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Does ICT Favor Vulnerable Group? Evidence from Poverty and Inequality Alleviation in Eastern Indonesia

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Abstract

The advancement of information technology has resulted in various economic effects. This study examines how access to Information and Communication Technology (ICT) influences poverty and income inequality in Eastern Indonesia, using panel data from 12 provinces between 2014 and 2024. To address potential endogeneity issues like reverse causality and omitted variable bias, the research utilizes Instrumental Variables (2SLS) models for estimation. The findings indicate that while there is a negative correlation between increased internet access and poverty levels, this relationship loses its causal significance once endogeneity is considered. Conversely, ICT consistently shows a negative and significant impact on income inequality, particularly evident in the model. This suggests that ICT is more effective in addressing inequality than in directly reducing poverty. Furthermore, structural factors such as unemployment, electrification, and GRDP per capita play a significant role in shaping the economic welfare dynamics in Eastern Indonesia. The study highlights that digital development can only be inclusive when supported by equitable infrastructure and high-quality human resources.

Keyword: ICT, Poverty, Inequality, Eastern Indonesia, Economic.

1. Introduction

Poverty remains a significant challenge in economic development, ideally tackled through growth that benefits the poor. Poverty is defined as a deprivation of well-being [1], while the United Nations prioritizes its eradication in the Millennium Development Goals and as the foremost pillar of the Sustainable Development Goals, aiming to end poverty in all its forms everywhere. Over time, enduring poverty can obstruct sustainable development, highlighting the need for more focused policy measures.

Initial scholarly works underscored the role of economic growth as the key factor in poverty alleviation, yet empirical research reveals that its impact is significantly shaped by income distribution patterns. Ravallion argues that growth can effectively reduce poverty only when its advantages are equitably shared and when initial inequality is low [2] [3]. Critique from Amartya Sen aligns with this by asserting that development should be perceived not just as a rise in income but as a broadening of capabilities.

This insight is supported by Wan. et. al findings, which demonstrate considerable cross-country differences in how poverty levels react to growth. In the study of inequality [4], Kuznets inverted-U hypothesis is increasingly seen as less universally applicable in the current economic landscape. Recent evidence shows that developing countries frequently experience high growth rates alongside increasing inequality, driven by globalization and structural changes that favor wealthier groups [3] [4] [5] [6] [7] [8] [9]. This highlights that inequality is not merely a function of development stages but is also heavily influenced by redistributive policies, labor market conditions, and the quality of national institutions.

Research on Information and Communication Technology (ICT) indicates that its effects vary across nations. A study discovered that ICT development has a more pronounced impact on economic growth in developing and emerging countries compared to developed ones [10]. This finding aligns who attributed the disparity to limited technological absorption capacity and opportunities for leapfrogging through technological spillovers [11]. Studies on ICT and poverty propose two potential outcomes: ICT can foster growth that benefits the poor, yet it may also exacerbate social inequality in developing nations [8] [12] [13]. In Indonesia, study on this field indicates that ICT significantly alleviates poverty, though regional estimates might be skewed due to overlooking endogeneity and reverse causality [14] [15]. This study specifically examines the impact of ICT on poverty and inequality in Eastern Indonesia, taking into account inter-regional differences.

The poverty rate in eastern Indonesia experienced a decline from 2014 to 2024. Initially, the poverty rate was in the range of 15.8%–16.3%, reflecting the still relatively vulnerable socioeconomic conditions, particularly in Eastern Indonesia. However, after 2017, the decline appears to have stabilized, although there was a slight increase in 2020 due to the impact of the pandemic. Overall, this trend indicates that various policy interventions have had a positive effect in reducing the average poverty rate across provinces. In 2024, poverty reached its lowest point at 12.72%, indicating a significant increase in welfare over the past decade. However, this figure is an aggregate

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average, so it is possible that there are disparities between regions, for example, Papua and NTT are still far above the national average. Next Average Headcount Index for Eastern Indonesia 2014-2025 on Figure 1.

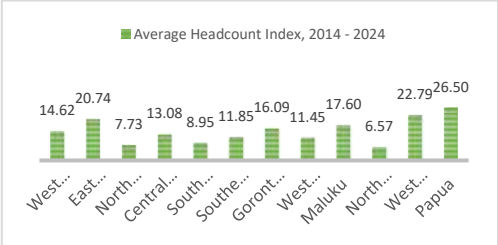

Figure 1. Average Headcount Index for Eastern Indonesia 2014-2025

The headcount index for the period 2014–2024 highlights a pronounced poverty disparity in Eastern Indonesia, with Papua and West Papua showing the highest poverty rates at about 26.50 percent and 22.79 percent, respectively. This aligns with previous studies that attribute such structural underdevelopment to insufficient infrastructure, geographical obstacles, and subpar basic services [8] [10] [11] [13]. In contrast, provinces such as North Maluku (6.57 percent), North Sulawesi (7.73 percent), and South Sulawesi (8.95 percent) report lower average poverty rates, likely due to economic diversification, vibrant trade and service sectors, and enhanced regional connectivity. This variation illustrates that poverty in Eastern Indonesia is highly varied and influenced by the geographic characteristics, fiscal capacity, and sectoral dynamics of each region.

On ther hand, the literature underscores the role of ICT as a key factor in reducing poverty [8] [13] [16] Cross-country indicates that ICT promotes economic growth, reduces inequality, and provides pathways out of poverty by expanding access to information, improving digital infrastructure, and offering skills development opportunities [8] [10] [17]. Niebel also noted that the impact of ICT varies across emerging, developing, and developed countries [10], while other found that internet penetration is advantageous for the poor as it significantly decreases the likelihood of households falling into poverty [18]. The discussion surrounding ICT's effects in developing countries reveals both inclusive and exclusive patterns: while some research points to the potential for increased inequality and unemployment, more recent studies indicate that digitalization, particularly in the financial sector, enhances inclusion and accelerates development [19] [20] [21].

The pathways of technological influence operate directly through increased productivity, investment, and financial deepening, and indirectly through access to education, information, health, financial way and other services [22] [23]. Evidence from Sub-Saharan Africa shows that tech hubs, mobile penetration, and internet usage can expand financial inclusion and reduce poverty [24] while Indonesia is experiencing similar dynamics through the expansion of fintech and the digitization of public services. Although numerous studies link ICT to economic growth [10] [25] [26] [27] [28], studies on its impact on the sharing economy and welfare distribution are still limited. Consistent with Cho et. al. [23], the literature emphasizes that technology analysis needs to consider the equity dimension for digital transformation to contribute to inclusive and sustainable growth. Next Poverty Level in Eastern Indonesia and Internet Access on Figure 2.

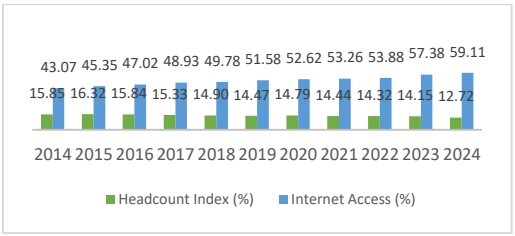

Figure 2. Poverty Level in Eastern Indonesia and Internet Access

The Indonesian government is actively pursuing poverty alleviation by expanding ICT infrastructure, which involves constructing the Palapa Ring and BTS in less developed regions, and leveraging digital financial technology to distribute social assistance programs such as the Family Hope Program (PKH), the Non-Cash Food Security Program (BPNT), the Pre-Employment Card Program (Kartu Prakerja), and the Smart Indonesia Program. Nonetheless, research highlights that the benefits of the internet are not evenly distributed. Some studies indicate that digital access can exacerbate inequalities when its benefits are more readily available to wealthier groups. Study by Chen and Yuan [29] [30] observed that households in the highest income quintile in rural China experienced greater economic gains from the internet, while Tsai noted that new digital job opportunities, like those for slash workers, have widened wage disparities between regions [20].

In Indonesia, the growth in ICT as a measure of internet access coincided with a decrease in income inequality from 2014 to 2024, yet the causal relationship remains ambiguous. Further investigation is required, particularly as Eastern Indonesia continues to face a significant digital divide. In provinces such as Papua, East Nusa Tenggara (NTT), and Maluku limited infrastructure, digital literacy, and access to devices impede the internet's potential as a catalyst for economic development and may worsen inequality [31]. This issue is particularly pressing as these regions also exhibit the highest levels of poverty and inequality in the nation. Next Internet access and inequality in Eastern Indonesia on Figure 3.

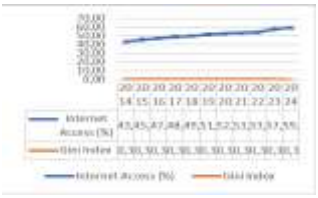

Figure 3. Internet access and inequality in Eastern Indonesia

In contrast, the national movement towards

digitalization has resulted in a notable increase in internet penetration over the past decade. Despite this, there is a lack of empirical research to assess whether this growth in internet access has led to fair benefits, especially for provinces in eastern Indonesia, which have distinct geographic and structural features. Moreover, most existing studies either focus on individual households or take a national approach, thus failing to account for the variations between provinces. As a result, the link between internet usage, poverty, and inequality in Eastern Indonesia remains uncertain. The issue of endogeneity between information technology developments. This research aims to fill this gap by exploring the impact of ICT development and economic growth, particularly in relation to efforts to alleviate poverty and inequality in Eastern Indonesia.

2. Research Method

This study draws on secondary data from a range of institutions, employing panel data to investigate 12 provinces in Indonesia from 2014 to 2024. The provinces were selected based on Presidential Regulation No. 2/2015, which is related to the 2015–2019 National Medium-Term Development Plan (RPJMN) and designates these provinces as part of the Eastern Indonesia region. The provinces included in the analysis are West Nusa Tenggara (NTB), East Nusa Tenggara (NTT), South Sulawesi, Central Sulawesi, Southeast Sulawesi, North Sulawesi, Gorontalo, West Sulawesi, Maluku, North Maluku, Papua, and West Papua. With a sample size of 132 observations, the research enables a comparative examination of the effects of development on poverty and inequality in the region. This study compares the impact of ICT development and economic factors in eastern Indonesia. The estimation model, which (1) the effect of ICT on poverty and (2) the effect of ICT on inequality in eastern Indonesia, is as follows: $POV, Inequality_{i,t} = \alpha_0 + \alpha_1 ICT_{i,t} + +\theta X' + \varepsilon_{i,t}$. (1).

α_0 = intercept; $\alpha_{1,2,3}$= regression model parameters. POV = poverty level in each province in the Eastern Indonesia Region in region i and year t based on headcount index calculations; Inequality = Gini index in each province in the Eastern Indonesia Region in region i and year t; ICT= Internet penetration indicators show the proportion of the population aged +25 years who accessed the internet in the last 3 months; $\theta X'$= Other control variables include average length of schooling, electricity, unemployment rate, GRDP per capita, and economic growth. $\varepsilon_{i,t}$ = error term of province i in year t; In panel analysis, a significant obstacle is endogeneity, which arises when explanatory variables are linked with errors due to omitted factors or reverse causality, such as the reciprocal relationship between poverty and inequality, causing bias in OLS, Fixed Effect, and Random Effect estimates. This research addresses the problem by employing the Instrumental Variables (IV) approach, which separates exogenous variation from endogenous variables through the use of appropriate instruments that are uncorrelated with error terms. By meeting these two requirements, the IV approach can reduce bias from omitted variables and resolve reverse causality, resulting in more dependable and precise causal estimates to clarify the connection between poverty, inequality, and technological development [6] [17] [19] [32] [33] [34] [35].

3. Result and Discussion

This research examines how information and communication technology (ICT) affects poverty and inequality in Eastern Indonesia, a region marked by significant diversity in internet access, mobile phone usage, and digital infrastructure. The descriptive statistics reveal notable differences among provinces: the average poverty rate stands at 14.83 percent, ranging from 6.03 to 28.40 percent, while income inequality, indicated by the Gini index, averages 0.366, with a span of 0.278 to 0.459. The main variable, ICT access, averages 51.09 percent, with a range of 37.91 to 63.94 percent. Meanwhile, the research tools, mobile phone ownership and internet expenditure, have average values of 55.79 percent and 15.29 (log), respectively, indicating the extent of internet penetration and the intensity of internet usage. Next Descriptive Statistics on Table 1.

Table 1. Descriptive Statistics

Variables	Mean	Std. Dev	Min	Max	Unit
Poverty rate	14.83	6.08	6.1	28.4	%
Gini index	0.37	0.04	0.3	0.46	Index
ICT access	51.09	6.08	37.9	63.94	%
Years of schooling	8.71	0.98	6.2	10.7	Year
Unemployment	4.58	1.71	2.1	10.51	%
Electricity	92.4	10.99	43.1	99.98	%
Percapita GDRP	10.6	0.48	9.5	11.88	Log IDR
Economic growth	11.01	5.77	-15.7	6.64	%
Mobile phone ownership	55.77	10.25	27.3	71.95	%

Control variables offer insights into important socio-economic factors. The average schooling duration is 8.71 years, the unemployment rate is 4.58 percent, and household electrification is impressively high at 92.38 percent. Regional economic indicators display notable disparities, with per capita GRDP (log) ranging from 9.52 to 11.79 percent, and economic growth averaging 11 percent, marked by significant volatility. This diversity offers a strong empirical basis for utilizing an instrumental variables approach to examine the influence of ICT on poverty and inequality in Eastern Indonesia.

The Hausman test conducted on the poverty model produced a chi-square statistic of 39.12, leading to the rejection of the null hypothesis that the differences in coefficients between Fixed Effects (FE) and Random Effects (RE) are random. This result underscores the inconsistency of the RE model, attributed to the correlation between ICT and unobserved provincial characteristics (unobserved heterogeneity). Consequently, the FE model emerges as the most

appropriate framework for analyzing poverty, consistent with the methodological guidance that suggests employing FE when there is a correlation with regional fixed effects. From an econometric standpoint, these findings also imply that ICT is endogenous to inequality, necessitating the use of an Instrumental Variables approach to derive an unbiased estimator.

To address endogeneity, this study uses an FE-based Two-Stage Least Squares (2SLS) approach. In the first stage, ICT was regressed against the proposed instrument, namely the percentage of the population owning mobile phones, which is theoretically relevant as a prerequisite for internet adoption. The first-stage FE estimation showed that mobile phones have a positive and significant effect on ICT, with a coefficient of 0.530 ($t = 6.16$; $p < 0.01$), indicating that a 1 percent increase in mobile phone ownership correlates with an approximately 0.53 percent increase in internet usage after controlling for socioeconomic characteristics and province fixed effects. The instrument's relevance was reinforced by the results of the weak IV test, where the F-value of 37.96 exceeded the minimum standard of $F > 10$ recommended [36]. Therefore, the mobile phone instrument can be categorized as very strong and suitable for use in identifying the causal influence of ICT in the 2SLS model. Next Result of ICT on Poverty on Table 2.

Table 2. Result of ICT on Poverty

Variables	(1) FE	(2) RE	(3) 2SLS
ICT access	-0.025	-0.598	-0.393
	(0.024)	(0.092)	(0.308)
Years of schooling	-2.216***	-1.632**	0.541
	(0.260)	(0.783)	(1.540)
Unemployment	0.294***	0.830***	0.297**
	(0.078)	(0.307)	(0.457)
Electricity	-0.011	-0.337***	-0.467***
	(0.015)	(0.054)	(0.096)
Log percapita GDRP	0.039	0.155	2.696
	(0.286)	(1.045)	(1.880)
Economic growth	-0.002	-0.001	-0.004
	(0.001)	(0.008)	(0.008)
Constant	31.455***	49.270***	42.977***
	(2.779)	(9.744)	(11.106)
Observations	132	132	132
R-squared	0.695	0.509	0.405
Number of prov_id	12	12	12

The estimation results reveal that the ICT coefficient is consistently negative across the FE, RE, and 2SLS models, implying a connection between internet access and poverty reduction. However, once endogeneity is addressed in the 2SLS model, this effect loses its significance, consistent with previous studies [26] [37], who pointed out that the ICT-poverty relationship is often distorted by simultaneity and reverse causality. This scenario is reflective of the situation in eastern Indonesia, where digital development lags behind, with about 70% of the population not yet receiving optimal services and a notable gap in ICT adoption between the western and eastern regions. Economic factors also contribute to access inequality: individuals from the poorest households are three times less likely to access the internet compared to those from the wealthiest groups and the cost of ICT services is higher in the eastern regions, particularly in Sulawesi and Maluku. In Papua, West Nusa Tenggara (NTB), and East Nusa Tenggara (NTT), the challenge is not the cost but the lack of infrastructure.

From a socio-economic perspective, the application of ICT in the eastern region is largely consumptive, with a predominant emphasis on instant messaging (80%) and social media (87%), which does not substantially boost productivity or reduce poverty (BPS, 2018). The impact of ICT is further constrained by skill-biased technological change, which widens the divide between workers with high and low skills. This observation aligns with the notion that certain control variables, like education, lose their importance after accounting for endogeneity, supporting Kaffenberger & Pritchett's argument regarding the reciprocal link between education and poverty. Conversely, unemployment consistently appears as a significant factor contributing to poverty increases across all models. Technology leverages productivity and efficiency [38] [39] [40] [41] [42]. Moreover, electrification has been shown to alleviate poverty [19] [26] [43], while per capita GRDP and economic growth have been found to be insignificant, supporting Ravallion conclusion that growth does not automatically lead to poverty reduction unless it is inclusive [3].

Insight from various regions reveal a consistent trend. In Sub-Saharan Africa, the spread of ICT through mobile technology, broadband, and skill enhancement has been demonstrated to promote development that benefits the impoverished and broadens financial access [24]. Additionally, technology plays a role in lowering social costs and enhancing the quality of life for the underprivileged [8]. Nonetheless, study in Africa indicates that ICT's effect on economic growth may be minimal without accompanying investments [44]. This result aligns in Togo, which discovered that ICT can improve living standards and decrease inequality when backed by robust institutional support and community expertise [45].

In Indonesia, the expansion of fintech highlights how digitalization can enhance access to economic services, including the distribution of social aid. Nevertheless, its application is uneven, with eastern Indonesia seeing a reduced impact on alleviating poverty and inequality [15]. It also discovered that ICT significantly contributes to poverty reduction, but their study did not account for endogeneity, which limits the strength of their causal conclusions.

Previous study [17] [25] [46] is primarily explore the relationship between ICT and economic growth, often neglecting its effects on poverty and inequality. Ostry & Berg emphasize the importance of incorporating equity into ICT-related development research to ensure that digital progress is truly inclusive [47]. Therefore, although ICT offers economic opportunities, the empirical findings, especially from the 2SLS analysis

in this study, indicate that its influence on poverty in eastern Indonesia is not yet causal and is heavily dependent on labor conditions and essential infrastructure. Discussion of model 2 dependent variable: Income Inquality. Next Result of ICT on Inequality on Table 3.

Table 3. Result of ICT on Inequality

Variables	(1) FE	(2) RE	(3) 2SLS
ICT access	-0.002***	-0.011**	-0.007**
	(0.000)	(0.001)	(0.004)
Years schooling	0.007	-0.023***	0.006
	(0.005)	(0.005)	(0.007)
Unemployment	-0.002	0.004**	0.001
	(0.001)	(0.002)	(0.003)
Electricity	-0.000	0.001	-0.001*
	(0.000)	(0.000)	(0.001)
Log percapita PDRB	-0.017***	0.032***	-0.023**
	(0.005)	(0.007)	(0.010)
Economic growth	-0.000	-0.000	-0.000**
	(0.000)	(0.000)	(0.000)
Constant	0.629***	0.235***	1.035***
	(0.052)	(0.066)	(0.334)
Observations	132	132	132
R-squared	0.494	0.298	0.861
Number of prov_id	12	12	12

Table 3 demonstrates that increased access to the internet (ICT) is statistically linked to a decrease in the inequality coefficient, and this association remains even after using an instrument (IV-mobile) to address endogeneity concerns. The decline in the coefficient in the IV model indicates that when adjustments for unobserved variables and reverse causality are made, the causal influence of ICT on inequality persists, albeit in a more subdued form. ICT access enables a broader range of individuals, including those from lower-income groups, to participate in the digital labor market, access price information, engage in online education, and utilize digital financial services, thereby expanding opportunities and reducing income distribution disparities.

Recent investigations lend support to this observation. For instance, the situation in Indonesia found that ICT penetration tends to mitigate inequality once it crosses a particular threshold [15]. In a similar vein, research conducted a global analysis and found that ICT development plays a significant role in diminishing income inequality, especially in countries where access is already widespread [28] [45] [48]. This suggests that in the context of the Indonesian panel, the influence of ICT on inequality is apparent, but it hinges on how technology access is distributed.

Incorporating education into these models produces varied outcomes is when some models reveal a notable negative impact. The OLS model indicates that more years of education can lead to reduced inequality, yet this effect is not significant in the IV model. This inconsistency may stem from the fact that education, when not paired with quality or digital relevance, might not equitably benefit all societal levels. Recent research underscores the importance of integrating ICT with education for inclusive benefits; for example, digital literacy and ICT skills are important for increasing economic opportunities.

As a result, while it is essential to prolong educational opportunities, the potential to diminish inequality may be constrained without extensive access to ICT and the development of relevant skills. Other economic indicators, such as GRDP per capita, also display significant negative coefficients in several models, suggesting that regions with higher per capita incomes typically experience lower inequality. This supports the notion that inclusive and geographically dispersed economic growth can improve access for vulnerable groups, rather than merely empowering elites. These results align that the effects of inclusive economic growth can support income equality efforts [6] [49]. However, Indonesia's archipelagic nature also presents challenges to this income equality [50].

The role of electricity in IV's results underscores the essential nature of foundational infrastructure, such as electricity and internet access, in ensuring technology is truly inclusive. Global studies have recently highlighted that digitalization, when not paired with equitable access to basic infrastructure, can actually increase inequality [13] [21] [31] [45]. The evidence suggests that digital technology, by itself, is not a guaranteed solution to inequality and poverty. For success, everyone needs internet access, digital skills, education, infrastructure, and fair policies. In Indonesia, leaders should focus on bringing the internet to remote and underserved areas. They should also work on improving digital skills through education and training. Economic growth and technology should reach beyond just cities and wealthy areas. ICT can play a key role in reducing income inequality and poverty.

4. Conclusion

Information and communication technology (ICT) plays a crucial role in fostering economic growth. Numerous studies have demonstrated that digital technology can contribute to the reduction of poverty and inequality, although its impact varies across different regions. In Eastern Indonesia, increased access to ICT is associated with a reduction in poverty; however, this correlation is weak when certain research methodologies are employed. This suggests that merely enhancing internet access does not directly alleviate poverty due to challenges such as limited digital skills, insufficient devices, and high costs. Nevertheless, ICT contributes to the reduction of income inequality by providing broader access to information, employment opportunities, and online markets. Factors such as unemployment and electricity access also influence poverty levels, while regional income and electricity availability help mitigate inequality. For ICT to be effective, robust infrastructure and equitable economic growth are essential. To enhance the efficacy of ICT in Eastern Indonesia, policies should prioritize the equitable distribution of digital resources, particularly in remote areas. This includes reducing internet costs and increasing public access points, as well as promoting device ownership among low-income

families. Initiatives to enhance digital skills within communities and small businesses are vital. Economically, digitalization should support small enterprises, expand e-commerce, and generate digital employment opportunities. Improving village electrification is also critical for digital infrastructure. By implementing this strategy, ICT can contribute to reducing inequality and accelerating poverty alleviation in Eastern Indonesia.

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