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THE EFFECT OF TELECOMMUNICATIONS INFRASTRUCTURE ON INCLUSIVE ECONOMIC GROWTH IN INDONESIA 2011–2021

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ABSTRACT

Inclusive economic growth refers to economic development that promotes equity, benefiting all segments of society, reducing inequality, and addressing unemployment. Indonesia, as one of the world's largest archipelago nations, faces challenges of uneven population distribution and varying socio-economic backgrounds, leading to persistent issues of inequality and unemployment. Telecommunication infrastructure plays a crucial role by establishing information and communication networks that can contribute to accelerating economic equality. This study aims to examine the impact of telecommunications infrastructure on inclusive economic growth in Indonesia, utilizing panel data from 34 provinces spanning the years 2011 to 2021 and employing the Fixed Effect Model (FEM) methodology. The findings demonstrate that indicators such as base transceiver station (BTS), cellular telephone usage, and internet connectivity have a positive effect on per capita income growth, while simultaneously reducing unemployment, inequality, and raising the inclusive economic development index ("Indeks Pembangunan Ekonomi Inklusif-IPEI"). Moreover, the effects of telecommunications infrastructure vary across different sub-regions, highlighting disparities in infrastructure development and variations in technological expertise across regions.

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1. Introduction.

Indonesia stands as one of the most populous countries globally, with a population of 276 million inhabitants according to World Bank data (The World Bank, 2021). Following China, India, and the United States, it ranks as the fourth most populous nation. Additionally, Indonesia boasts the distinction of being one of the world's largest archipelagic countries, encompassing an area of 1.916.906,77 km^2 across 16.766 islands. The country exhibits a diverse range of ethnic and cultural backgrounds due to its numerous ethnic groups. However, population distribution within Indonesia is uneven, with approximately sixty-eight percent (68%) residing in Java Island (BPS, 2021).

Indonesia possesses abundant natural resources and a significant number of human resources (HR), which can be optimally utilized as sources of strength to drive economic growth (Sutrisno, 2021). Nonetheless, economic inequality, poverty, and unemployment continue to pose significant challenges for Indonesia today (Hutabarat et al., 2023). As per data from the Central Bureau of Statistics (BPS, 2021), Java Island exhibits high economic activity and contributes the largest share of Gross Domestic Product (GDP) in Indonesia, amounting to 57.89%. This implies that more than half of Indonesia's GDP is generated in Java Island, acting as the focal point of the national economy. In contrast, Maluku and Papua contribute the smallest share to Indonesia's GDP at 2.49%. These figures highlight the substantial variation and inequality in GDP contributions across islands or regions (Anggoro, 2019).

Concurrently, theories of economic development continue to evolve. The current economic development strategies focus on enhancing the quality of growth, with a particular emphasis on inclusive economic growth. Inclusive economic growth entails the participation of all stakeholders in fostering economic progress, aiming to reduce poverty, inequality, and unemployment alongside economic expansion (Klasen, 2017). Moreover, inclusive economic growth plays a vital role in sustainable economic development, as outlined in the international agreement on Sustainable Development Goals (SDGs).

Todaro and Smith (2005) assert that the availability of infrastructure within a country is a crucial factor in accelerating productivity and promoting economic development to enhance the standard of living for the wider population. Furthermore, McKinley (2010) emphasizes that access to economic infrastructure such as electricity, roads, and information and communication technology serves as a significant indicator of inclusive growth. Telecommunications infrastructure is a rapidly expanding sector in this regard.

Overview of Telecommunications in Indonesia.

The 1945 Constitution of the Republic of Indonesia enshrines the right of every citizen to develop themselves by fulfilling their basic needs, accessing education, benefiting from science and technology, arts and culture, in order to enhance their quality of life and contribute to the welfare of humanity. Likewise, individuals have the right to communicate and access information to develop their personal and social environments. They also have the right to search for, obtain, own, store, process, and convey information through all available channels (Article 28C and Article 28F of the 1945 Constitution and its Amendments). To uphold these fundamental rights, Telecommunications Law No. 36/1999 mandates that each telecommunications network operator and/or service provider contribute to universal service.

Equity and quality growth are the main focuses of Indonesia's development, with infrastructure being a key driver. While the development of base transceiver station (BTS) infrastructure in Indonesia has shown significant progress over the years, achieving equitable development remains a challenging task for the government. The country's diverse topography, characterized by mountains, valleys, small islands, and remote areas that are difficult to access, poses obstacles to the development of telecommunications infrastructure and necessitates substantial investment costs. As a result, telecommunications infrastructure is predominantly concentrated in mainland and urban areas, with Java and Sumatra islands housing the majority of installations. Consequently, this infrastructure inequality has resulted in a digital divide.

Research Objectives.

Various studies have examined the role of telecommunications infrastructure in inclusive economic growth in African countries. However, different influences may arise in countries with distinct characteristics compared to those in the African region. Indonesia, as one of the largest archipelago nations in the world and one of the leading emerging market countries in Asia, has the potential to leverage telecommunications infrastructure to increase productivity and foster inclusive economic growth. Therefore, this study aims to investigate the impact of telecommunications infrastructure on inclusive economic growth in Indonesia, specifically focusing on per capita income, inequality, unemployment, and the inclusive economic development index (IPEI).

2. Theoretical Review.

2.1. Inclusive Economic Development.

According to Samans et al. of the World Economic Forum (2015), inclusive economic development refers to sustained and broad-based growth across all sectors of the economy over several decades. It entails creating opportunities and employment for the working-age population, reducing poverty, and mitigating excessive income inequality. Similarly, Ianchovichina & Lundström (2009) from the World Bank (2009) define inclusive development as equitable growth that provides equal opportunities to all individuals through job creation, market expansion, and improved living conditions for the poor.

McKinley, in collaboration with the Asian Development Bank (ADB) (2010), developed a composite index for measuring a country's inclusive economic development. This index comprises four significant components: (a) development, productive labor, and economic infrastructure, (b) poverty and income inequality (including gender equality), (c) human capabilities, and (d) social protection.

In Indonesia, the National Development Planning Agency (Bappenas) evaluates economic inclusiveness at the national, provincial, and district/city levels using the Inclusive Economic Development Index ("*Indeks Pembangunan Ekonomi Inklusif*-IPEI"). Bappenas defines inclusive economic development as an approach that fosters broad access and opportunities for the community in an equitable manner, enhances welfare, and reduces disparities between different groups and regions. The IPEI, formulated by Bappenas, incorporates three pillars: indicators of economic development and development, indicators of income equality and poverty reduction, and indicators of expanding access and opportunities. The IPEI was developed by Bappenas to capture Indonesia's development goals more specifically. Additionally, the IPEI can compare the level of inclusiveness between provinces, districts, and cities to determine the appropriate policy direction for each province and its alignment with the national level (Bappenas, 2019). The IETI is a comprehensive measure used to analyze the level of inclusiveness in Indonesia's current and future development.

2.2. Telecommunications and Inclusive Economic Development

Considering the various definitions and factors involved in determining inclusiveness, researchers refer to the works of Adejumo et al. (2020), Mutiiria et al. (2020), and Ofori & Asongu (2021) to select inclusive economic indicators, namely economic development, unemployment, and inequality. These three variables are the main components in calculating the inclusive economic development index recommended by McKinley (2010).

2.2.1. The Relationship of Telecommunications to Economic Development

Various modern theories of economic development have highlighted the significance of infrastructure and demonstrated a strong relationship between infrastructure and economic development. Noteworthy theories include the neo-Schumpeterian theory and Solow's neo-classical growth theory. Both theories emphasize the role of infrastructure as part of technology and as an input factor in the economy, which enhances the production process, advances technology, and improves labor quality. The value added resulting from the infrastructure effect has a positive impact on firms, leading to economic development (Bahrini & Qaffas, 2019).

Norton (1992) found that the underdevelopment of telecommunications infrastructure hinders the development of many countries, as the lack of information availability contributes to high transaction costs, thereby suboptimalizing the economy. This aligns with the view of M. M. Rahman (1996) that telecommunications infrastructure enhances production process efficiency by reducing production costs and transaction and coordination costs in both multinational and local businesses. It also promotes foreign direct investment and improves a country's export performance. Furthermore, in microanalysis, telecommunications, particularly through cellular phones, can reduce information asymmetry, facilitate easier access to credit,

and increase business flexibility and responsiveness (Maliranta & Rouvinen, 2004; Polikanov & Abramova, 2003).

Adejumo et al. (2020) and Pradhan et al. (2013) categorize the impact of ICT development on economic development into two parts: direct effects and indirect effects, as illustrated in Figure 1. Direct effects encompass contributions to domestic output, job creation, regional income growth, and effects on the balance of payments, among others. Indirect effects manifest as network externalities or "spillover" effects that significantly impact the economy, although the results may not be immediately evident, as they require time to materialize (Thompson & Garbacz, 2008). The assumption of positive spillovers stems from the non-rivalry, non-excludability, and public good principles inherent in technological adaptability and diffusion (Onakoya, 2012). Consequently, everyone can benefit from technology, leading to productive economic development (Adejumo et al., 2020). An example of an indirect effect is the enhancement of firm productivity without a corresponding increase in output, often attributed to the spread and application of knowledge and technology. Moreover, telecommunications creates investment opportunities, encourages capital accumulation, expands market reach, and improves access to services such as healthcare, education, and environmental protection (Rahman, 1996).

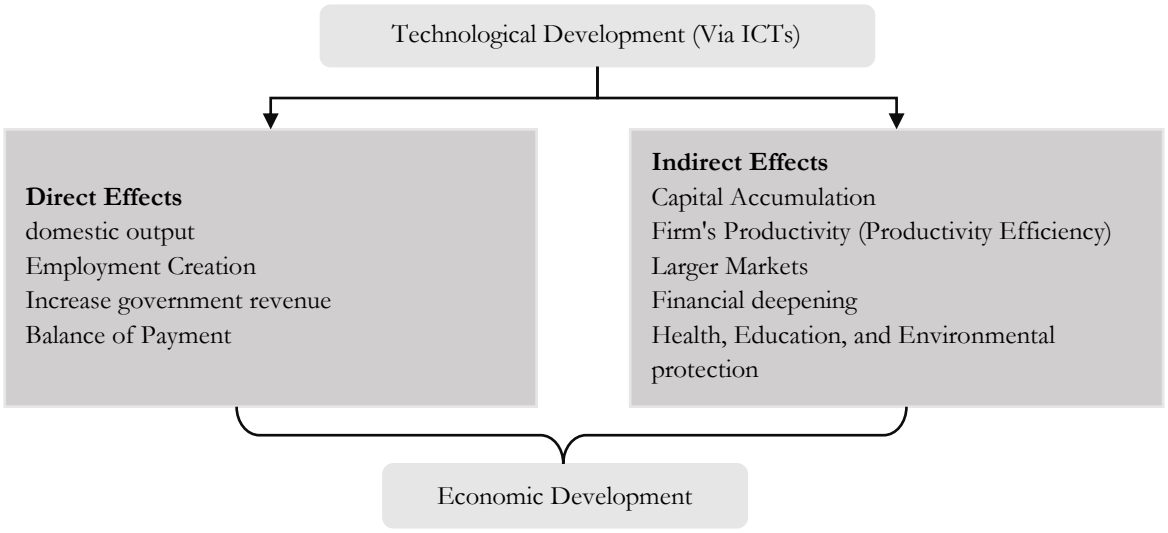

Figure 1. The Relationship between Technology and Economic development. Source: Adejumo et al. (2020), Pradhan et al. (2013).

While the contribution of infrastructure to economic development is widely acknowledged by economists, empirical studies on infrastructure yield mixed evidence. For instance, in less developed countries, Devarajan et al. (1996) found a negative impact of infrastructure investment, while Sahoo (2010) identified a positive and significant relationship between infrastructure development and economic development in China. Additionally, Wylie (1996) demonstrated that infrastructure has a positive and significant impact on economic development in Canada. Despite the diverse findings, the primary objective of infrastructure development in each country remains the same: to foster economic development.

2.2.2. Relationship between Telecommunications and Unemployment

The rapid development of telecommunications technology and digital transformation has had a profound impact on various aspects of life. One such area is the digital economy, which leverages information and communication technology to enhance safety and efficiency. Industries that still rely on conventional methods are compelled to undergo digital

transformation. Companies that successfully adapt to these technological advancements will thrive, while those unable to do so face the risk of bankruptcy and a decline in their ability to employ workers effectively (labor efficiency).

The digital era has made many things easier, but it has also brought negative consequences, particularly in terms of employment. This aligns with Schumpeter's theory (1942) of creative destruction (Witt, 2016), where technology replaces existing products with higher quality alternatives, employing more efficient production methods (Bosma et al., 2011). Moreover, John Maynard Keynes (1933) argued that technological unemployment occurs when technological advancements outpace the skills of the workforce and companies struggle to keep up with these changes (Krutova et al., 2022). Alvin Hansen (1938) highlighted the potential threat to economic development due to population growth and technological innovation (Adejumo et al., 2020). Brynjolfsson and McAfee (2014) posit that advancements in software technology increase the pace of technological innovation, disrupting the labor market and resulting in job displacement.

In theory, the long-term use of technology is likely to have a positive impact on economic development, but there are potential negative consequences to consider. While technological advancements enable higher productivity and output, they can also lead to a reduction in labor demand, resulting in long-term economic development decline. Technology can replace low-skilled labor (Rifkin, 2014), leading to a situation where the demand for labor falls short of the available supply, ultimately causing unemployment (Casey, 2018).

2.2.3. Relationship between Telecommunications and Inequality

Telecommunications infrastructure plays a crucial role in fostering economic development by enhancing productivity in both industries and households (Bello et al., 2023; Ofori & Asongu, 2021). However, the benefits of telecommunications may not be accessible to all, leading to a digital divide (Panichsombat, 2016). The digital divide, as defined by Warschauer (2004), refers to the social stratification resulting from unequal access, adaptation, and creation of knowledge through the use of information and communication technologies.

Disparities in technology utilization contribute to income inequality, particularly when access to resources such as telecommunications infrastructure is unevenly distributed among individuals (Zillien & Hargittai, 2009). Individuals without access to telecommunications are unable to actively participate in the national digital economy, exacerbating income inequality (Howard & Mozejko, 2021). This situation is prevalent in developing countries, where the development of telecommunications infrastructure is not evenly spread across all regions. Unequal regional development leads to inter-regional disparities, with certain regions benefiting more than others (Chatterjee & Turnovsky, 2012). Additionally, the impact of technology on income inequality heavily relies on the complementary relationship between technology and skills or education (Patria and Erumban, 2020). In other words, income inequality tends to be smaller in developed countries compared to developing countries, as individuals in developed countries are assumed to have greater exposure to digital skills and literacy (Panichsombat, 2016).

Infrastructure is a vital component of regional development. Regions with well-developed infrastructure tend to experience higher economic development rates and improved community welfare (Sukwika, 2018). As telecommunication services become more affordable, the benefits of information and communication technologies spread across various segments of society, contributing to the reduction of income inequality (Patria & Erumban, 2020). Therefore, this study aims to provide evidence of the impact of ICT adoption on income inequality as one of the composite variables of inclusive economic development.

2.3. Research Hypothesis

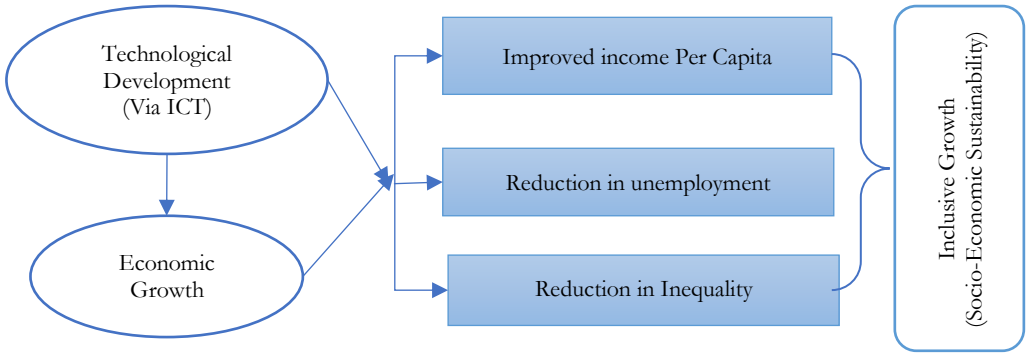

Figure 2. The technology-economic development and sustainability framework
Source: Adejumo et al. (2020).

Based on the previous description, the hypothesis in this study is that telecommunications infrastructure has a positive impact on inclusive economic development by increasing per capita income and reducing the level of inequality. Consequently, this reduction in inequality leads to a decrease in the number of unemployed individuals, resulting in an increase in the inclusive economic development index (Figure 2).

The regression results are expected to give the following final values:

1) BTS, internet, and cellular phones are positively and significantly correlated to income per capita (GRDP per capita).
2) BTS, internet, and cellular phone are positively and significantly correlated to income per capita (GRDP per capita).
3) BTS, internet, and cellular phones are negatively and significantly correlated with unemployment (open unemployment rate).
4) BTS, internet, and cellular phones are positively and significantly correlated to the inclusive economic development index ("IPEI").

The development of adequate telecommunications infrastructure in each region, along with a high level of telecommunications adoption, is expected to foster development. Previously underdeveloped regions can then catch up with already developed regions, thereby reducing regional disparities and facilitating inclusive growth at the national level.

3. Research methods.

This research employs the fixed effect model (FEM) method and relies on secondary data obtained from the Central Statistics Agency (BPS), reports from the Ministry of Communication and Information, and the Bappenas website. The study utilizes unbalanced panel data from 34 provinces in Indonesia, covering the period from 2011 to 2021, except for North Kalimantan, which only includes data from 2015 to 2021.

The econometric equation model is based on the research conducted by Adejumo et al. (2020), Mutiiria et al. (2020), and Ofori & Asongu (2021), and is generally represented as follows:

$$Y_{it} = \alpha + \sum \beta\, Telecommunication_{it} + \sum \delta\, Control_{it} + \varepsilon$$

In the equation above, Y represents the dependent variable, which measures indicators of inclusive economic development. Telecommunication is the independent variable, comprising BTS telecommunications infrastructure, the level of internet usage adoption, and

cellular phone usage. Control represents the control variable used in the study. The subscript "it" denotes cross section i at time t. Additionally, this study employs a log-log (double log) model.

Table 1. Research Variables.

Variables (Labels)	Definition	Unit	Data source
Dependent Variable (Indicator of Inclusive Economic development)			
Gross Regional Domestic Product per capita *(LogGRDPper capita)*	GRDP divided by the number of people living in the province	Thousand Rupiahs	BPS 2011-2021
Annual Gini ratio (LogGini)	Indicators to measure income inequality	Points, 0 To 1	BPS 2011-2021
Open unemployment rate (TPT)	The percentage of the number of unemployed to the total labor force	Percentage	BPS 2011-2021
Inclusive Economic Development Index (LogIPEI)	A tool to measure the inclusiveness of development in Indonesia through aspects of economic development, inequality and poverty, as well as access and opportunity	Points, 1 To 10	Bappenas 2011-2021
Main Independent Variable (Telecommunication)			
BTS Coverage *(LogBTS)*	The number of base stations per 1 million population in one province, the availability of signal quality in an area	BTS/1 million population	Ministry of Communication and Information 2011-2021
Use of cell phones (Cellular)	Percentage of population owning/operating cell phones	Percentage	BPS 2011-2021
Internet use *(Internet)*	Percentage of population accessing the internet in the last 3 months	Percentage	BPS 2011-2021
Control Variables			
GRDP at Constant Prices (ADHK) *(LogGRDP)*	The added value of goods and services is calculated using prices prevailing in a certain year as the base year	Billion Rupiah	BPS 2011-2021
Electricity distribution (LogElectricity)	The amount of electrical energy supplied from the substation to consumers	Gigawatt hours (GWh)	BPS 2011-2021
Education (LogEducation)	The average number of years taken by residents aged 15 and over to pursue education	Year	BPS 2011-2021
Consumer Price Index *(LOGCPI)*	An index used to measure the average price of products, whether goods or services, which are commonly consumed or used by household consumers	Points	BPS 2011-2021
Dummy Covid-19 *(Dummy_Covid19)*	The interaction between telecommunications technology and economic development	Value 0 and 1	
BTS x GRDP *Log(BTSxGRDP)*	The corona virus dummy variable for years that are not affected is 0 and 1 for those that are affected		

4. Research Result

Table 2. Estimating the Effect of Telecommunications on GRDP Per Capita.

Independent Variable	Dependent Variable: LogGRDP per capita					
	Cellular phones			Internet		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
1	2	3	4	5	6	7
LogBTS	0.1701***	0.1148***	0.1178***	0.3507***	0.1748***	0.1827***
	(0.0408)	(0.0427)	(0.0419)	(0.0248)	(0.033)	(0.0325)
Cellular phones	0.0296***	0.0115**	0.0122**			
	(0.0055)	(0.0052)	(0.0051)			
Internet				0.0026	0.0007	0.0003
				(0.0018)	(0.0019)	(0.0018)
LogGRDP		1.0719***	1.0896***		1.139***	1.1783***
		(0.1833)	(0.18)		(0.1959)	(0.1928)

Table 2. Continued.

1	2	3	4	5	6	7
LogElectricity		0.3742***	0.3471**		0.423***	0.4026***
		(0.1397)	(0.1373)		(0.1393)	(0.137)
LogEducation		0.0797	0.0468		0.0765	0.0442
		(0.12)	(0.1181)		(0.1209)	(0.1192)
LogCPI		-0.2535	-0.1061		-0.254	-0.1196
		(0.1902)	(0.1909)		(0.1955)	(0.19580
Dummy_Covid19		-0.2682***	-0.2783***		-0.2896***	-0.2986***
		(0.046)	(0.0452)		(0.0464)	(0.0457)
Log(BTSxGRDP)			0.0063***			0.0061***
			(0.0017)			(0.0017)
_cons	8.2541***	-4.8637**	-5.8903**	8.6888***	-5.7774**	-7.0177***
	(0.0918)	(2.4713)	(2.4411)	(0.0957)	(2.5601)	(2.5398)
Observations	370	370	370	370	370	370
R-squared	0.7962	0.8443	0.8505	0.7797	0.842	0.8479
Adj R2	0.7748	0.8254	0.8318	0.7566	0.8228	0.8289

*Standard errors are in parentheses *** p<.01, ** p<.05, * p<.1*
Note: The BTS variable used is BTS Coverage

Table 3. Estimating the Effect of Telecommunication on Inequality.

	Dependent Variable: LogGINI					
Variable dependent	**Cellular phones**			**Internet**		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
LogBTS	-0.0258***	-0.0163***	-0.0167***	-0.0541***	-0.0306***	-0.0317***
	(0.0053)	(0.0054)	(0.0053)	(0.0033)	(0.0043)	(0.0042)
Cellular phones	-0.0052***	-0.003***	-0.0031***			
	(0.0007)	(0.0007)	(0.0006)			
Internet				-0.0007***	-0.0006**	-0.0006**
				(0.0002)	(0.0002)	(0.0002)
LogGRDP		-0.0722***	-0.0746***		-0.0726***	-0.0776***
		(0.0234)	(0.0229)		(0.0254)	(0.025)
LogElectricity		-0.0437**	-0.04**		-0.0534***	-0.0507***
		(0.0178)	(0.0175)		(0.018)	(0.0177)
LogEducation		-0.0571***	-0.0526***		-0.0562***	-0.0521***
		(0.0153)	(0.015)		(0.0156)	(0.0154)
LogCPI		0.1137***	0.0935***		0.1052***	0.0878***
		(0.0243)	(0.0243)		(0.0253)	(0.0253)
Dummy_Covid19		0.0236***	0.025***		0.0311***	0.0323***
		(0.0059)	(0.0057)		(0.006)	(0.0059)
Log(BTSxGRDP)			-0.0009***			-0.0008***
			(0.0002)			(0.0002)
_cons	-0.1202***	-0.003***	0.6069*	-0.2059***	0.5276	0.6883**
	(0.012)	(0.0007)	(0.3105)	(0.0127)	(0.3314)	(0.3287)
Observations	370	370	370	370	370	370
R-squared	0.8618	0.8991	0.9037	0.8443	0.8946	0.8986
Adj R2	0.8474	0.8868	0.8917	0.828	0.8818	0.8859

*Standard errors are in parentheses *** p<.01, ** p<.05, * p<.1*
Note: The BTS variable used is BTS Coverage

Table 4. Estimating the Effect of Telecommunication on the Open Unemployment Rate (TPT).

	Dependent Variable: TPT					
Variable dependent	**Cellular phones**			**Internet**		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
1	2	3	4	5	6	7
LogBTS	0.0384	-0.0338	-0.0434	-0.3121***	-0.3296***	-0.3516***
	(0.1286)	(0.1448)	(0.1426)	(0.0763)	(0.1103)	(0.1093)

Table 4. Continued.

1	2	3	4	5	6	7
Cellular phones	-0.0799***	-0.0731***	-0.0752***			
	(0.0172)	(0.0175)	(0.0173)			
Internet				-0.0180***	-0.0293***	-0.0282***
				(0.0054)	(0.0063)	(0.0062)
LogGRDP		-1.1544*	-1.2094**		-0.5413	-0.6508
		(0.6221)	(0.6128)		(0.6556)	(0.6491)
LogElectrical		2.1466***	2.231***		2.026***	2.0829***
		(0.474)	(0.4674)		(0.4661)	(0.4612)
LogEducation		-1.4505***	-1.3481***		-1.4291***	-1.3391***
		(0.4073)	(0.4022)		(0.4046)	(0.4011)
LogCPI		1.0647*	0.6063		0.5463	0.1712
		(0.6455)	(0.6499)		(0.6544)	(0.6592)
Dummy_Covid19		0.0951	0.1266		0.3466**	0.3719**
		(0.156)	(0.1539)		(0.1554)	(0.1538)
Log(BTSxGRDP)			-0.0196***			-0.0171***
			(0.0058)			(0.0058)
_cons	9.6511***	5.0015	8.1927	8.0726***	.0302	3.4908
	(0.2897)	(8.3857)	(8.3107)	(0.2947)	(8.5686)	(8.5507)
Observations	370	370	370	370	370	370
R-squared	0.4501	0.514	0.5302	0.4332	0.5202	0.5326
Adj R2	0.3925	0.4549	0.4715	0.3738	0.4619	0.4742

*Standard errors are in parentheses *** p<.01, ** p<.05, * p<.1*
Note: The BTS variable used is BTS Coverage

Table 5. Estimating the Effect of Telecommunications on IPEI.

	Dependent Variable: LogIPEI					
Independent Variable	**Cellular phones**			**Internet**		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
LogBTS	0.0356***	0.018**	0.0183**	0.0582***	0.0263***	0.027***
	(0.0072)	(0.0075)	(0.0075)	(0.0043)	(0.0058)	(0.0058)
Cellular phones	0.0045***	0.0017*	0.0018**			
	(0.001)	(0.0009)	(0.0009)			
Internet				0.0008***	0.0003	0.0003
				(0.0003)	(0.0003)	(0.0003)
LogGRDP		0.1132***	0.1147***		0.1138***	0.117***
		(0.0322)	(0.0321)		(0.0343)	(0.0343)
LogElectrical		0.0557**	0.0533**		0.0613**	0.0596**
		(0.0246)	(0.0245)		(0.0244)	(0.0244)
LogEducation		0.0817***	0.0788***		0.0812***	0.0785***
		(0.0211)	(0.0211)		(0.0212)	(0.0212)
LogCPI		-0.1564***	-0.1436***		-0.1517***	-0.1406***
		(0.0334)	(0.0341)		(0.0343)	(0.0348)
Dummy_Covid19		-0.0221***	-0.023***		-0.0264***	-0.0271***
		(0.0081)	(0.0081)		(0.0081)	(0.0081)
Log(BTSxGRDP)			0.0005*			0.0005*
			(0.0003)			(0.0003)
_cons	1.2089***	0.2824	0.1934	1.2908***	0.243	0.1403
	(.0162)	(0.4345)	(0.4359)	(0.0166)	(0.4486)	(0.4517)
Observations	370	370	370	370	370	370
R-squared	0.7982	0.8474	0.8489	0.7892	0.8462	0.8475
Adj R2	0.7771	0.8289	0.83	0.7672	0.8275	0.8284

*Standard errors are in parentheses *** p<.01, ** p<.05, * p<.1*
Note: The BTS variable used is BTS Coverage

Furthermore, this study also examines the impact of telecommunications infrastructure on the Inclusive Economic Development Index ("IPEI") while considering specific sub-regions: Sumatra, Java, Bali and Nusa Tenggara, Kalimantan, Sulawesi, Maluku, and Papua. The control variables incorporate the complete set of control variables outlined in Table 1.

Table 6. Estimating Results of Telecommunications Influence on IPEI by Sub-Region.

	Dependent Variable: LogIPEI						
Independent Variable	**Sumatra**	**Java**	**Bali and Nusa Tenggara**	**Kalimantan**	**Sulawesi**	**Maluku**	**Papua**
LogBTS	0.0052	0.0052	0.0302	0.0117	0.0314**	0.0112	0.1136***
	(0.008)	(0.0243)	(0.0392)	(0.016)	(0.0132)	(0.0228)	(0.0256)
Cellular phones	0.0032***	0.0022	0.0003	0.0043*	0.0011	0.0022	0.0054
	(0.0011)	(0.0022)	(0.0042)	(0.0025)	(0.0014)	(0.0025)	(0.0031)
Control Variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes
_cons	0.2781	-2,579	3.9507*	1.4376	-2.5598***	-0.6736	-1.5423
	(0.742)	(1.8098)	(2.0606)	(0.9937)	(0.6813)	(2.5759)	(1.5049)
Observations	99	66	33	51	66	22	22
R-squared	0.9215	0.8508	0.8704	0.9309	0.9536	0968	0.9831
Adj R2	0.9061	0.8135	0.8115	0.9091	0.942	0.9441	0.9705
LogBTS	0.0218***	0.02	0.0747**	0.0277**	0.0228**	0.0605*	0.0404**
	(0.0075)	(0.0214)	(0.032)	(0.0106)	(0.01)	(0.0311)	(.0164)
Internet	0.0011**	0.0005	-0.0047***	0.0013	0.0008	-0.0034	0.0044***
	(0.0005)	(0.001)	(0.0015)	(0.0008)	(0.0005)	(0.0024)	(.0011)
Control Variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes
_cons	0.8028	-2.0271	3,002*	1.7661*	-2.1503***	-3.0529	-1.2766
	(0.9612)	(2,736)	(1,735)	(1.0123)	(0.7287)	(2,558)	(1.0612)
Observations	99	66	33	51	66	22	22
R-squared	0.9177	0.8485	0.9094	0.9306	0.9552	0.9708	0.9915
Adj R2	0.9017	0.8106	0.8682	0.9087	0.944	0.949	0.9851

*Standard errors are in parentheses *** p<0.01, ** p<0.05, * p<0.1*
Note: The BTS variable used is BTS Coverage

5. Discussion.

The estimation results in Table 2, Table 3, Table 4, and Table 5 show that modifying the model by adding different control variables to the equation produces regression coefficients with similar differences. Model 3, which uses the interaction between telecommunication technology and economic development, is the best model among the other two models. This conclusion is based on considering high R^2 or Adjusted R^2 values, more significant coefficients, and a direction that aligns with the expected assumptions.

The estimation results in Table 2 show that BTS has a significantly positive effect on GRDP per capita. Additionally, a 1% increase in the proportion of cellular phone users is associated with a 0.0122% increase in GRDP per capita, with a significance level of α=5%. Furthermore, a 1% increase in the proportion of internet users is linked to a 0.0003% increase in GRDP per capita, although this result is not significant. These findings are consistent with the research conducted by Adejumo et al. (2020) and Mutiiria et al. (2020), which suggest that telecommunications infrastructure and its usage enable people to access economic activities more easily and participate in productive endeavors. Additionally, access to reliable electrical energy is crucial for the functioning and utilization of BTS by the wider community (Mutiiria et al., 2020; Oshota, 2019). A high-quality electricity supply encourages the provision of energy required for the operation of reliable telecommunications equipment. The variable measuring average years of schooling (education) shows an increase in GRDP per capita, although the results are not yet significant. Education plays an important role in fostering community income growth. Individuals with higher education levels are more likely to possess the knowledge necessary to operate cellular phones and access the internet. However, the average length of schooling in Indonesia is currently around 8.25 years, equivalent to grade 3 of junior high school. Moreover, the CPI (consumer price index) variable exhibits a negative coefficient on per capita income growth, although it is not significant, indicating that inflation may reduce

GRDP per capita. These results align with the findings of Panichsombat (2016), Adejumo et al. (2020), Bahrini and Qaffas (2019), Yilmazkuday (2022), and Mutiiria et al. (2020). Another control variable, the impact of the Covid-19 pandemic (dummy_Covid19), shows a significant negative coefficient on GRDP per capita, suggesting that the pandemic has adversely affected economic development.

Furthermore, the estimation results in Table 3 indicate that a 1% increase in the proportion of cellular phone and internet usage leads to a reduction of 0.0031% and 0.0006% in the Gini ratio, respectively. Moreover, education also contributes to the reduction of inequality. This finding aligns with previous studies by Adejumo et al. (2020), Patria and Erumban (2020), Alderete (2017), and Panichsombat (2016), which suggest that individuals with higher levels of education tend to possess the necessary knowledge to operate the internet and cellular phones. Additionally, an increase in electricity distribution significantly affects the reduction of the Gini ratio. The operation of BTS towers and the usage of internet/cellular phones heavily rely on electrical energy. The Covid-19 pandemic has a significant positive effect on inequality, which is consistent with the research of Esseau-Thomas et al. (2022), who found that the pandemic and public health factors have important impacts on the economy and income inequality. In the regression test results, inflation significantly increases inequality, which is consistent with the findings of Patria and Erumban (2020).

Table 4 illustrates that the development of telecommunications infrastructure, represented by BTS variables, cellular phone users, and internet users, has a negative impact on the unemployment rate. This finding aligns with the research conducted by Adejumo et al. (2020) and Ogbonna et al. (2022). The utilization of telecommunications can contribute to job creation and the development of higher productivity, which in turn can absorb the labor force and lead to a decrease in the unemployment rate. Regarding the control variables, an increase in GRDP and education significantly reduces the open unemployment rate. It is assumed that higher education enhances the ability to utilize digital access, thereby creating more opportunities for job creation and employment (Alderete, 2017). However, the electricity situation in Indonesia has not been able to effectively reduce the unemployment rate. This could be attributed to the unequal distribution of electricity access across the country, as indicated by varying electrification ratio figures for each province. Furthermore, the Covid-19 variable exhibits a positive and significant association with the open unemployment rate. This aligns with the study by Bauer & Weber (2020), which found that Covid-19 containment policies had detrimental effects on the economy, leading to an increase in unemployment.

Lastly, Table 5 examines the impact of telecommunications on inclusive economic development indicators using the IPEI composite index. The test results indicate that telecommunications infrastructure (BTS, cellular telephone usage, and internet usage) has a positive effect on the inclusive economic development index ("IPEI"). This finding is consistent with the research conducted by Bello et al. (2022), Mutiiria et al. (2020), Nchake and Shuaibu (2022), and Ofori and Asongu (2021). In Model 3, a 1% increase in cellular phone usage leads to a 0.0018% increase in IPEI at a 5% significance level, while the impact of the internet on IPEI is only 0.0003% and is not statistically significant. The control variables, namely GRDP, education, and electricity, demonstrate significant effects in driving inclusive growth in Indonesia. Conversely, an increase in the consumer price index has a negative impact with a 1% significance level. Moreover, the Covid-19 dummy variable exhibits a negative relationship with inclusive growth. The Covid-19 pandemic has resulted in a decline in production activities, as many companies have reduced labor costs.

The BTSxGRDP interaction variable from the estimation results in Tables 2, 3, 4, and 5 is utilized to describe the long-term implications of telecommunications technology on achieving inclusive economic development, as reflected in indicators such as per capita income, unemployment rate, and inequality. The findings indicate that telecommunications play a role in

increasing per capita income, reducing the unemployment rate, and minimizing inequality. Consequently, this leads to an overall increase in the inclusive economic development index. These findings align with the research conducted by Adejumo et al. (2020) and Mutiiria et al. (2020).

This study also examines the impact of telecommunications infrastructure on inclusive economic development indicators across different sub-regions. Telecommunications infrastructure serves as the main dependent variable, while the inclusive economic development index ("IPEI") is the independent variable. The estimation results, presented in Table 6, reveal diverse outcomes for each region. The lack of consistency in the results suggests that the level of telecommunications infrastructure development varies across regions, and there are disparities in technological expertise among regions (Nchake and Shuaibu, 2022; Alderete, 2017; Adeleye et al., 2020). This is supported by research conducted by Alleman et al. (1994), which emphasizes that aside from the availability of telecommunications infrastructure, regions must also possess human resources (HR) capable of utilizing telecommunications services. The significance of this condition becomes evident when BTS exhibits a significant value, but the adoption rate has an insignificant value or even exhibits an opposite direction of the coefficient. If the quality of human resources is unable to harness the available telecommunication services, then the existing telecommunications infrastructure cannot impact the country's economic level (Apdillah et al., 2022). Adequate electricity capacity, as an infrastructure supporting the operation of BTS, is also essential.

6. Conclusion

Based on the conducted research, it can be concluded that BTS telecommunications infrastructure and the adoption of telecommunications usage have a significant influence on increasing per capita growth, reducing unemployment, mitigating inequality, and enhancing the inclusive economic development index ("IPEI") with varying levels of significance. Education and electricity, as control variables, play a crucial role in promoting optimal utilization of telecommunications technology among communities. The Covid-19 pandemic and the increase in the Consumer Price Index (CPI) significantly hamper the quality of inclusive economic development indicators. Furthermore, the lack of consistent results across sub-regions indicates that infrastructure development and the quality of education are still unevenly distributed across regions. The utilization of the interaction variable between telecommunications and GRDP growth, which describes technology-modulated growth in the long run, exhibits a positive effect and encourages the improvement of inclusive economic development indicators.

7. Suggestion

The government should establish regulations that facilitate affordable and accessible telecommunications services, ensuring equitable distribution. Additionally, the basic education curriculum should incorporate essential knowledge of digital literacy, emphasizing the use and significance of telecommunications technology to support the development of Indonesian human resources in the face of the fourth industrial digitalization era. Furthermore, electricity service providers should actively contribute to expanding 4G internet coverage throughout Indonesia. Overall, a synergistic approach involving various relevant regulators and ministries is necessary to initiate and implement policies that encourage increased utilization of technology.

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