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Information and communication technology, inequality change, and regional development in Indonesia

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ABSTRACT

Although the advancement of technology provides numerous opportunities to boost economic growth and development, equal distribution may not be guaranteed. Thus, this study seeks further elaboration as to whether information and communication technology (ICT) development has a role to play in the inequality in Indonesia. Using municipal level data from 2018, the study provides both linear and non-linear models to be estimated using OLS and 2SLS. Major findings include: (i) the availability of basic ICT infrastructure was strongly linked to the reduction of inequality; (ii) the actual ICT use was positively associated with inequality, albeit at a diminishing rate, revealing a non-linear relationship similar to Kuznets' curve; (iii) the ICT skill variable comprising the education level had direct correlation with ICT use instead of inequality, with an additional score on ICT skill being associated with an increase in ICT use; (iv) the relationship between ICT use and inequality differed depending on the level of economic development, with lower-income regions experiencing the inverted U-shaped relationship as in the original Kuznets curve and higher-income regions experiencing the U-shaped curve.

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INTRODUCTION

Inequality has been a center of discourse for decades due to its persistence around the world, regardless the countries' income levels. According to World Inequality Report (2018), inequality has swiftly dominated North America, India, Russia, and China since 1980. As a matter of fact, United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) called Indonesia out on account of its high inequality contribution toward the region between 1990s and 2010s, along with China and India as the most densely populated nations (UNESCAP, 2018). This urgent call was not a trivial matter for it bore damaging effect on economic and society.

Meanwhile, during the past decade, Information and Communication Technologies (ICTs) brought by high-speed Internet has continued to spread at unprecedented speed and scale throughout the world. In line with the trend of global ICT development, the ICT development in Indonesia is also expanding, with internet penetration rate reported to have reached 47.69% or over 126 million internet users as of 2019 (BPS, 2020). With the emergence of technology, it certainly offers a great deal of opportunities to boost economic growth and economic development while equal distribution may not be guaranteed.

Past studies evaluating the effect of ICT development on regional economies have been inconclusive on whether it will further aggravate or alleviate inequality. On the constructive side, technology enables productivity enhancement that allows the economy to accelerate (Czernich et al., 2011; Jahangard & Pourahmadi, 2013) and knowledge sharing that helps society to access basic resources as well as services, thus granting more equal distribution (Sun et al., 2014). On the other hand, it may exacerbate the existing inequality when there is lack of access due to limited infrastructure and capabilities supporting the poor (Vicente & López, 2011).

In the wake of rising internet prominence, researchers have been focusing more on its role within regional dynamics. Taking into account globalization and tax policy, Ningsih & Choi (2018) studied the internet penetration effect on income inequality among Southeast Asian nations and concluded that technological change, represented by the number of internet users, has significantly reduced income inequality. A more recent study by Kocsis (2020) highlighted the user acceptance as a key driver in reducing inequality regarding internet infrastructure. He argued that if one cannot find any reasonable advantage of using internet, it is highly unlikely that he/she will embrace the technology due to lack of knowledge or instruments.

Unlike the previously mentioned research, Kim (2012) scrutinized two kinds of curves depicting how technology-inequality relationship changes with the level of technological development. The first is an inverted U-shaped curve which is based on the role of technology as the engine of growth, whereas the second is a U-shaped curve that is based on theory of innovation by Schumpeterian. The cross-national study supported the second version where inequality initially goes down before rising with technological advancement once it reaches a certain threshold. The U-shaped curve is also found in the works of Gravina & Lanzafame (2019).

In light of such dispute, it is said that Indonesia incorporates a stimulating start-up ecosystem that covers five sectors including e-commerce, online media, online transportation, travel, and digital financial services, leading to a large coming of the digital economy. Yet its penetration rate is considered lower than many of its peers in Asia Pacific, owing to the inadequate ICT infrastructure and uneven digital utilization among its users (McKinsey, 2016). As a result, a deepening internet divide appears across socio-economic groups (Sujarwoto & Tampubolon, 2016).

This study differs from the previous study in the way that it attempts to probe into ICT development as a factor of inequality in Indonesia, instead of the other way around (Sujarwoto & Tampubolon, 2016). Instead of inequality among individuals, the inequality here is defined as how each region differs to one another in terms of the living standards of its residents or other elements like public access to education and health services. The result of this study is expected to equip the government with a better understanding of ICT involvement in shaping regional inequality in the hope of avoiding serious policy implications. Moreover, this empirical study will provide more insight for future studies concerning inequality across regions and ICT development in Indonesia.

RESEARCH METHOD

The study was conducted using municipal level data from 2018, covering all 514 regencies and cities. In terms of inequality, the Gini index was used to represent overall inequality of household expenditure in a district based on the data from National Socio-economic Survey (Susenas) published by Indonesian Central Bureau of Statistics (BPS). The value ranged from 0 to 1, meaning perfect equality and complete inequality, respectively. Gini is considered a good measure because it satisfies the minimum requirements: symmetry, mean independence, population size independence, and Pigou-Dalton transfer sensitivity.

Meanwhile, the ICT development incorporates ICT readiness, ICT use, and ICT skill. The ICT readiness, indicating the availability of ICT infrastructure, was represented by the percentage of villages covered by at least 3G mobile network within a district/city. The information on ICT infrastructure distribution across regencies came from the BPS-published Indonesian Village Potential Census (Podes) 2018. ICT use and ICT skill, on the other hand, are indices composed of several indicators that portray the actual use of the ICTs and the capacity to operate them, respectively.

Through Principal Component Analysis (PCA), several original measures could be reconstructed with few components that summarized the maximum possible and various information to some extent. The ICT use forming variables were the percentage of households with telephone (both fixed and mobile telephone), percentage of households with computer (either fixed in one place or a portable one), percentage of individuals using the internet within the last three months from any location via fixed or mobile network, and percentage of individuals who own mobile cellular phone.

Unfortunately, indicators capturing abilities to operate ICTs are currently unavailable. Hence, the level of education and literacy can be considered as a good proxy especially in developing countries such as Indonesia in which education level can be a major barrier. And with the inclusion of ICT in school curricula, attending school means higher chance for students' exposure to ICTs. Thus, the ICT skill forming variables were average years of schooling, secondary gross enrolment ratio, and tertiary gross enrolment ratio.

As for the control variables, this study included the inter-regional recent migration and trade openness to account for the level of mobile labor, goods, and services in a region since regional economies are considered much more open than national economies due to the minimum barrier to trade including tariff, distance, socio-culture, and legal or political considerations. Other control variables, including log of population, log of population density, and log of GRDP per capita, were added, accounting for social and economic structure of each regions.

To assess the impact of ICT development on inequality thoroughly, the study incorporated several model specifications covering both linear and non-linear specifications. Both were estimated not only with Ordinary Least Squares (OLS) but also Two-Stage Least Squares (2SLS). The latter was particularly employed to deal with endogeneity problem, causing instrumental variables (IV) to come into play. The model specifications are as follows:

(i) Linear Model estimated by OLS

$$Gini_i = \beta_0 + \beta_1 ICT\ Readiness_i + \beta_2 ICT\ Use_i + \beta_3 ICT\ Skill_i + \beta_4 Z_i + u_i \qquad (1)$$

(ii) Non-linear Model estimated by OLS

$$Gini_i = \beta_0 + \beta_1 ICT\ Readiness_i + \beta_2 ICT\ Use_i + \beta_3 ICT\ Use^2{}_i + \beta_4 ICT\ Skill_i + \beta_5 Z_i + u_i \qquad (2)$$

(iii) Linear Model estimated by 2SLS

$$Gini_i = \beta_0 + \beta_1 ICT\ Readiness_i + \beta_2 ICT\ Use_i + \beta_3 Z_i + u_i \qquad (3)$$

$$ICT\ Use_i = \pi_0 + \pi_1 ICT\ Skill_i + \pi_2 Ln\ Pop\ Density_i + \pi_3 Ln\ Pop\ Density^2{}_i + \pi_4 Z_i + v_i \qquad (4)$$

(iv) Non-linear Model estimated by 2SLS

$$Gini_i = \beta_0 + \beta_1 ICT\ Readiness_i + \beta_2 ICT\ Use_i + \beta_3 ICT\ Use^2{}_i + \beta_4 Z_i + u_i \qquad (5)$$

$$ICT\ Use^*{}_i = \pi_0 + \pi_1 ICT\ Skill_i + \pi_2 ICT\ Skill^2{}_i + \pi_3 ICT\ Skill^3{}_i + \pi_4 Ln\ Pop\ Density_i + \pi_5 Ln\ Pop\ Density^3{}_i + \pi_6 Ln\ Pop\ Density^4{}_i + \pi_7 Z_i + v_i \qquad (6)$$

where $Gini$ represents overall inequality of household expenditures; $ICT\ Readiness$ represents the availability of ICT infrastructure and access; $ICT\ Use$ represents the actual use of ICTs; $ICT\ Skill$ represents the capacity to operate ICTs; Z represents control variables used in this study including recent migrant, trade openness, log of population, log of population density, and log of GRDP per capita; u represents the error term; and the subscript i refers to the observed municipalities.

Since the response variable is the Gini index which has a value bound between 0 and 1, the use of common linear regression might result in fitted values that are outside of the lower and upper bounds Ferrari and Cribari-Neto (2004). Consequently, a transformation of the response variable was required, with its values assumed to be on the real line and its mean modelled as a linear predictor based on a set of exogenous variables. This kind of model is called a beta regression model. Thus, a betafit regression established by Ferrari and Cribari-Neto (2004) was applied as a robustness check for models a and b.

There were two equations involved in models c and d: a structural equation and a reduced form equation, respectively. The endogenous variables in these models were $ICT\ Use$ for linear relation and $ICT\ Use^*$ for non-linear relation. The latter comprised the $ICT\ Use$ and $ICT\ Use^2$. Simultaneously, the instrumental variables employed for the linear model were $ICT\ Skill$, natural log of population density ($Ln\ Pop\ Density$) and its squared term. And, naturally the non-linear model has more instrumental variables, consisting of $ICT\ Skill$, $ICT\ Skill$ squared and cubed, as well as $Ln\ Pop\ Density$, its cubed term and to the fourth power.

To be able to deliver unbiased estimation, it is essential that an IV designed for an endogenous variable satisfy the following pre-requisites: it should not have any correlation with the residual and must be relevant or correlated with the instrumented variable. According to International Telecommunication Union (ITU), the level of ICT use is mainly supported by ICT skills or capacities since knowledge and expertise related to ICT are considered necessary for maximum utilization. Additionally, for population density, as one would expect, the reason behind the high level of ICT use in a region is partially due to the high volume of people within a region. Consequently, this study argues that both ICT skill and population density may serve as IVs for ICT use. Meanwhile, adding IVs of some squares and additional terms such as the cubed term and to the fourth power of the exogenous variables is considered as general approach in the face of non-linear model estimation (Wooldridge 2010).

RESULT AND DISCUSSION

The ICT Development in Indonesia

Each region of Indonesia has a different level of ICT development, leading to the so-called digital divide. In relation to ICT readiness, the infrastructure delivering network service was still unavailable in many regions, especially those outside Java and Bali. This shortfall was particularly apparent to the Papua region since there were 90% of regencies and cities whose villages were covered by lower-than 50% mobile network (Figure 1). With the limited access to the infrastructure, the actual use of ICT in those areas was bound to be lower in comparison to municipalities in Java and Bali. The percentage of individuals accessing internet were barely over 50% in the majority of regions outside Java and Bali (Figure 2). In addition, the low use of ICT could be attributed in part to the municipality's low educational level. Considering the average years of school and gross enrolment of both secondary and tertiary school, Figure 3 suggests that only few regions enjoyed high level of education by scoring higher ICT skill index than their peers. The gap was remarkably large as the high-rank regencies scored three up to four times higher than those in the low-rank regencies.

Meanwhile, the inequality as determined by Gini index was relatively similar across Indonesia in 2018 (Figure 4). Even so regions in Java, Bali, Sulawesi and Papua appeared to have, on average, higher inequality than their peers in Sumatera, Nusa Tenggara, Maluku, and Kalimantan. In fact, provinces with highest proportions of regencies or municipalities whose Gini index more than that of National were Papua Barat, Yogyakarta, and Jakarta. With this revelation, the correlation of ICT development toward inequality in Indonesia needs to be assessed further since regencies and cities in Java, Bali, Sulawesi and Papua region scored higher inequality than their peers in other regions, even though the two previously mentioned regions (Java and Bali) had greater access to ICT infrastructure and use of ICTs while the latter two (Sulawesi and Papua) had limited access to ICT infrastructure.

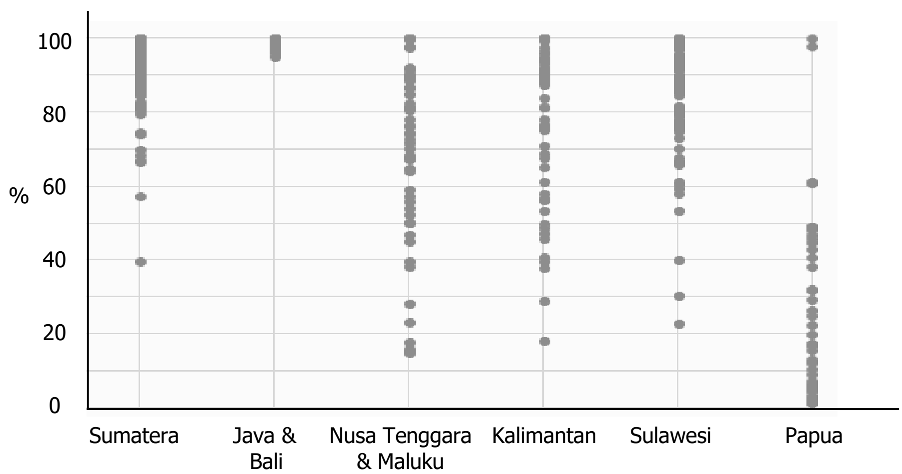

Figure 1. The percentage of villages covered by at least 3G mobile network within municipalities in 2018

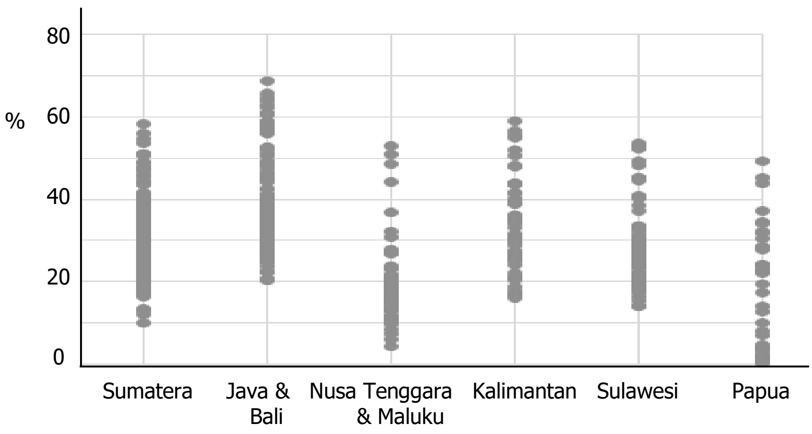

Figure 2. The percentage of individuals using internet within municipalities in 2018

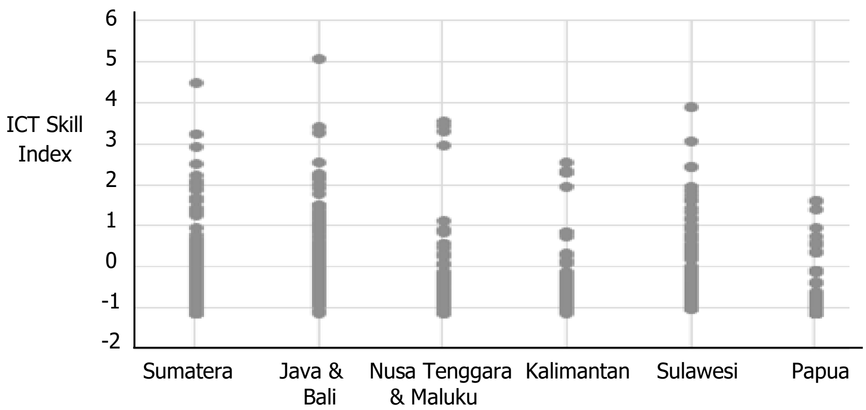

Figure 3. ICT skills across regions Indonesia in 2018

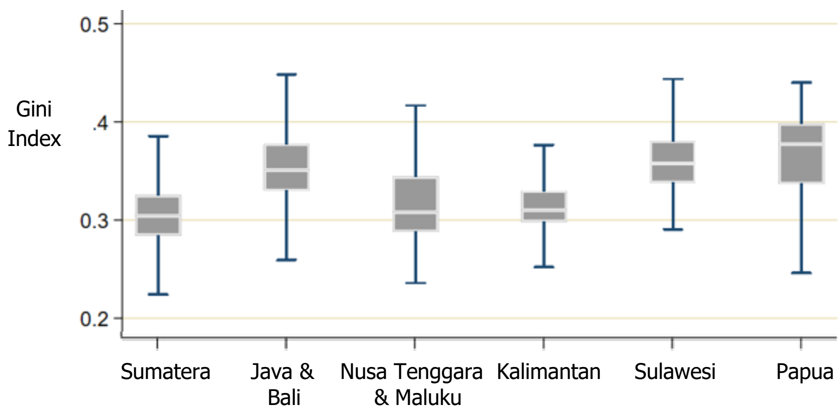

Figure 4. Inequality across regions in Indonesia in 2018

Table 1. Variable Estimate Affecting on Indonesia's Inequality

Variable	Gini (Linear OLS estimation)	Gini (Non-linear OLS estimation)	Gini (Linear 2SLS estimation)	Gini (Non-linear 2SLS estimation)
ICT Readiness	-0.0595***	-0.0805***	-0.0689***	-0.117***
	(0.0108)	(0.0135)	(0.0111)	(0.0214)
ICT Use	0.0181***	0.0187***	0.0304***	0.0469***
	(0.0043)	(0.0043)	(0.0038)	(0.0072)
ICT Use Squared		-0.00439**		-0.00854***
		(0.0017)		(0.0033)
ICT Skill	0.00226	0.00374		
	(0.0026)	(0.0027)		
Recent Migrant	0.221***	0.241***	0.153*	0.114
	(0.0794)	(0.0794)	(0.0811)	(0.0847)
Trade Openness	-0.0124***	-0.0118***	-0.0132***	-0.0132***
	(0.0032)	(0.0032)	(0.0032)	(0.0033)
Ln Population	0.00518**	0.00506**	0.00441*	0.00409*
	(0.0024)	(0.0024)	(0.0024)	(0.0025)
Ln Population Density	0.00242	0.00457**		
	(0.0018)	(0.0019)		
Ln GRDP per capita	-0.00806**	-0.00810**	-0.0154***	-0.0245***
	(0.0038)	(0.0038)	(0.0039)	(0.0052)
Constant	0.374***	0.384***	0.492***	0.647***
	(0.0573)	(0.0571)	(0.0623)	(0.0857)
Observations	514	514	514	514
R-squared	0.199	0.209	0.185	0.132

***, **, and * denote significant level 0.01, 0.05, 0.1
Numbers in parentheses are standard errors

ICT Development and Inequality

The empirical results of ICT development on Indonesia's inequality are presented in Table 1. According to the results, each model is fairly equivalent by comparison of R-squared values. And based on the heteroskedasticity test, each model is efficient under homoskedasticity, suggesting that the value of explanatory variables has no information containing the variance of the unobservable.

Concerning ICT readiness, it can be argued that it does have a role in alleviating the inequality since the coefficient sign was negative and statistically significant. By having coefficient value ranging from 0.06 to 0.12, it means that every one percent increase in the percentage of villages covered by at least 3G mobile network within a district/city contributed to the drop of inequality by 0.06 up to 0.12. In this case the lack of access towards vital resource such as ICT infrastructure can be a barrier in technology diffusion, which facilitates the transfer of information and, as a result, reduces socioeconomic disparities between regions (Celbis & Combrugghe, 2014).

Conversely, ICT use appears to exacerbate the inequality since the result was significant and positive towards inequality. However, its correlation comes across as nonlinear as the squared form of ICT use index was significantly associated with the inequality as well. Considering that the squared term of ICT use had a negative relation with inequality and coefficient value less than that of the ICT use, it can be inferred that the effect of ICT use on inequality was non-constant as the additional use of ICTs may initially worsen the inequality before gradually rectifying it.

A robustness test was performed using betafit regression, and the marginal effects of ICT variables on Gini (Table 2) confirmed that the relationship between the use of ICT and inequality was indeed non-linear, with the inverted U-shaped curve. This relationship is an extension of Kuznets curve in which technology becomes the key driver of economic growth. As economy grows, so does inequality. Naturally, those successfully embracing technology and taking part in the growth are the main beneficiary, leaving behind others and widening the wealth gap. As emerging innovations become more widely adopted, the initial benefit will fade, resulting in a narrowing of the income gap (Barro, 1999). Thus, it is completely unsurprising to find an inverted curve as in the Kuznets curve in this study.

As for ICT skill, instead of having direct and significant correlation with inequality, it became a satisfactory IV for the third and fourth model specifications along with log of population density. Based on the first regression of 2SLS (Table 3), it had significant and positive correlation with ICT use, whereas its squared and cubic forms had significant relation towards the squared form of ICT use. With the coefficient value of 0.3, it can be argued that one additional point in ICT skill induced the increase of ICT use by 0.3. This finding is in line with the notion that one should have basic knowledge on technology and discover the fringe benefit of utilizing it before fully adopting the technology (Kocsis, 2020).

In addition, several tests concerning the relevance of IV were also performed in the first regression of 2SLS (Table 2). The under-identification test showed the p-value where the rejection of null hypothesis indicates that the model was identified. Whereas, the weak instrument identification test applied proved that IVs were sufficiently strong as the Cragg-Donald Wald F statistics shown were higher than 10 (Baum et al., 2003). Finally, the p-value displayed in over-identifying restriction test reflected the acceptance of null hypothesis, revealing that the instruments used were valid as they were uncorrelated with the error term, and that the IVs were correctly excluded from the estimated equation.

Table 2. Marginal Effects of ICT Variables on Inequality

Variable	Gini (Linear)	Gini (Non-Linear)
ICT Readiness	-0.058***	-0.081***
	(0.011)	(0.013)
ICT Use	0.018***	0.019***
	(0.004)	(0.004)
ICT Use Squared		-0.005***
		(0.002)
ICT Skill	0.002	0.004
	(0.003)	(0.003)
Recent Migrant	0.215***	0.235***
	(0.079)	(0.079)
Trade Openness	-0.013***	-0.012***
	(0.003)	(0.003)
Ln Population	0.005**	0.005**
	(0.002)	(0.002)
Ln Population Density	0.002	0.004**
	(0.002)	(0.002)
Ln GRDP per capita	-0.008**	-0.008**
	(0.004)	(0.004)

***, **, and * denote significant level 0.01, 0.05, 0.1
Numbers in parentheses are standard errors

Table 3. Variable Estimate Affecting IT Use

Variable	Linear 2SLS Estimation	Non-linear 2SLS Estimation	Non-linear 2SLS Estimation (ICT Use^2)
ICT Skill	0.288***	0.307***	-0.0125
	(0.0224)	(0.0303)	(0.0683)
ICT Skill^2		0.0174	0.429***
		(0.0275)	(0.0620)
ICT Skill^3		-0.00783	-0.0603***
		(0.00631)	(0.0142)
Ln Population Density	-0.262***	-0.227***	0.625***
	(0.0569)	(0.0593)	(0.134)
Ln Population Density^2	0.0390***		
	(0.00465)		
Ln Population Density^3		0.00779***	-0.0226***
		(0.00173)	(0.00390)
Ln Population Density^4		-0.000448***	0.00239***
		(0.000142)	(0.000321)
ICT Readiness	1.194***	1.240***	-3.294***
	(0.121)	(0.122)	(0.274)
Recent Migrant	3.538***	3.549***	2.485
	(0.751)	(0.753)	(1.699)
Trade Openness	0.0835***	0.0822***	0.194***
	(0.0309)	(0.0307)	(0.0693)
Ln Population	0.0329	0.0334	0.0151
	(0.0233)	(0.0233)	(0.0525)
Ln GRDP per capita	0.463***	0.459***	-0.164**
	(0.0316)	(0.0318)	(0.0717)
Constant	-6.727***	-6.641***	2.352**
	(0.479)	(0.483)	(1.089)
Observations	514	514	514
Under identification	0.000	0.000	0.000
Weak identification	251.97	24.40	24.21
Over identification	0.103	0.2135	

Table 4. Variable Estimate Affecting Inequality across Groups of Municipalities in Indonesia

Variable	Gini (OLS)	Gini (2SLS)
ICT Readiness	-0.0865***	-0.113***
	(0.0133)	(0.0230)
ICT Use	0.0258***	0.0541***
	(0.0046)	(0.0072)
ICT Use Squared	-0.0064***	-0.0084
	(0.0023)	(0.0056)
Above-median Group	-0.0090*	
	(0.0054)	
Above-median Group*ICT Use	-0.0235***	-0.0329***
	(0.0050)	(0.0059)
Above-median Group*ICT Use Squared	0.0112***	0.0124**
	(0.0031)	(0.0051)
ICT Skill	0.0032	
	(0.0027)	
Recent Migrant	0.2490***	0.1410*
	(0.0779)	(0.0826)
Trade Openness	-0.0113***	-0.0125***
	(0.0031)	(0.0033)
Ln Population	0.0045*	0.0045*
	(0.0024)	(0.0024)
Ln Population Density	0.0051***	
	(0.0020)	
Ln GRDP per Capita	-0.0077	-0.0273***
	(0.0047)	(0.0064)
Constant	0.3920***	0.6650***
	(0.0611)	(0.0960)
Observations	514	514
R-squared	0.250	0.176

***, **, and * denote significant level 0.01, 0.05, 0.1
Numbers in parentheses are standard errors

With the confirmation of the nonlinear relation of ICT use on inequality, its margin was assessed in search of variations in the role of ICT use among different levels of economic development. Thus, instead of categorizing based on the spatial arrangement, it focused on the comparison between regions with GRDP per capita above the median value and those below-median value. Based on the regression results (Table 4), both OLS and 2SLS estimations confirmed the defiance of the above median group which belonged to the higher-income regions. The ICT use interactions with the group exhibit a U-shaped curve, with the inequality initially decreasing with additional use of ICT but gradually increasing after reaching a turning point.

Simultaneously, the predictive margins and average marginal effects of ICT use across the groups were calculated to provide a more vivid picture of the differences between the higher-income and lower-income groups. Figures 5 and 6 show the different associations between the use of ICT and inequality within the two groups. The low-income saw the inverted U-shaped curve in which inequality increase with the additional use of ICTs before making a downturn at the higher end of it. On the contrary, the higher-income regions experienced the U-shaped curve as inequality slightly declined with the increasing use of ICTs only to rebound and score even higher inequality.

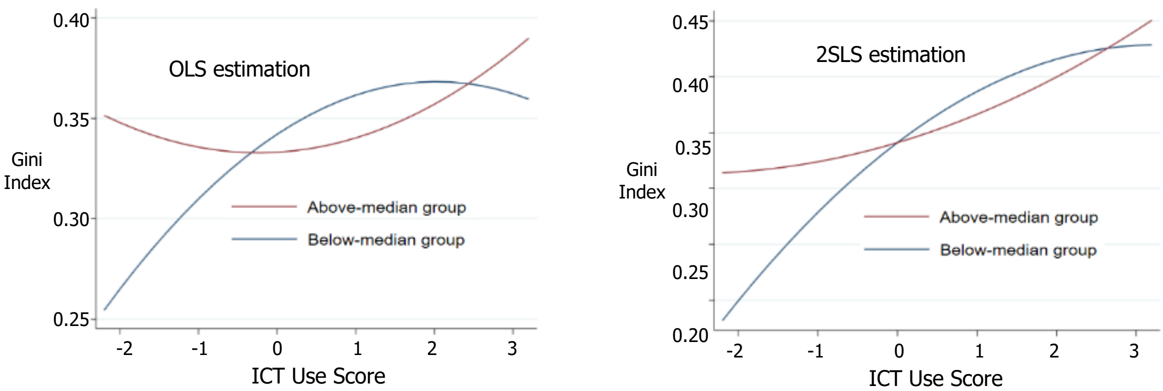

Figure 5. Predictive margins of ICT use on inequality across groups of municipalities

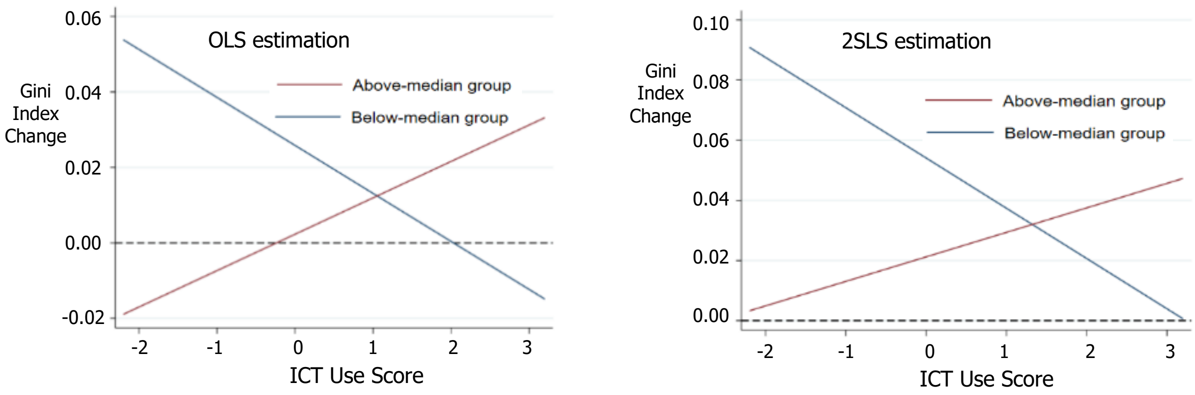

Figure 6. Average marginal effects of ICT use on inequality across groups of municipalities

How this polarization is closely related to the development stage of each region is further explained as follows. First, in the lower level of economic development, the additional use of ICT promotes not only economic growth but also inequality in the region as the economy shifts, from a struggling and less technologically advanced sector such as agriculture to a thriving and more technologically advanced sector such as industries. Those moving to a more advanced sector are benefited from the higher income, resulting in the widening income gap. Eventually, the inequality caused by sectoral mobility decreases as the transition is completed.

Second, for the higher-level economic development, the nature of innovation constitutes the developmental phases. In the early phase, the role of ICTs is as an equalizer because brand new products and processes are developed in result of numerous innovative initiatives by new entrepreneurs, causing barriers induced by the former innovation to be lowered or even wiped out. Albeit this 'creative destruction' known as Schumpeterian innovation Mark I, the later phase, known as Schumpeterian innovation Mark II, shows a strong tendency toward "creative accumulation," in which only few large firms having a significant amount of physical or human capital drive the technology innovation, thus setting high barriers for new entry and causing inequality to soar.

Research Implication

Given that today's world is closely interrelated through ICTs, assessing the impact of ICT development on inequality in Indonesia has a number of critical implications for policymakers. First, as ICT readiness turns out to have strong and negative association with inequality, ensuring the availability and access to ICT infrastructure is essential in reducing inequality. However, there has been unequal distribution of telecommunications services such as electricity, landline networks, internet cafés, mobile phone signal networks, and base transceiver stations (BTS) across regencies in Indonesia (Sujarwoto & Tampubolon, 2016). This unequal access to ICT infrastructure leads to unequal economic opportunities. As confirmed by Untari et al. (2019), there is a positive association between ICT infrastructure and economic growth in Indonesia which in turn lowering the level of inequality. Besides, the advancement of technology has a positive impact on overall socioeconomic development (Wang et al., 2021). Hence, providing basic ICT infrastructure and network at a minimum throughout the archipelago is indispensable, particularly towards regions outside Java and Bali. All the more since the internet has become ever more prominent during the COVID-19 pandemic and digital transformation is set as one of the key objectives in the Medium-Term National Development Plan (RPJMN) 2020-2024.

Second, promoting digital inclusiveness should be the next primary agenda because the inequality induced by the use of ICT is in part due to only a fraction of the society benefiting from it, leaving behind others who have not adopted ICTs. According to Patria and Erumban (2020), a certain adoption rate should be obtained for ICT use to have a positive impact on the level of inequality. Although the inverted U-shaped curve indicates that the increasing effect of ICT use on inequality is only temporary, it is critical to ensure that no one is left behind once the digital transformation occurs, because leaving the digital divide unattended can result in unbalanced socioeconomic development (Wang et al., 2021). Furthermore, the availability of ICT infrastructure and network does not automatically lead to full ICT adoption due to various factors such as technology resistance and low digital literacy. Thus, it requires strategic and far-reaching policies able to embrace all segments within society especially the poor and disadvantages.

As previously stated, resistance to technology and a lack of digital literacy are barriers to ICT adoption, implying that user acceptance is the most important factor in embracing the technology (Kocsis, 2020). This user acceptance is heavily reliant on having a basic understanding of technology as well as the benefits of using it, both of which can be gained through education. Following the findings of this study, it was revealed that there is a strong and positive relationship between educational attainment and the use of ICTs, rather than a direct correlation with inequality. Not only will education help to bridge the digital divide (Sujarwoto & Tampubolon, 2016; Wang et al., 2021), but it will also improve access to and skilled use of ICT, which in turn reducing the inequality through activities that generate income and provide benefits to consumers (Mushtaq & Bruneau, 2019). For that reason, improving education should be an integral part of any digital inclusion strategy.

Even though the educational level may not have direct correlation to the inequality, but the level of inequality can impose pitfall in reaching equal opportunity for education (Asongu et al., 2019). Therefore, the government’s redistributive policies and spending such as cash transfer, subsidies, and other forms of social assistance, are extremely vital for relieving the inequality caused by ICTs. However, because the ramifications of ICT-induced inequality differ depending on the level of development of each region, the redistributive policies should be designed specifically based on each region's stage of development. For regions with the inverted U-shaped curve, the policies should be directed to overcome the possible digital divide once ICTs become the driver of the economic growth. As for regions facing the U-shaped curve, the policies should be designed to prevent any conditions that may impair the fair competition in the new more-technology-advanced sector by reducing the entry barrier or enforcing rules and regulation. Such personalized policies can be provided by each regional government with the support of the central government, indicating the importance of institutional development to alleviate the ICT-induced inequality (Adams & Akobeng, 2021).

CONCLUSION AND SUGGESTION

By utilizing the municipal level data covering all of 514 regencies and cities, this study attempts to look into the role of ICT development on inequality in Indonesia. The ICT development includes the availability of basic ICT infrastructure, the use of ICTs, and the capacity to operate it. Given the data limitation, data from 2018 was used, resulting in a cross-sectional study. The study provides both linear and non-linear models to be estimated using OLS and 2SLS, aiming for a thorough assessment.

The major findings of this study include the following matters. First, the accessibility on basic ICT infrastructure has a role in alleviating inequality, contributing to its drop up to 0.12. However, the actual use of ICTs has a non-linear relationship with inequality; at a lower level of ICT use, it gives rise to inequality before the pace of the increase slows down at a higher level of this variable, revealing a pattern similar to the Kuznets curve. Second, the ICT skill variable comprising the education level appears to have direct correlation with ICT use instead of inequality, in which an additional score on ICT skill will induce the increase of ICT use by 0.3, confirming that basic knowledge is a prerequisite for engaging in ICTs. Finally, the association between ICT use and inequality varied across economic development levels, in which lower-income regions exhibit the inverted U-shaped curve as in the original Kuznets’ curve whereas higher-income regions are subjected to the U-shaped curve, further revealing the contrasting role of ICTs on inequality across regions in Indonesia.

As the world today is closely interconnected with ICT, analyzing the role of ICT development on inequality in Indonesia has several critical impacts on policymakers. First, providing a minimum level of fundamental ICT infrastructure and network across the archipelago, especially to regions outside Java and Bali, is essential. The next primary agenda should be to promote digital inclusion through strategic policies, which can encompass all the sectors of society, particularly the poor and the disadvantages. Educational improvement should be an integral part of any digital inclusion strategy. Last, the government's redistributive policies and spending are extremely vital for relieving the inequality caused by ICT. However, it should be designed specifically in accordance with the developmental stage of each region since the ramifications of inequality induced by ICT differ from each region in relation to its level of development.

To expand the current study, one might want to conduct a longitudinal study or a panel study as it allows to study changes or developments in the characteristics of the targeted population over period of time. Apart from that, the inequality applied in this study is limited to inequality within region rendering regions as separate entities. It is highly recommended that the future study takes into account the spatial effect, enabling one to assess the technological interdependence towards inter-regional inequality and further probe into the existent of regional convergence.

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