan untuk menganalisis pentingnya teknologi informasi dan komunikasi (TIK) bagi pembangunan ekonomi. Pembangunan TIK telah banyak dipelajari dan dipahami dengan baik, namun dampaknya terhadap ketimpangan pendapatan kurang didokumentasikan dengan baik. Oleh karena itu, studi ini menggunakan kumpulan data panel di 34 provinsi di Indonesia selama 2013-2020 untuk mengkaji dampak pembangunan TIK terhadap ketimpangan pendapatan. Metode ekonometrika Generalized Method of Moments (GMM) dengan model estimasi Sistem GMM menunjukkan bahwa pembangunan TIK (Indeks Pembangunan Teknologi Informasi dan Komunikasi) yang lebih tinggi dapat mengurangi ketimpangan pendapatan (Gini Ratio). Ini menyiratkan bahwa pembangunan TIK tidak berkontribusi memperburuk ketimpangan pendapatan. Namun, hal tersebut dapat berperan dalam memitigasi dan mengurangi ketimpangan pendapatan di Indonesia. Faktor sosial-ekonomi dan politik juga penting dalam mengurangi ketimpangan pendapatan. Oleh karena itu, kebijakan redistribusi dan pengeluaran pemerintah sangat penting untuk mengurangi ketimpangan pendapatan akibat pembangunan TIK. Kebijakan tersebut harus disesuaikan dengan kebutuhan masing-masing daerah untuk pembangunan TIK.*

***Kata Kunci:** Pembangunan TIK, Ketimpangan Pendapatan, Faktor Sosial Ekonomi dan Politik, Model GMM.*

INTRODUCTION

The rapidly growing use of information and communication technology (ICT) in the current globalization era increases economic productivity in various sectors (Haseeb et al., 2019). ICT is rapidly integrating into everyday life (Ihm & Hsieh, 2015), facilitating communication (Hernández-Encuentra et al., 2009; Xie et al., 2012), time savings, and easy information dissemination (Adams & Akobeng, 2021). ICT increases productivity improves transparency and governance, builds social capital, and empowers individuals (Maiti & Awasthi, 2020). Moreover, studies show that high productivity is achieved by firms that rely heavily on ICT (Luo & Bu, 2016). Digital technology increases information and communication speed, scope, and efficiency. Additionally, it blurs the boundaries between producers and consumers, virtual and real, and global, national and local (Jurriëns & Tapsell, 2017).

Kocsis (2020) showed digital infrastructure's power to create access to online services and jobs for everyone and bridge the digital divide. Digital infrastructure also facilitates connection to the internet network, as well as data collection and exchange (Evangelista et al., 2014; Sheldon, 2004). Data from ASEAN countries shows that the digital economy sector's potential could be seen in the number of internet users. Figure 1 shows that 150 million of Indonesia's 270.6 million people are internet users, the highest recorded in ASEAN. In Singapore, 4.92 million of the total 5.70 million people are internet users. The figures show that Indonesia's progress in ICT adoption positively contributes to overall social and economic well-being. However, it is still unclear, with much debate about its distribution effect.

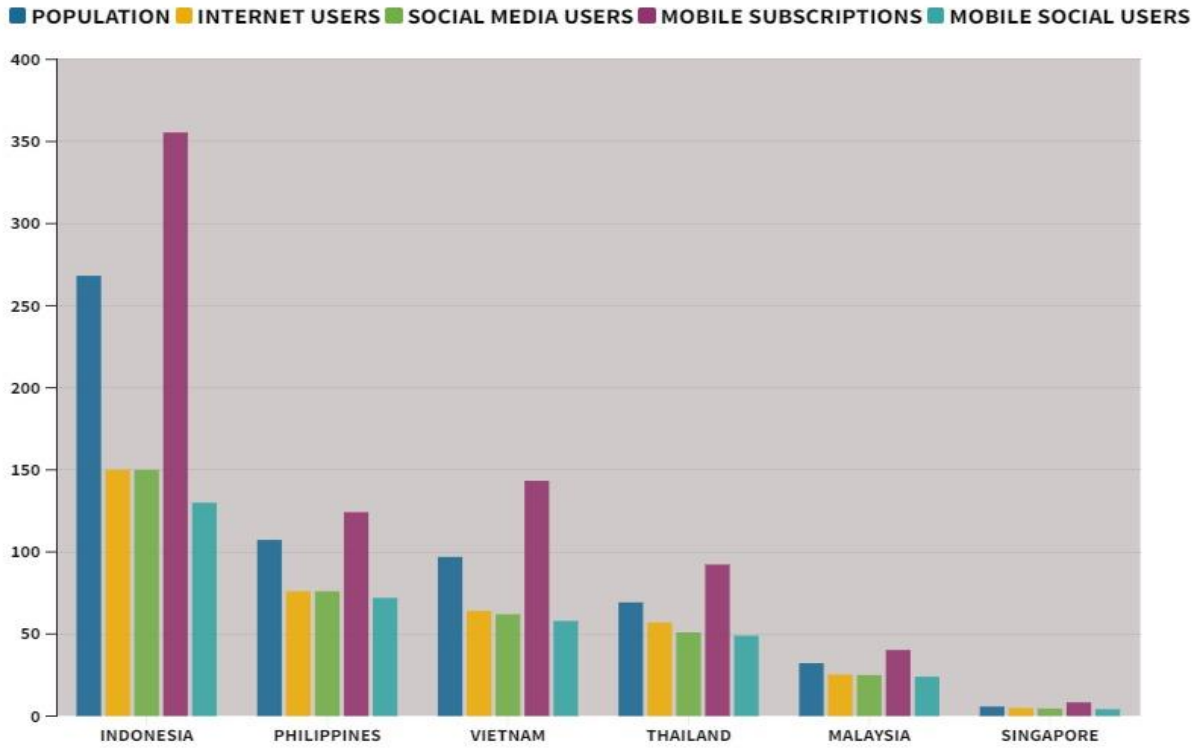

Figure 1. ASEAN Digital Population (millions), 2019
Source: Southeast Asia Digital, Social and Mobile, Author's Calculation

Indonesia has one of the most active populations globally and a vibrant startup ecosystem. However, its implementation is still in the early digitization stages and has not achieved the advantages of modern technology (Erwin et al., 2020; Widyanto & Haryanto, 2021). The ICT Development Index (IDI) measures digital capabilities in Indonesia. The IDI score is a measurement standard used by the Central Statistics Agency for ICT development in the fields following the International Telecommunication Union (ITU). This score is calculated by considering access and infrastructure, users, and expertise, where a higher score implies better development. The index measures and compares ICT development and the regional digital divide.

The increasingly widespread and beneficial digital technology must be anticipated for unwanted impacts. As a developing country, Indonesia's macroeconomic problems need attention because they could harm the economy in the long term, such as inequality. Data from the Sustainable Development Goals (SDGs)

index shows that Indonesia has the lowest SDGs score of 35.28% in ASEAN in overcoming inequality (SDGs, 2022). The Central Statistics Agency provides IDI scores for each province and analyzes the correlation between the scores and socio-economic indicators, such as the Gini Index. Developing increasingly advanced ICT could reduce income inequality (Statistics Indonesia, 2020). Regions with high income inequality have low IDI scores, raising concerns about the quality between the two variables. The question is whether high income inequality (Gini Ratio) hinders information and communication technology development index or vice versa. Therefore, this study aimed to examine ICT as an income inequality determinant to analyze the effect of information and communication technology development index as an ICT adoption indicator on the Gini Index as an income inequality indicator.

Section 2 of this paper discusses the literature review, while Section 3 presents datasets and methodologies for estimating the relationship between ICT, socioeconomic, and politics on income inequality. Moreover, Sections 4, 5, and 6 present the results, discussions, conclusions, and policy recommendations.

LITERATURE REVIEW

The adoption of ICT should encourage economic development (Adams & Akobeng, 2021) because it contributes to economic growth (Borés et al., 2003). ICTs offer a multidimensional approach to poverty alleviation and economic development and influence social and human capital (Gruber & Koutroumpis, 2011; Matalqah & Warad, 2017; Roller & Waverman, 2011). According to Rosenberg (1972), new technologies have productive purposes critical to economic development. The output of technological progress could be utilized for inclusive development. Furthermore, ICT determines sustainable and inclusive economic development from a national and business perspective (Miśkiewicz, 2018; Farouq & Sulong, 2020). Many characteristics influence the development of ICT, and its emergence could increase or decrease income inequality (Adams & Akobeng, 2021; Asongu & Le Roux, 2017; Richmond & Triplett, 2018; Tchamyou et al., 2019; Tong & Dall'Erba, 2008).

Access to information and communication technology can increase access to knowledge, in Indonesia access to technology is still experiencing gaps (Setyadi, 2022).The development of information and communication technology has promising potential in the macroeconomic concept (Salahuddin & Alam, 2016). It is a source of new productivity opportunities to create social inclusion that helps MSMEs (Jahanshahi et al., 2011; Khurana et al., 2019). ICT development also supports economic growth, facilitates market participation, and indirectly reduces the national and global problem of income inequality (Zhuang et al., 2009). However, the lack of access and skills to use ICT could exacerbate wage gaps and income inequality. For this reason, many empirical studies have been conducted on the relationship between ICT and income inequality.

Dell'Anno & Solomon (2014) stated that ICT positively impacts income inequality mediated by education and the quality of institutions. Ali et al. (2019) used Australian household data from 2011 to 2017 and found that ICT positively correlates with income distribution. Furthermore, Cioacă et al. (2020) examined the case for the European Union and found a significant positive impact of internet access on income distribution. Mendonça et al. (2015) distinguished access to ICT from skills and abilities in Portugal. Richmond & Triplett (2018) asserted that ICT helps reduce income inequality by increasing access to resources, information, and markets. Its adoption negatively impacts countries with high income inequality (Noh & Yoo, 2008). The negative influence of ICT adoption on income inequality has been empirically proven (Asongu, 2015; Asongu and Odhiambo, 2019; Kocsis, 2020; Ahmed et al., 2020). The results showed that the average access index is twice the average skill index, with the poor highly concentrated in both indices. This finding reinforces the idea that ICT developments increase income inequality.

Kuznets' theory of economic growth and income inequality explains how technology affects income inequality (Kuznets, 1955). The theory shows how the disparity experienced by countries at the start of industrialization would increase but decrease after a certain income level, known as an inverted U-curve. Technological advances cause economies of scale to bring more value to the urban industrial sector than the rural agricultural industry (Krugman, 1991). ICT progress could be exogenous and endogenous simultaneously, where its characteristics could influence it to become a public good or service. According to

Romer (1989), the benefits from technological spillover could be felt by countries with various variations. Therefore, ICT development could cause economic development and human capital inequality between countries (Verspagen, 1993).

The labor market could be used to measure the impact of ICT developments on income inequality. Bound & Johnson (1989) stated that the technology characteristics biased towards skills were the main reason for the change in the wage structure. ICT development has played an essential role in increasing the participation of a high-skilled than a low-skilled workforce (Autor et al., 1998). It represents a technical shift in skills bias, where the benefits are disproportionate to the workforce positioned to utilize these opportunities (Acemoglu, 1998; Goldin & Katz, 2009). According to Galbraith (2012), the demand for labor-intensive consumption goods suppresses wage distribution. In contrast, the demand for capital-intensive investment goods and labor skills increases income inequality. Downes (2009) showed that the distribution of ICT development is slow and uneven in each country, as seen from the gradually changing social, economic, and political systems. Combined with unequal access and infrastructure availability (Agahari, 2018), ICT developments could strengthen economic stratification and widen inequality (Falck et al., 2016). The various empirical evidence on the impact of ICTs on income inequality in many countries makes it difficult to draw comparative conclusions. Therefore, this study contributes to the literature by using cross-province to investigate the impact of ICT development on income inequality.

METHODS

This study aimed to analyze the effect of ICT development on income inequality in 34 provinces in Indonesia from 2013 to 2020. It used quantitative secondary data from the Central Statistics Agency. The data were processed from the Gini ratio or index as the dependent variable that measured income inequality. The independent variable was the IDI score, the degree of ICT development in a country. The variables affecting income inequality included poverty, labor force participation, foreign and domestic investment, and democracy. This study assumed that ICT development could reduce income inequality. The dynamic panel data regression method was used to determine the impact of ICT development on income inequality in 34 provinces in Indonesia.

Data were analyzed using the dynamic panel data or Generalized Method of Moment (GMM). This method adds a dependent variable lag to serve as an independent or predictor variable in the model (Gujarati, 2004:656). It was used to analyze the dynamic economy, meaning a dependent variable is influenced by other variables and by its past value. The dynamic panel approach was used for two reasons. First, it is a standard estimator and provides a framework for comparison and assessment. Second, dynamic panels provide a simple alternative to other estimators, especially maximum likelihood (Arellano & Bond, 1991). The dynamic panel regression model used is as follows:

$$Y_{i,t} = \alpha + \beta Y_{i,t-1} + \gamma X_{i,t-1} + \eta_i + \varepsilon_{i,t} \quad (1)$$

Where Y is the dependent variable, X is the explanatory variable vector, α is the intercept, β and γ are vector coefficients of the predictor variable, η is the fixed effect time, ε is the error component of the model, i is the number of observations (*cross-section*), and t is time (*time series*). In equation (1), the variable $Y_{i,t}$ is a function of $\varepsilon_{i,t}$, meaning $y_{i,t-1}$ is also a function of $\varepsilon_{i,t}$. Therefore, there is a correlation between the regressor variable $y_{i,t-1,}$ and *error* $(\varepsilon_{i,t})$, causing the pool last square (PLS) estimator to be biased and inconsistent. This causes endogeneity problems, where estimating the model using a fixed or random effects approach produces biased and inconsistent estimators (Baltagi, 2005:135). Therefore, Arellano & Bond (1991) proposed GMM to overcome this problem using the following methodology:

$$Y_{i,t} - Y_{i,t-1} = \beta \left(Y_{i,t-1} - Y_{i,t-2}\right) + \gamma \left(X_{i,t} - X_{i,t-1}\right) + (\varepsilon_{i,t} + \varepsilon_{i,t-1}) \quad (2)$$

In equation (2), *first-differencing* eliminates the intercept and the province-specific effect (η_i). However, the estimation of equation (2) would be biased and inconsistent because the lag of the dependent variable $\left(Y_{i,t-1} - Y_{i,t-2}\right)$ and the *error term* $(\varepsilon_{i,t} + \varepsilon_{i,t-1})$ would be correlated. The selected explanatory variables may also be endogenous. Arellano & Bond (1991) proposed the following moment limitation to eliminate endogeneity in the model.

$$\mathrm{E}\left[Y_{i,t-n}(\varepsilon_{i,t} - \varepsilon_{i,t-1})\right] = 0 \; for \; n \geq 2; t = 3, \ldots\ldots, T \quad (3)$$

$$\mathrm{E}\left[X_{i,t-n}(\varepsilon_{i,t} - \varepsilon_{i,t-1})\right] = 0 \; for \; n \geq 2; t = 3, \ldots\ldots, T \quad (4)$$

The moment limitation is applied under the assumption that the disturbance term is not serially correlated and the regressor is weakly exogenous. This means that the regressor is not correlated with the present and future values of the disturbance term but may be correlated with the past realization of the disturbance term (Guru & Yadav, 2019). Therefore, a valid instrument would lag the values of the explanatory variables. The OLS estimation of equation (2) would also be biased and inconsistent because the dependent variable in the equation could be correlated with error. This study used the following equation modified and developed by (Adams & Akobeng, 2021):

$$\begin{aligned} GINI_{i,t} - GINI_{i,t-1} = \; & \beta\left(GINI_{i,t-1} - GINI_{i,t-2}\right) + \gamma\left(IDI_{i,t} - IDI_{i,t-1}\right) \\ & + \gamma\left(LogPOVERTY_{i,t} - LogPOVERTY_{i,t-1}\right) \\ & + \gamma\left(LABOR_{i,t} - LABOR_{i,t-1}\right) + \gamma\left(LogFDI_{i,t} - LogFDI_{i,t-1}\right) \\ & + \gamma\left(LogDDI_{i,t} - LogDDI_{i,t-1}\right) \\ & + \gamma\left(DEMOCRACY_{i,t} - DEMOCRACY_{i,t-1}\right) \\ & + (\varepsilon_{i,t} + \varepsilon_{i,t-1}) \end{aligned} \quad (5)$$

Where GINI is income inequality (index), IDI is the information and communication technology development index, LogPOVERTY is the number of poor people, LABOR is the labor force participation rate (percent), LogFDI is the foreign investment (Million US$), LogDDI is the domestic investment (Billion Rupiah), DEMOCRACY is the index of democracy (index), β is the coefficient vector of the predictor variables, ε is the model's error component, i is the cross-sectional identity, and t is the analysis period. The operational definition of each variable can be seen in Table 1.

Table 1. Operational Variables

Variable Code and Label	Definition Variable	Source
Dependent Variable		
GINI Gini Ratio (Index)	Income inequality is reflected through people's per capita expenditure in a certain period in an area.	Statistics Indonesia
Independent Variabel		
IDI ICT Development Index (Index)	A composite index that combines 3 sub-indices (infrastructure, use and expertise) which is used to compare ICT in regions over time.	Statistics Indonesia
POVERTY Number of Poor People (Percent)	Percentage of poor population who are below the poverty line.	Statistics Indonesia
LABOR Labor force Participation Rate (Percent)	Percentage of population aged 15 years and over who have a permanent job.	Statistics Indonesia
FDI Foreign Direct Investment (Million US$)	Foreign investment is an investment activity that uses all or joins domestic investment to do business in the territory of the country Republic of Indonesia.	Statistics Indonesia

Variable Code and Label	Definition Variable	Source
DDI Domestic Direct Investment (Billion Rupiahs)	Domestic investment is an investment activity that uses domestic capital to do business in Indonesia.	Statistics Indonesia
DEMOCRACY Democrcy Index (Index)	The democracy index describes the level of development of democracy measured from the aspects of civil liberties, political rights and democratic institutions.	Statistics Indonesia

Source: Statistics Indonesia

RESULTS AND DISCUSSIONS

Table 2 shows the estimation results from the first differences model of GMM and System GMM. The results of the specification test of the dynamic panel data regression model were selected using the System GMM model. This is because Blundell and Bond correlated the bias and poor precision of the First Differences GMM estimator with a weak instrument characterized by parameter concentration. Furthermore, the additional light stationarity limitation on the initial condition process extends the System GMM estimator using the lag difference of y_{it} and the lag-level of y_{it} as instruments for level-level and first differences equations, respectively. The results showed that the System GMM estimator increased efficiency compared to First Differences GMM (Baltagi, 2005:147-148)**.**

Arellano and Bond (1991) and Blundell and Bond (1998) suggested that the two-step estimator in the Monte Carlo study leads to even less efficiency gains, but the associated asymptotic error may be downward biased. Therefore, the estimation was conducted in a dynamic panel data regression model with a system GMM approach of a two-step estimator. Various diagnostic tests were also performed as applicable. The instrument's validity was tested with the Sargan test, while the serial correlation was tested with the Arellano Bond test on AR (1) and AR (2). This ensured that the estimate obtained was consistent with the null hypothesis of no autocorrelation. The Sargan test statistic in Table 2 shows that the instrument selected is valid because it supports the null hypothesis with insignificant results. Similarly, the Arellano-Bond test statistics showed no serial correlation in all the estimated models. This is because the statistical test on AR (1) and AR (2) was significant and insignificant, respectively.

Table 2. Estimation Results of Dynamic Panel Data Regression

Variabel	Dep. Var = Income Inequality (GINI)	
	First-differences GMM	System GMM
Constant	0.392***	0.294***
	(0.000)	(0.000)
$GINI_{i,t-1}$	-0.233***	0.043
	(0.000)	(0.054)
IDI	-0.002**	-0.002***
	(0.001)	(0.000)
LogPOVERTY	0.038***	0.015***
	(0.000)	(0.000)
LABOR	-0.002***	-0.0002
	(0.000)	(0.582)
logFDI	-0.002*	0.0004
	(0.028)	(0.454)
logDDI	-0.007***	-0.006***
	(0.000)	(0.000)
DEMOCRACY	0.00005	0.0004*
	(0.749)	(0.042)
Sargan Test	28.020	30.708

Variabel	Dep. Var = Income Inequality (GINI)	
	First-differences GMM	System GMM
	(0.139)	(0.283)
Arellano-Bond Test		
for AR(1)	-2.026	-3.238
	(0.043)	(0.001)
for AR(2)	-0.685	-0.234
	(0.493)	(0.815)

Impormation: * p<0.05; ** p<0.01; *** p<0.001

Source: Statistics Indonesia, Author's Calculation

The System GMM estimation is the best model that explains the impact of IDI, indicating ICT adoption, on the Gini Index, indicating income inequality. The model gives the coefficient of -0.002 for the IDI variable regression. This indicates that the variable significantly and negatively affects income inequality. More advanced ICT reduces the Gini coefficient, meaning that greater ICT development in a country reduces income inequality. These results are in line with (Khan et al., 2020; Tchamyou et al., 2019; Adams & Akobeng, 2021).

The regression coefficient for the variable of the number of poor people (logPOVERTY) is 0.015. This indicates that the variable significantly and positively affects income inequality. The higher the poverty, the higher the income inequality, or vice versa. Poverty affects income inequality when people cannot meet their daily basic needs. It contributes to income reduction, increasing income inequality. These results are in line with (Hassan et al., 2015; Apergis et al., 2011; Leight, 2010; Tabassum & Majeed, 2008).

The labor force participation rate (LABOR) regression coefficient is -0.0002. This means that the variable negatively and insignificantly affects income inequality. The results imply a weak correlation between labor force participation and income inequality, supporting Lee (2005). Therefore, state intervention is needed to reduce income inequality through taxation, income transfer, and the unequal extraction and allocation of state resources to various sectors, such as employment.

The regression coefficient of the foreign investment variable (logFDI) is 0.0004, meaning the variable positively but insignificantly affects income inequality. This implies that income inequality increases with investment. The results are consistent with (Bhandari, 2007; Herzer et al., 2014; Kaulihowa & Adjasi, 2018; Kentor, 2014; Lee, 2005; Mahutga & Bandelj, 2008; Seyadi et al., 2022). Disparities in regional development increase income inequality in Indonesia, where the preference for foreign investment is more concentrated in the capital-intensive tertiary sector than in the labor-intensive primary and secondary sectors. Therefore, the distribution of domestic investment across various provinces is uneven. The benefits of foreign investment, especially in creating jobs, are only concentrated in certain areas. This results in differences in people's income between provinces.

The regression coefficient of the domestic investment variable (logDDI) is -0.006, meaning that the variable significantly and negatively affects income inequality. The domestic investment focuses on certain companies or countries, with additional investment to absorb labor. This is because labor is absorbed during producing goods and services, enabling workers to get wages that increase their purchasing power. Therefore, more investment used in producing goods and services increases labor absorption, resulting in an even distribution of income per capita. These results support previous studies that increasing domestic investment reduces income inequality (Chaudhry & Imran, 2013; Yamada et al., 2003).

The regression coefficient of 0.0004 for democracy means that the variable significantly and positively affects income inequality. Income redistribution is not automatically introduced during the implementation of democracy in Indonesia. Democracy affects political capital and institutions, the crucial pillars of democracy. However, Indonesia's democratic system is not always supported by corruption-free parliamentary institutions. Democracy cannot create conducive conditions for economic activity, exacerbating the problem of income inequality. These results support (Bollen & Jackman, 1985; Bollen & Grandjean, 2016; Lee, 2005; Zulkarnaen, 2017).

The rapid ICT development supported by technological advances allows people to access information according to their needs. The results showed that ICT developments significantly and negatively impact income inequality. The development through inclusion, efficiency, and innovation facilitates expanding the information base at a lower cost. This creates opportunities previously unattainable to the poor and disadvantaged. Furthermore, ICT adoption could help reduce income inequality because it increases the workers' overall productivity (Lloyd-Ellis, 1999). ICT is used to transmit information faster, easier, and cheaply for economic activities (Noh & Yoo, 2008). Moreover, advances in ICT reduce transaction costs, increasing productivity and efficiency (Evans, 2019; Adeola et al., 2018). Mushtaq & Bruneau (2019) also found that ICT adoption improves the rural communities' welfare by providing market information to farmers to increase their bargaining power and income-generating ability.

Equitable access to ICT infrastructure impacts socio-economic development (Njangang et al., 2021). Internet-based service capacity is much needed in Indonesia now and in the future. This is due to the many developments in cellular telephones and internet services, especially in the post-COVID-19 pandemic. There is an increase in staying connected to the office, schools, colleges, ordering necessities, and entertainment. Additionally, digital transformation has been stipulated in the Strategic Plan of the Ministry of Communication and Informatics 2020-2024 and the Medium-Term Development Plan 2020-2024. The wider community must adopt ICT to reduce income inequality (Patria & Erumban, 2020). The results show that the inverted U-curve indicates that the increasing effect of ICT use on income inequality is temporary. It is vital to ensure that no society is left behind in the digital transformation to realize equal socioeconomic development. Therefore, policies are needed that target the public to adopt ICT developments. The COVID-19 pandemic and the rapid technological development have changed people's lives and work habits. In line with this, ICT adoption highly depends on its basic understanding and use. Income inequality caused by ICT development depends on the development of each region. Therefore, redistribution policies must be based on the needs of each region and supported by the central government. This implies developing ICT infrastructure and increasing digital literacy to reduce income inequality (Adams & Akobeng, 2021).

CONCLUSIONS

Income inequality is a problem for a country's development because it impacts the economy and people's lives. Many studies have discussed this problem, but only a few have examined it based on ICT development economic, social, and political factors. The increasing ICT development shows that people should adapt to current technological developments to make their daily lives easier. This study found that ICT adoption in Indonesia could help reduce income inequality. The results contribute to the current literature debate on the determinants of income inequality. Technological developments enhance communication and affect social development. This shows that community activities are inseparable from the technology used in today's digital era.

This study on the impact of digital technology on income inequality in Indonesia has important policy implications for the government. First, redistribution policies and government spending should reduce income inequality due to ICT development. They must distribute access and infrastructure, use, and expertise equitably in various provinces in Indonesia. Second, economic and political factors influence the efforts to reduce income inequality. These include domestic investment, poverty, and democracy factors. Quality human resources would be highly productive, especially working to earn income and become political actors. The workers would play a role in creating a sound government system for social welfare. Therefore, political actors and corruption-free parliamentary institutions are indispensable in creating conducive conditions for economic activity to reduce income inequality. Third, further studies could calculate the spatial effect of ICT development on regional income inequality.

LIMITATIONS

The importance of ICT development is only felt at the district or city level, whose index data is very challenging. Therefore, this current study only used provincial-level data.

REFERENCES

Acemoglu, D. (1998). Why do new technologies complement skills? Directed technical change and wage inequality. *Quarterly Journal of Economics*, 113, 1055–1089. Acemog.

Adams, S., & Akobeng, E. (2021). ICT , governance and inequality in Africa. *Telecommunications Policy*, *45*(10), 102198. https://doi.org/10.1016/j.telpol.2021.102198

Adeola, O., Evans, O., & Hinson, R. E. (2018). *Tourism and economic wellbeing in Africa*.

Agahari, W. (2018). *Inovasi digital Indonesia: maju di Pulau Jawa, timpang di wilayah timur [Indonesia's digital innovation: progress in Java, lame in the east*]. The Conversation Indonesia. https://theconversation.com/inovasi-digital-indonesia-maju-di-pulau-jawatimpang-di-wilayah-timur-92012

Ahmed, S., Jaeho, C., Kokil, J., Eichstaedt, J. C., & Ungar, L. H. (2020). The Internet and Participation Inequality: A Multilevel Examination of 108 Countries. *International Journal of Communication*, *14*, 1542–1563.

Ali, M. A., Alam, K., Taylor, B., & Rafiq, S. (2019). Do income distribution and socio-economic inequality affect ICT affordability? Evidence from Australian household panel data. *Economic Analysis and Policy*, *64*, 317–328. https://doi.org/10.1016/j.eap.2019.10.003

Apergis, N., Dincer, O., & Payne, J. E. (2011). On the dynamics of poverty and income inequality in US states. *Journal of Economic Studies*, *38*(2), 132–143. https://doi.org/10.1108/01443581111128370

Arellano, M., & Bond, S. (1991). *Some Tests of Specification for Panel Data : Monte Carlo Evidence and an Application to Employment Equations*. *58*(2), 277–297.

Asongu, S. (2015). The impact of mobile phone penetration on African inequality. *International Journal of Social Economics*, *July 2015*. https://doi.org/10.1108/IJSE-11-2012-0228

Asongu, S. A., & Odhiambo, N. M. (2019). How enhancing information and communication technology has affected inequality in Africa for sustainable development: An empirical investigation. *Sustainable Development*, 27, 647–656.

Asongu, S. A., & Le Roux, S. (2017). Enhancing ICT for inclusive human development in Sub-Saharan Africa. *Technological Forecasting and Social Change*, *118*, 44–54. https://doi.org/10.1016/j.techfore.2017.01.026

Autor, D. H., Katz, L. F., & Krueger, A. B. (1998). Computing inequality: Have computers changed the labor market? *Quarterly Journal of Economics*, *113*(4), 1169–1213. https://doi.org/10.1162/003355398555874

Baltagi BH. (2005). *Econometric Analysis of Panel Data, Ed.3, John Wiley & Sons, Ltd, England*.

Bhandari, B. (2007). Effect of Inward Foreign Direct Investment on Income Inequality in Transition Countries. *Journal of Economic Integration*, *22*(4), 888–928. https://doi.org/10.11130/jei.2007.22.4.888

Blundell, Richard, and Stephen Bond. (1998). "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models." *Journal of Econometrics*. https://doi.org/10.1016/S0304-4076(98)00009- 8

Bollen, K. A. ., & Grandjean, B. D. . (2016). The Dimension (s) of Democracy : Further Issues in the Measurement and Effects of Political Democracy. *American Sociological Review*, *46*(5), 651–659. https://doi.org/10.2307/2094946

Bollen, K. A., & Jackman, R. W. (1985). Political Democracy and the Size Distribution of Income. *American Sociological Review*, *50*(4), 438. https://doi.org/10.2307/2095432

Borés, C., Saurina, C., & Torres, R. (2003). Technological convergence: A strategic perspective. *Technovation*, *23*(1), 1–13. https://doi.org/10.1016/S0166-4972(01)00094-3

Bound, J., & Johnson, G. (1989). Changes in the Structure of Wages During the 1980's: an Evaluation of Alternative Explanations. *NBER Working Paper*, *20*(August), 146–146. http://www.nber.org/papers/w2983

Chaudhry, I. S., & Imran, F. (2013). Does trade liberalization reduce poverty and inequality? Empirical evidence from Pakistan. *Pakistan Journal of Commerce and Social Sciences*, *7*(3), 569–587. www.econstor.eu

Cioacă, S. I., Cristache, S. E., Vuţă, M., Marin, E., & Vuţă, M. (2020). Assessing the impact of ICT sector on sustainable development in the European Union: An empirical analysis using panel data. *Sustainability (Switzerland)*, *12*(2). https://doi.org/10.3390/su12020592

Dell'Anno, R., & Solomon, H. O. (2014). Informality, Inequality, and ICT in Transition Economies. *Eastern European Economics*, *52*(5), 3–31. https://doi.org/10.1080/001287755.2014.1004264

Downes, L. (2009). *The Laws of Disruption: Harnessing the New Forces That Govern Life and Business in the Digital Age*. Basic Books.

Erwin, A., Abbas, B. S., Kuncoro, E. A., & Ngatindriatun. (2020). Study of Dynamic Capabilities, Start-Up Growth And Ecosystem in Indonesia. *Psychology and Education*, *57*(9), 269–277. https://doi.org/doi.org/10.17762/pae.v57i9.273

Evangelista, R., Guerrieri, P., & Meliciani, V. (2014). The economic impact of digital technologies in Europe. *Economics of Innovation and New Technology*, *23*(8), 802–824. https://doi.org/10.1080/10438599.2014.918438

Evans, O. (2019). Repositioning for Increased Digital Dividends: Internet Usage and Economic Well-being in Sub-Saharan Africa. *Journal of Global Information Technology Management*, *22*(1), 47–70. https://doi.org/10.1080/1097198X.2019.1567218

Falck, O., Heimisch, A., & Wiederhold, S. (2016). Returns to ICT Skills. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2744714

Farouq, I. S., & Sulong, Z. (2020). THE IMPACT OF ECONOMIC GROWTH, OIL PRICE, AND FINANCIAL GLOBALIZATION UNCERTAINTY ON FINANCIAL DEVELOPMENT : EVIDENCE FROM SELECTED LEADING AFRICAN COUNTRIES. *International Journal of Bussiness, Economics and Management*, *7*(5), 274–289. https://doi.org/10.18488/journal.62.2020.75.274.289

Galbraith, J. K. (2012). The Macroeconomics of Income Distribution. *Inequality and Industrial Change*, *November 1998*, 3–15. https://doi.org/10.1017/cbo9781139175210.002

Goldin, C., & Katz, L. F. (2009). The race between education and technology: A review article. *Journal of Human Capital*, *3*(2), 177–196. https://doi.org/10.1086/645089

Gruber, H., & Koutroumpis, P. (2011). Mobile Telecommunications and the Impact on Economic Development. *Economic Policy*, *July*, 387–426.

Gujarati, D. . (2004). *Basic Econometrics, Fourth Edition*. McGraw-Hill.

Guru, B. K., & Yadav, I. S. (2019). Financial development and economic growth: panel evidence from BRICS. *Journal of Economics, Finance and Administrative Science*, *24*(47), 113–126. https://doi.org/10.1108/JEFAS-12-2017-0125

Haseeb, A., Xia, E., Saud, S., Ahmad, A., & Khurshid, H. (2019). Does information and communication technologies improve environmental quality in the era of globalization? An empirical analysis. *Environmental Science and Pollution Research*, *26*(9), 8594–8608. https://doi.org/10.1007/s11356-019-04296-x

Hassan, S. A., Zaman, K., & Gul, S. (2015). The Relationship between Growth-Inequality-Poverty Triangle and Environmental Degradation: Unveiling the Reality. *Arab Economic and Business Journal*, *10*(1), 57–71. https://doi.org/10.1016/j.aebj.2014.05.007

Hernández-Encuentra, E., Pousada, M., & Gómez-Zúniga, B. (2009). ICT and older people: Beyond usability. *Educational Gerontology*, *35*(3), 226–245. https://doi.org/10.1080/03601270802466934

Herzer, D., Hühne, P., & Nunnenkamp, P. (2014). FDI and Income Inequality-Evidence from Latin American Economies. *Review of Development Economics*, *18*(4), 778–793. https://doi.org/10.1111/rode.12118

Ihm, J., & Hsieh, Y. P. (2015). The implications of information and communication technology use for the social well-being of older adults. *Information Communication and Society*, *18*(10), 1123–1138. https://doi.org/10.1080/1369118X.2015.1019912

Jahanshahi, A. A., Nawaser, K., Khaksar, S. M. S., & Kamalian, A. R. (2011). The relationship between government policy and the growth of entrepreneurship in the micro, small & medium enterprises of India. *Journal of Technology Management and Innovation*, *6*(1), 66–76. https://doi.org/10.4067/S0718-27242011000100007

Jurriëns, E., & Tapsell, R. (2017). Challenges and opportunities of the digital 'revolution' in Indonesia. *Digital Indonesia: Connectivity and Divergence*, *2020*, 275–288. https://doi.org/10.1355/9789814786003-007

Kaulihowa, T., & Adjasi, C. (2018). FDI and income inequality in Africa. *Oxford Development Studies*, *46*(2), 250–265. https://doi.org/10.1080/13600818.2017.1381233

Kentor, J. (2014). *The Long Term Effects of Globalization on Income Inequality, Population Growth, and Economic Development*. *48*(4), 435–455. https://doi.org/10.1525/sp.2001.48.4.435

Khan, N., Ismail, S., Wali, A., Kazim, R., & Azam, T. (2020). The influence of information communication technology development on income inequality. *Artech Journal*, *1*(1, 2020), 11–18. https://www.researchgate.net/publication/348827440

Khurana, S., Haleem, A., & Mannan, B. (2019). Determinants for integration of sustainability with innovation for Indian manufacturing enterprises : Empirical evidence in MSMEs. *Journal of Cleaner Production*, *229*,

374–386. https://doi.org/10.1016/j.jclepro.2019.04.022
Kocsis, D. (2020). Exploring the relationship between IT infrastructure and income inequality through diffusion of innovations theory. *Proceedings of the Annual Hawaii International Conference on System Sciences*, *2020-Janua*, 4493–4502. https://doi.org/10.24251/hicss.2020.549
Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy*, *99*(3), 483–499. https://doi.org/10.1086/261763
Kuznets, S. (1955). Economic Growth and Income Inequality. *American Economic Review*, *99*(2), i–viii. https://doi.org/10.1257/aer.99.2.i
Lee, C. S. (2005). Income inequality, democracy, and public sector size. *American Sociological Review*, *70*(1), 158–181. https://doi.org/10.1177/000312240507000108
Leight, E. H. (2010). *The Relationships Between Inequality , Economic Growth , and Political Control : Explorations Using U . S . State-level Panel Data , 1969 - 2005*. 1969–2005.
Lloyd-Ellis, H. (1999). Endogenous technological change and wage inequality. *American Economic Review*, *89*(1), 47–77. https://doi.org/10.1257/aer.89.1.47
Luo, Y., & Bu, J. (2016). How valuable is information and communication technology? A study of emerging economy enterprises. *Journal of World Business*, *51*(2), 200–211. https://doi.org/10.1016/j.jwb.2015.06.001
Mahutga, M. C., & Bandelj, N. (2008). Foreign investment and income inequality: The natural experiment of Central and Eastern Europe. *International Journal of Comparative Sociology*, *49*(6), 429–454. https://doi.org/10.1177/0020715208097788
Maiti, D., & Awasthi, A. (2020). ICT Exposure and the Level of Wellbeing and Progress: A Cross Country Analysis. In *Social Indicators Research* (Vol. 147, Issue 1). Springer Netherlands. https://doi.org/10.1007/s11205-019-02153-5
Matalqah, M. M., & Warad, T. M. (2017). The Impact of Telecom Infrastructure on the Economic Growth: The Case of Oil-producing and Non-Oil Producing Arab Countries. *International Journal of Economics and Financial Issues*, *7*(3), 423–428. http:%0Awww.econjournals.com
Mendonça, S., Crespo, N., & Simões, N. (2015). Inequality in the network society: An integrated approach to ICT access, basic skills, and complex capabilities. *Telecommunications Policy*, *39*(3–4), 192–207. https://doi.org/10.1016/j.telpol.2014.12.010
Miśkiewicz, R. (2018). *The importance of knowledge transfer on the energy market*. *21*(2), 49–62. https://doi.org/10.24425/122774
Mushtaq, R., & Bruneau, C. (2019). Microfinance, financial inclusion and ICT: Implications for poverty and inequality. *Technology in Society*, *59*(May), 101154. https://doi.org/10.1016/j.techsoc.2019.101154
Njangang, H., Beleck, A., Tadadjeu, S., & Kamguia, B. (2021). Do ICTs drive wealth inequality? Evidence from a dynamic panel analysis. *Telecommunications Policy*, *46*(2), 102246. https://doi.org/10.1016/j.telpol.2021.102246
Noh, Y. H., & Yoo, K. (2008). Internet, inequality and growth. *Journal of Policy Modeling*, *30*(6), 1005–1016. https://doi.org/10.1016/j.jpolmod.2007.06.016
Patria, H., & Erumban, A. (2020). Impact of ICT Adoption on Inequality. *The Journal of Indonesia Sustainable Development Planning*, *1*(2), 125–139. https://doi.org/10.46456/jisdep.v1i2.58
Richmond, K., & Triplett, R. E. (2018). ICT and income inequality: a cross-national perspective. *International Review of Applied Economics*, *32*(2), 195–214. https://doi.org/10.1080/02692171.2017.1338677
Roller, L.-H., & Waverman, L. (2011). Telecommunications Infrastructure and Economic Development: A Simultaneous Approach. *Traditional Telecommunications Networks*, *1*, 293–314. https://doi.org/10.4337/9781781950630.00019
Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, 98(5), S71–S102. https://doi.org/10.3386/w3210
Rosenberg, N. (1972). Factors affecting the diffusion of technology. *Explorations in Economic History*, *10*(1), 3–33. https://doi.org/10.1016/0014-4983(72)90001-0
Salahuddin, M., & Alam, K. (2016). Information and Communication Technology, electricity consumption and economic growth in OECD countries: A panel data analysis. *International Journal of Electrical Power and Energy Systems*, *76*, 185–193. https://doi.org/10.1016/j.ijepes.2015.11.005

SDGs. (2022). *Sustainable Development Report*. https://www.sdgindex.org/

Setyadi, S. (2022). Inequality of Education in Indonesia by Gender, Socioeconomic Background and Government Expenditure. *EKO-REGIONAL: Jurnal Pembangunan Ekonomi Wilayah*, *17*(1), 27–36. https://doi.org/https://doi.org/10.20884/1.erjpe.2022.17.1.2895

Seyadi, S., Indriyani, L., & Tri Resmawati, R. (2022). ESTIMATING THE IMPACT OF SOCIAL AND ECONOMIC FACTORS ON INCOME INEQUALITY IN INDONESIA. *BULETIN STUDI EKONOMI*, *27*(1), 53–63. https://ojs.unud.ac.id/index.php/bse/article/view/81785

Sheldon, P. J. (2004). eTourism: Information Technology for Strategic Tourism Management. *Annals of Tourism Research*, *31*(3), 740–741. https://doi.org/10.1016/j.annals.2004.03.002

Statistics Indonesia. (2020). *Indeks Pembangunan Teknologi Informasi dan Komunikasi*. https://www.bps.go.id/publication/2021/10/06/c17a0162c93579c862278ae6/indeks-pembangunan-teknologi-informasi-dan-komunikasi-2020.html

Tabassum, A., & Majeed, M. T. (2008). Economic growth and income inequality relationship: Role of credit market imperfection. *Pakistan Development Review*, *47*(4), 727–743. https://doi.org/10.30541/v47i4iipp.727-743

Tchamyou, V. S., Erreygers, G., & Cassimon, D. (2019). Inequality, ICT and financial access in Africa. *Technological Forecasting and Social Change*, *139*(August), 169–184. https://doi.org/10.1016/j.techfore.2018.11.004

Tong, D., & Dall'Erba, S. (2008). SPATIAL DISPARITIES IN THE CHINESE ICT SECTOR : A REGIONAL ANALYSIS. *Region et Developpment*.

Verspagen, B. (1993). *Uneven Growth Between Interdependent Economies: A[n] Evolutionary View on Technology Gaps, Trade, and Growth.* Avebury.

Widyanto, H. A., & Haryanto, J. O. (2021). Mapping the E-Business Ecosystem in Indonesia: A Comprehensive Analysis. In M. N. Almunawar, M. A. Ali, & S. A. Lim (Eds.), *Handbook of Research on Innovation and Development of E-Commerce and E-Business in ASEAN* (pp. 159–178). IGI Global. https://doi.org/10.4018/978-1-7998-4984-1.ch009

Xie, B., Watkins, I., Golbeck, J., & Huang, M. (2012). Understanding and Changing Older Adults' Perceptions and Learning of Social Media. *Educational Gerontology*, *38*(4), 282–296. https://doi.org/10.1080/03601277.2010.544580

Yamada, K., Lim, J., Dale, J. H., Chen, H., Shinn, P., Palm, C. J., Southwick, A. M., Wu, H. C., Kim, C., Nguyen, M., Pham, P., Cheuk, R., Karlin-Newmann, G., Liu, S. X., Lam, B., Sakano, H., Wu, T., Yu, G., Miranda, M., … Ecker, J. R. (2003). Empirical Analysis of Transcriptional Activity in the Arabidopsis Genome. *Science*, *302*(5646), 842–846. https://doi.org/10.1126/science.1088305

Zhuang, J., Gunatilake, H., Niimi, Y., Khan, M. E., Jiang, Y., Hasan, R., Khor, N., Lagman-Martin, A. S., Bracey, P., & Huang, B. (2009). Financial sector development, economic growth, and poverty reduction: A literature review. *ADB Economics Working Paper Series*, *173*(173), 1–48. https://doi.org/10.2139/ssrn.1617022

Zulkarnaen, I. (2017). Socio-Political and Economic Determinants of Income Inequality in Indonesia. *Jurnal Perencanaan Pembangunan: The Indonesian Journal of Development Planning*, *1*(3), 224–239. https://doi.org/10.36574/jpp.v1i3.21