



How Investment Mediates Infrastructure Effect on Economic Growth in Indonesia

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Abstract

The availability of adequate infrastructure is one of the important foundations in encouraging investment and economic growth in a country. In Indonesia, over the last ten years, infrastructure development has become one of the main priorities to improve competitiveness and public welfare. This study aims to analyze the effect of the availability of road, electricity, and telecommunications infrastructure on investment and economic growth in Indonesia. The analysis uses panel regression analysis and path analysis methods in 34 provinces during the period 2014-2023. The research findings show that road infrastructure has no effect on economic growth, electricity infrastructure has a positive and significant effect on economic growth, while telecommunications infrastructure has a negative and significant effect on economic growth. Other findings show that investment partially mediates the effect of electricity and telecommunications infrastructure on economic growth; however, it does not mediate the effect of road infrastructure on economic growth. For this reason, the government needs to prioritize the development of electricity and telecommunications infrastructure because of its significant contribution to economic growth. Further evaluation and adjustment of road infrastructure policies are needed. Increasing investment, especially in sectors related to electricity and telecommunications infrastructure, also needs to be encouraged because it has a positive impact on economic growth.

Introduction

The development goal of the Indonesian state is to realize a prosperous society. One way to achieve this goal is through economic development. The success of economic development is characterized by high and equitable economic growth throughout society [1–3]. This contributes to improving people's welfare, which shows the role of economic growth in the development of a region [4]. In developing countries such as Indonesia, economic growth is a top priority. This is done to reduce poverty, increase per capita income, and improve the community's quality of life. Various government efforts have been made to boost economic growth in Indonesia, one of which is through infrastructure development [5,6]. Infrastructure plays an important role in a country's economic development, especially in developing countries like Indonesia. Road, electricity, and telecommunications infrastructure are the main components that support economic activity, improve connectivity between regions, and accelerate the flow of goods, services, and information [7–11]. In Indonesia, with a huge area consisting of thousands of islands, equitable infrastructure development is both a challenge and a priority to drive economic growth.

Quality infrastructure development is an important element in improving economic growth in developing countries. According to endogenous economic growth theory, investment in infrastructure increases productivity through positive externality effects [12,13]. Good infrastructure can reduce transaction costs, improve the efficiency of the flow of goods and

services, and open access to wider markets. The availability of quality infrastructure not only directly affects economic growth, but also creates an environment conducive to investment [14,15]. Such investment acts as a catalyst that utilizes infrastructure to create added value in the economy. Mediation analysis introduced by Baron & Kenny [16] is one of the tools to explain the role of investment acting as a mediating variable, the role of investment as a mediator strengthens the impact of infrastructure on economic growth [17]. For example, toll roads that connect remote areas with economic centers not only improve connectivity but also attract private sector investment in the region, such as the development of industrial or tourism areas [18,19]. Telecommunications infrastructure also plays an important role in the digitalization era, where increased internet access drives innovation and strengthens global competitiveness [8,20]. Therefore, infrastructure development supported by appropriate investment policies can create a synergistic effect in driving sustainable economic growth [21,22].

In the period 2014-2023, the Indonesian government has launched various massive infrastructure development programs, including National Strategic Projects (PSN). This program aims to improve accessibility, productivity, and economic competitiveness [23,24]. Indonesia's economic growth in the 2014-2023 period showed a fairly stable trend despite global challenges, including the COVID-19 pandemic. The average GDP growth is around 5 percent per year, driven by increased domestic consumption, exports, and investment. One of the key elements in maintaining this growth was infrastructure development, which became the government's main focus in the period. Projects such as the trans-Sumatra highway, new airports, and ports, and the expansion of electricity and telecommunications networks were pursued to improve connectivity and national productivity.

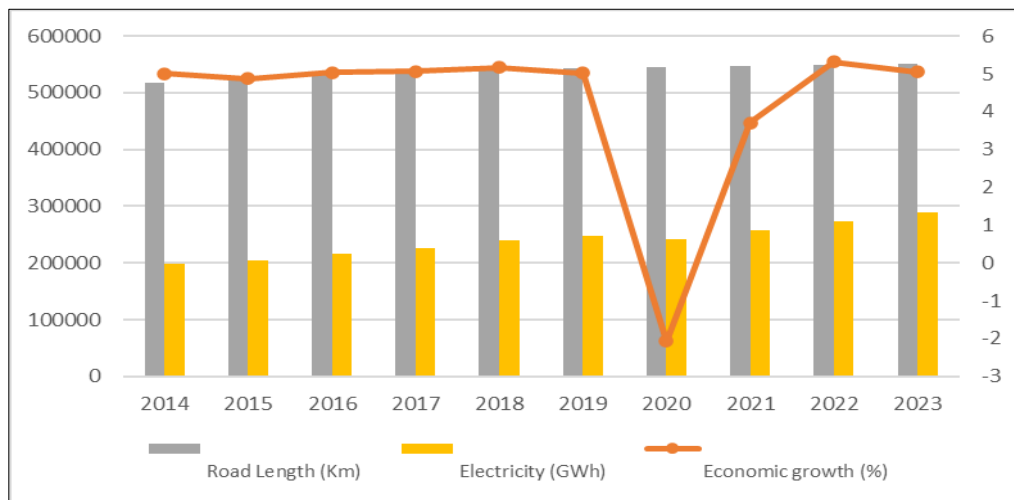


Figure 1. Development of road and electricity infrastructure and Indonesia's economic growth 2014-2023 (Source: Statistics Indonesia)

Figure 1 above shows that, in the period 2014-2023 the length of roads in Indonesia has continued to increase in recent years where the length of roads in Indonesia reached 550,735 Kilometers (Km) in 2023. This figure is an increase of about 6.23 percent compared to 2014 when the existing road length amounted to 517,753 km. This shows that the level of connectivity continues to improve. Road infrastructure is one of the most strategic economic infrastructures among various types of service provision in developing countries [7]. This is due to the existence of adequate road infrastructure that allows trade or exchange between regions, regions that export and regions that need imports will be interconnected, this can increase global trade, industrial development, and competitiveness by reducing intra- and inter-country disparities thereby strengthening inter-regional interactions that have an impact on economic growth and regional development [25,26]. Road infrastructure supports all sectors of the economy and is widely regarded as an efficient engine of growth in developing countries [27].

The development of road infrastructure can remove distribution barriers and maintain accessibility to employment, ensure connectivity of residential areas, and reduce transportation costs and production inputs [28,29].

Furthermore, Figure 1 also shows the development of electricity infrastructure. Electricity grid infrastructure plays an essential role in the economic growth of a region, especially in the development of human resources. The availability of reliable electricity allows schools and hospitals to operate more effectively. This improves access to education and health for the community. In addition, it also allows people to enjoy a variety of basic services that ultimately drive economic development and improve people's quality of life [10,30]. The development of electricity infrastructure is reflected in the amount of electricity that has been distributed. The amount of electricity distribution tends to continue to increase steadily during the 2014-2023 period with only a slight decrease in 2020 as a result of the pandemic. In 2021 the amount of electricity distributed increased significantly. According to the 2022 Performance Achievement Report and 2023 Work Plan of EBTKE Subsector (ESDM), the electrification rate in Indonesia has reached 99.63 percent in 2022. This means that there are still around 0.37 percent of the Indonesian population who do not have access to electricity or there are still around 1.02 million Indonesians who do not have access to electricity. Electricity is a basic necessity for human life, both for personal and industrial use. High electricity consumption in a country is generally associated with rapid economic growth. This is due to several factors, including an increase in per capita income, global economic expansion, and technological developments. Increased electricity consumption also drives the growth of the manufacturing industry, as this industry is highly dependent on electricity.

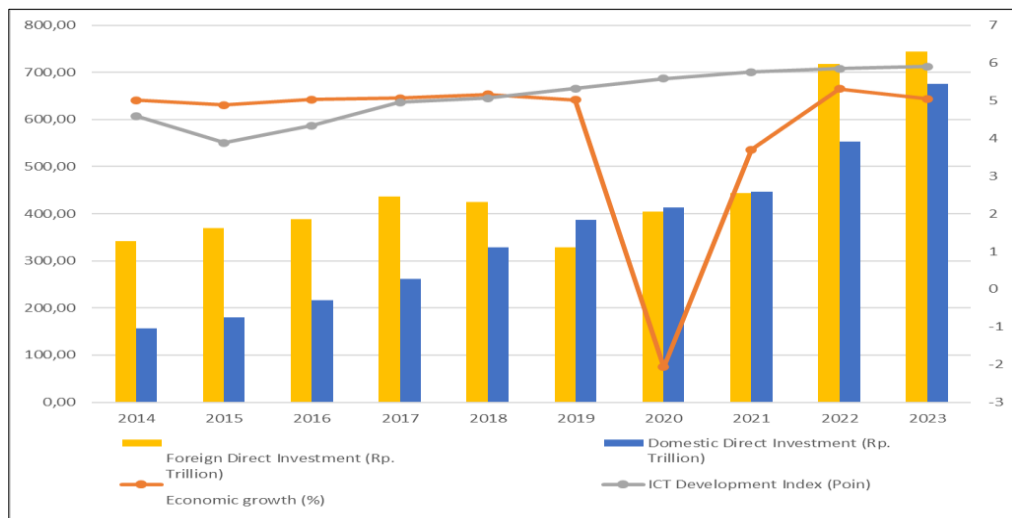


Figure 2. Development of telecommunication infrastructure, investment and economic growth in Indonesia 2014-2023 (Source: Statistics Indonesia)

In addition to road and electricity infrastructure, telecommunications infrastructure also plays an essential role in economic development. The last 25 years have seen dramatic technological changes, including the growth of telecommunications, the spread of the Internet, and the widespread use of mobile phones and portable electronic devices [9]. Adequate telecommunications infrastructure can increase productivity by facilitating communication and collaboration between individuals and companies and increase competitiveness by making it easier for companies to access new information and technology, which in turn encourages corporate innovation and creativity [31,32]. In Indonesia, the development of telecommunications network infrastructure is proxied by the Information and Communication Technology Development Index (IP-ICT). Figure 1.2 shows that the IP-ICT in Indonesia has consistently increased from year to year in the last 10 years, with an average increase of 0.2

points per year. This condition is much different from the development of economic growth, which tends to stabilize at five percent. In terms of position, Indonesia's ICT development is moderate as indicated by the ICT Development Index value which is in the range of 5 on a scale of 10. This figure is still lower than that of developed countries, such as South Korea at 8.85 and the UK at 8.65 [33].

Figure 2 also shows that, in the period 2014-2023, there was a significant increase in investment in Indonesia, this is characterized by an upward trend in Foreign Direct Investment (FDI) and Domestic Direct Investment (DDI). Although there was a decrease in FDI in 2019, however, in terms of development until 2023, investment in Indonesia tends to increase. In general, the size of economic growth is influenced by private capital related to the value of investment to increase a country's capital stock known as investment [34]. This is supported by the World Bank report which states that the importance of a big push in public investment in infrastructure by the government is not only to support productive investment but also to support the country's economic activity. Although investment is one of the important factors in driving economic growth, it is not certain that all investments in the infrastructure sector can have a direct and significant impact on economic growth. This is indicated by the level of economic growth that tends to stagnate.

Many studies have addressed the relationship between infrastructure and economic growth, with results suggesting that infrastructure plays an important role in driving economic activity [7–10]. In addition, there are not many studies that explain the relationship between investment and economic growth [17,34]. However, more specific studies on the effect of road, electricity and telecommunication infrastructure separately on investment and economic growth in Indonesia are still relatively limited. In addition, most previous studies have not deeply explored the role of investment as a mediating variable in the relationship between infrastructure and economic growth, especially in the context of a developing country like Indonesia. This study aims to fill this gap by analyzing the impact of each type of infrastructure on investment and economic growth in Indonesia and evaluating the extent to which investment can be a significant mediating mechanism.

Statistics Indonesia data showing a positive correlation between improvements in road, electricity, and telecommunications infrastructure and the amount of investment with an average economic growth of 5 percent in Indonesia in the 2014-2023 period, at first glance, indicates the government's success in encouraging economic growth through infrastructure development and investment. However, behind these growth figures, some gaps need to be considered more deeply. Although infrastructure and investment have experienced significant increases, the resulting economic growth has not been optimal. With considerable improvements in infrastructure and investment, economic growth is still stagnant at around 5 percent and has not reached its higher potential. This raises questions about the effectiveness of infrastructure development and investment in driving economic growth. Increased infrastructure and investment should have a greater impact on national productivity and competitiveness, but the results have not fully met expectations. This study seeks to dig deeper into the mechanism of the relationship, especially by assessing the role of investment as a mediating variable that can strengthen the impact of infrastructure on economic growth. The results of this study are expected to provide input for the government in formulating more effective infrastructure development and investment policies, to improve people's welfare.

Materials and Methods

This study uses a quantitative approach by analyzing the effect of road infrastructure, electricity and telecommunications on economic growth (Model 1), the effect of road infrastructure, electricity and telecommunications on investment (Model 2) and the effect of investment on economic growth (Model 3) and the effect of road infrastructure, electricity and

telecommunications on economic growth with investment as a mediating variable. The data used in this study is panel data which is a combination of time series and cross section data. Because it is a combination of two types of data, panel data regression will have more observations [35]. In this analysis, the cross-section data consists of 34 provinces in Indonesia, and the time series covers the period from 2014 to 2023. The reason for choosing 34 provinces and the time span is because the required data is available in full and is considered to have represented Indonesia as a whole even though currently the number of provinces has reached 38 provinces, but research data in 4 new provinces is not sufficient, namely southwest Papua, southern Papua, central Papua and Highland Papua. Furthermore, to facilitate the interpretation of the analysis results and to overcome the problem of variable scale when the data has a very wide range of values, the independent variables and mediating variables in this study are transformed in the form of natural logarithms (ln). The secondary data collected in this study were obtained from the official website of Statistics Indonesia (BPS).

Table 1. Operational definition of variables.

Status	Variable Name	Symbol	Variable Definition	Units
Dependent	Economic Growth	EG	Gross Regional Domestic Product (GRDP) rate at constant 2010 prices of 34 Indonesian provinces.	Percent
Independent	Road Infrastructure	RI	Length of roads in good condition by all levels of government authority from 34 provinces in Indonesia.	Kilometers
	Electricity Infrastructure	EI	The amount of electricity distributed from 34 provinces in Indonesia.	Gigawatt-hour
	Telecommunication Infrastructure	TI	Percentage of the population aged 5 years and over who have ever accessed the internet from 34 provinces in Indonesia.	Percent
Mediation	Investment	IV	Realization of Gross Fixed Capital Formation at constant 2010 prices of 34 provinces in Indonesia.	Rupiah

The researcher will reveal the results of regression analysis and path analysis (Sobel test). This involves identifying the optimal regression model of panel data, checking classical assumptions, panel data regression analysis from 2014 to 2023 in 34 provinces in Indonesia, as well as the presentation and significance of the results. The significance of the mediating effect in this study uses the Sobel Test. The Sobel test is conducted by testing the strength of the indirect effect of the independent variable (X) to the dependent variable (Y) through the mediating variable (M) [16]. Based on the analysis of the basic equation of the panel data regression model, the model equation analyzed in this study is divided into 3 equations (direct effect) using the semi-log model as follows.

The direct effect of infrastructure consisting of road infrastructure, electricity, and telecommunications on economic growth is written in the Equation 1 (Model 1).

$$EG_{it} = \beta_0 + \beta_1 \ln RI_{it} + \beta_2 \ln EI_{it} + \beta_3 TI_{it} + \varepsilon_{it} \tag{1}$$

Furthermore, to analyze the influence of infrastructure variables consisting of road infrastructure, electricity, and telecommunications on investment (Model 2) is written in the form of the Equation 2.

$$\ln IV_{it} = \beta_0 + \beta_1 \ln RI_{it} + \beta_2 \ln EI_{it} + \beta_3 TI_{it} + \varepsilon_{it} \tag{2}$$

Lastly, to analyze the effect of investment variables on economic growth (Model 3), it is written in the form of the Equation 3.

$$EG_{it} = \beta_0 + \beta_1 \ln IV_{it} + \varepsilon_{it} \tag{3}$$

Where EG is economic growth, $lnRI$ is road infrastructure, $lnEI$ is electricity infrastructure, TI is telecommunication infrastructure, $lnIV$ is investment, β_0 is constant, $\beta_1-\beta_3$ are regression coefficients, ε is error term, i denotes the i^{th} subject, and t denotes the t^{th} year.

Panel data regression analysis is carried out through several stages, starting with model selection estimation. There are three stages of testing for the selection of the best model to be used in this study in model 1, model 2 and model 3 including: Chow Test, Hausman Test, and Lagrange Multiplier Test [36]. Furthermore, classical assumption testing aims to verify that the estimated parameter coefficients meet the Best Linear Unbiased Estimator (BLUE) criteria [37]. Given the number of observations in the study of 340 which exceeds the minimum threshold of 100 observations, normality testing is not relevant [35]. Meanwhile, the autocorrelation test assumption only applies to time series data. Therefore, autocorrelation testing on panel data is considered to have no informative value [38]. Thus, this study only tests two classical assumptions, namely: multicollinearity test and heteroscedasticity test.

Results and Discussion

Descriptive Statistics

Descriptive statistical analysis presents data on the characteristics of each variable used in the study, the data displayed consists of mean, median, maximum, minimum, and standard deviation values. The data provides an overview of the distribution and variation of the variables used, table 2 shows the descriptive statistics of the variables used in the study in the period 2014-2023 for 34 provinces in Indonesia. Based on the data in the table, it can be seen that all variables have 340 observations. Economic growth (EG) has an average (mean) of 4.58 percent, a maximum value of 22.94 percent and a minimum value of -15.74 percent. Descriptive statistics of road infrastructure (LN_RI) obtained an average value of 9.47 maximum value of 10.97 minimum value of 8.06 and the median value is 9.48. While the electricity infrastructure variable (LN_EI) has an average value of 7.82, a maximum value of 10.97, a minimum value of 5.19 and a median value of 7.77. Telecommunications infrastructure (TI) obtained an average value of 41.31, a maximum value of 85.55, a minimum value of 5.84 and a median value of 39.73. Finally, investment (LN_IV) obtained an average value of 31.50, a maximum value of 34.26, a minimum value of 29.28 and a median value of 31.33.

The data used in this study qualifies for regression analysis because it has a relationship between the independent variable and the dependent variable that can be measured quantitatively. In addition, the data has sufficient variation in the independent variables. Thus, this data can be used to generate a valid and reliable regression model.

Table 2. Descriptive statistics.

Statistic	EG	LN_RI	LN_EI	TI	LN_IV
Mean	4.581794	9.473974	7.824354	41.31003	31.50261
Median	5.085000	9.482541	7.770645	39.73500	31.33217
Maximum	22.94000	10.65775	10.97788	85.55000	34.26785
Minimum	-15.74000	8.065579	5.192957	5.840000	29.28948
Std. Dev.	3.464380	0.642156	1.386132	19.88654	1.148576
Observations	340	340	340	340	340

The Results of Panel Regression Model Selection

The Chow test is conducted to determine the best model between the Common Effect Model and the Fixed Effect Model that will be used to estimate panel data. Based on Table 3, the prob value of the Cross-section Chi-square is smaller than alpha (α) ($0.0000 < 0.05$), so H_0 is rejected. The next test is the Hausman Test. This test aims to select the most appropriate model between the Fixed Effect Model and the Random Effect Model that will be used to estimate panel data.

Table 3 shows that the prob value of Cross-section random is smaller than alpha (α) (0.046 and 0.023 <0.05), which means H0 is rejected. The Lagrange Multiplier test is no longer conducted because the results of the Chow Test and Hausman Test have confirmed that the Fixed Effect Model (FEM) is the best model for the three equations.

Table 3. Results of Chow Test dan Hausman test (Model I, II, and III)

Model	Test	Effects Test	Stat.	d.f.	Prob.	Conclusions
Model I	Chow Test	Cross-section F	3.219	(33,303)	0.000	FEM
		Cross-section Chi-square	102.201	33.000	0.000	
	Hausman Test	Cross-section random	7.993	3.000	0.046	FEM
Model II	Chow Test	Cross-section F	131.027	(33,303)	0.000	FEM
		Cross-section Chi-square	926.810	33.000	0.000	
	Hausman Test	Cross-section random	36.233	3.000	0.000	FEM
Model III	Chow Test	Cross-section F	3.267	(33,305)	0.000	FEM
		Cross-section Chi-square	102.935	33.000	0.000	
	Hausman Test	Cross-section random	5.132	1.000	0.023	FEM

The Results of the Classical Assumption Test

The classic assumption test is carried out using the multicollinearity test and heteroscedasticity test. Heteroscedasticity testing using the RESABS method in the analysis tool with the provisions of the probability value, namely if the probability value of each variable is greater (>0.05) with an alpha level of 5%, heteroscedasticity does not occur.

Based on the results in Table 4, the heteroscedasticity test results are carried out by regressing the independent variables with absolute residuals (RESABS). The regression results in models I, II, and model III show that all variables in the model show a probability value greater than alpha (α) prob> 0.05, so it can be concluded that the model is free from symptoms of heteroscedasticity.

Table 4. Heteroscedasticity test results.

Model	Variable	Coef.	Std. Er.	t-stat.	Prob.
Model I	LN_RI	0.8641	1.5619	0.5532	0.5805
	LN_EI	-0.2792	0.8669	-0.3220	0.7476
	TI	0.0249	0.0114	2.1748	0.0604
Model II	LN_RI	0.0415	0.0393	1.0572	0.2912
	LN_EI	-0.0045	0.0218	-0.2099	0.8339
	TI	0.0001	0.0002	0.3902	0.6966
Model III	LN_IV	0.6409	0.6857	0.9345	0.3508

To detect whether or not there are symptoms of multicollinearity can be seen from the magnitude of the correlation coefficient of each variable. If the value of the partial correlation coefficient of the variables is greater than 0.80, there are symptoms of multicollinearity, and vice versa [35]. Based on the results of Table 5, it is known that the correlation matrix value between each variable is smaller than 0.80, where the correlation value of the Road Infrastructure variable (LN_RI) with the Electricity Infrastructure variable (LN_EI) and Telecommunications Infrastructure (TI) and investment (LN_IV) has a correlation of 0.4596; -0.1313; 0.5312; 0.3445; 0.7233 and 0.3029 <0.80. This indicates that there are no multicollinearity symptoms between the variables used in this study.

Table 5. Multicollinearity test results.

Independent Variable	LN_RI	LN_EI	TI	LN_IV
LN_RI	1.000000			
LN_EI	0.459688	1.000000		
TI	-0.131348	0.344549	1.000000	
LN_IV	0.531251	0.723305	0.302929	1.000000

The Results of Direct Effect Estimation

In model I analysis, the best model used is the FEM model, this model analyzes the direct effect of Ln_RI, Ln_EI, and TI variables on EG. While in the model II analysis, the FEM model was again selected as the best model. This model is then used to analyze the direct effect of Ln_RI, Ln_EI, and TI variables on Ln_IV. The estimation results of the three models are presented in Table 6. Based on the data from the analysis of model I, it can be concluded that the Ln_RI variable has an insignificant effect on EG. Ln_EI variable has a positive and significant effect on EG, while TI has a negative and significant effect on EG. Based on the F test, it is known that the F-statistic value is 3.398 with a p-value = 0.0000 <0.01. These results indicate that with a significance level of 1 percent road infrastructure, electricity infrastructure, and telecommunications infrastructure together (simultaneously) have a significant effect on economic growth in Indonesia.

Table 6. Panel data regression results for model I, II, and III.

Model	Variable	Coef.	Std. Er.	t-stat.	Prob.
Model I	LN_RI	-3.399678	2.337426	-1.454453	0.1469
	LN_EI	3.002012**	1.297362	2.313935	0.0213
	TI	-0.054939***	0.017167	-3.200233	0.0015
	R-squared	0.287643			
	Adj. R-squared	0.203007			
	F-stat.	3.398573			
	F-stat. (Prob.)	0.000000			
Model II	LN_RI	-0.074727	0.085461	-0.874396	0.3826
	LN_EI	0.409895***	0.047434	8.641318	0.0000
	TI	0.002349***	0.000628	3.741801	0.0002
	R-squared	0.991337			
	Adj. R-squared	0.990307			
	F-stat.	963.0973			
	F-stat. (Prob.)	0.000000			
Model III	LN_IV	2.112633**	1.009270	2.093228	0.0372
	R-squared	0.264533			
	Adj. R-squared	0.182546			
	F-stat.	3.226539			
	F-stat. (Prob.)	0.000000			

Note: *** and ** indicate significance at the 1% and 5% levels, respectively.

Furthermore, the results of model II analysis show that the Ln_RI variable does not affect the Ln_IV variable while the Ln_EI and TI variables have a positive and significant effect on the Ln_IV variable with the coefficient of each variable of 0.40 and 0.002. where there is an increase in the Ln_EI variable by 1 percent, it will increase the Ln_IV variable by 0.4 percent as well as when there is an increase in the TI variable by 1 percent, it will increase the Ln_IV variable by 0.002 percent. Based on the F test, it is known that the F-statistic value is 963.097 with a p-value = 0.0000 <0.01. These results indicate that with a significance level of 1 percent, it can be concluded that road infrastructure, electricity infrastructure, and telecommunications infrastructure together (simultaneously) have a significant effect on investment in Indonesia.

Then in model III, the Ln_IV variable has a positive and significant effect on the EG variable with a coefficient of 2.11 where when there is an increase in the Ln_IV variable by 1 percent, it will increase the EG variable by 2.11 percent.

The Results of Indirect Effect Estimation

The Stages 1-3 of the direct effect analysis results must show significant results. Furthermore, assuming that stages 1-3 show significant effect results and at stage 4 the analysis results show an insignificant effect, the mediating variable is called full mediation and if it shows a significant effect, it is called partial mediation [16]. Calculating the significance of investment mediation on the effect of road infrastructure, electricity infrastructure, and telecommunications infrastructure on economic growth is done with the Sobel test.

Table 7. Sobel test estimation results.

Variable	Sobel Test Value		
	t-stat	Std. Er.	Prob.
LN_RI	-0.8628	0.6929	0.3882
LN_EI	4.5277	0.7242	0.0005
TI	3.0590	0.0061	0.0022

Note: t-table value = 1.967049

Table 7 shows that the significance of investment mediation on the effect of road infrastructure on economic growth is $0.3882 > 0.05$. Thus it can be concluded that investment does not mediate the effect of road infrastructure on economic growth in Indonesia. Furthermore, electricity and telecommunications infrastructure shows that the significance of investment mediation on economic growth is 0.0005 and $0.0022 < 0.05$. Thus it can be concluded that investment can mediate the effect of electricity and telecommunications infrastructure on economic growth in Indonesia. The partial mediation effect occurs in the electricity and telecommunications infrastructure variable because the electricity and telecommunications infrastructure variable affects economic growth both directly and indirectly through the investment variable.

Discussion

The results of the analysis show that road infrastructure does not have a significant effect on economic growth in Indonesia, this is in line with studies in India showing the existence of a long-term equilibrium relationship between road transportation infrastructure and macroeconomic variables which shows that road improvements can increase output and employment, that road infrastructure can have a significant effect in the long run [39]. The effects of road construction do not directly impact economic growth but it takes time in the long term for this effect to be felt by the community such as growing new economic centers. Partial test results of electricity infrastructure has a significant effect on economic growth, based on research in China and ASEAN member countries, the research findings show that the development and improvement of electricity network infrastructure can optimize the allocation of electricity resources and encourage regional economic growth while improving the quality of life of the people [10,40]. With the availability of reliable electricity, schools and hospitals can operate more effectively. This increases access to education and health for the community. In addition, it also allows the community to enjoy various basic services such as lighting, clean water, and telecommunications which ultimately encourage economic development and improve the quality of life of the community.

Telecommunication infrastructure has a negative effect on economic growth in Indonesia. This result is in line with the study conducted by Prasetyo [41] which states that telecommunications infrastructure hurts economic growth in ASEAN. The development of telecommunications infrastructure in ASEAN does not directly affect economic growth, this is because the development of telecommunications infrastructure alone has not been able to stimulate economic growth. It is important to build other factors such as a conducive business environment to increase investment, transportation networks to improve the quality of basic infrastructure, education to improve the quality of the workforce, and increasing expert skills that will later be

able to optimize the existing telecommunications system. If the development of telecommunications infrastructure continues to be carried out without being supported by the development of other factors in parallel, the potential benefits that should be obtained from the development of telecommunications infrastructure will be limited. Another study found a negative impact of telecommunications infrastructure on economic growth in several countries, concluding that ICT plays a major role in the growth of the upper and middle-income groups, but fails to contribute to the growth of lower-middle-income countries [42].

Then, Road infrastructure, electricity infrastructure, and telecommunications infrastructure together (simultaneously) have a significant effect on economic growth in Indonesia. This finding is in line with research [7,31,43,44] which states that infrastructure (roads, electricity, and telecommunications) has an influence on economic growth in a region. According to Rodrik [45] the main principle of the inclusive growth theory includes the development of infrastructure that can connect people to economic opportunities and increase their access to essential services. As is known, there is an imbalance in the availability of infrastructure in Indonesia. This condition is due to the uneven distribution of the population, so that much infrastructure is more concentrated on the island of Java which has the largest population with economic activity in Indonesia. As a result, economic growth on the island of Java is better and more stable compared to other islands (regions) in Indonesia.

The results of the analysis of the influence of infrastructure on investment show that road infrastructure does not have a significant influence on investment in Indonesia. These results are in line with the findings of Mahyoga & Sri Budhi [46] which concludes that road infrastructure does not have a significant effect on investment in Bali Province for the 2016-2020 period, the imbalance in development between districts in Bali is still experiencing inequality as a result of uneven infrastructure, the lack of complete infrastructure including transportation and road facilities to support economic activities is still considered inadequate, causing investors to be more interested in investing in South Bali only.

Meanwhile, electricity and telecommunications infrastructure have a positive and significant impact on investment in Indonesia. The findings of Khan et al. [47] show that there is a long-run causal relationship between energy and foreign investment. The study confirms that energy consumption and its infrastructure attract foreign investors positively. Previously the findings of Dong et al. [48] emphasized that the presence of energy infrastructure will increase FDI inflows in China. This means that developed countries such as China, with low greenhouse gas emission restrictions, will attract more FDI. Foreign companies choose a country as a destination to invest based on the availability of good energy infrastructure guarantees. Energy can go beyond the production stage and increase the productivity and efficiency of companies in various ways. For example, Information and Communication Technology requires electricity infrastructure and creates information flows that indirectly reduce the time, distance, and costs of companies. Likewise, the transportation sector requires energy, which indirectly reduces delivery time. Then telecommunications infrastructure has the potential to increase a country's ability, especially developing countries, to attract foreign investment. The research results of Suh & Boggs [9] confirmed that telecommunications infrastructure networks were an important factor in foreign investment in 19 developing countries and 19 developed countries from 1995 to 2004. Previously, Dewan & Kraemer. [49] reported that telecommunications and information infrastructure networks have a positive and significant influence on foreign investment in developed countries.

Based on the F test, road infrastructure, electricity infrastructure, and telecommunications infrastructure simultaneously have a significant influence on investment in Indonesia [25,31]. Mankiw [50] argues that the availability of various types of infrastructure is one of the non-economic factors that can influence investment in a region. This opinion is in line with the current picture of infrastructure availability in Indonesia where there is a fairly large gap in the

Indonesian region. The descriptive analysis shows that the availability of infrastructure (roads, electricity, and telecommunications) is highly concentrated in the provinces on the island of Java. This condition directly affects the size of investment entering Java where during the 2014-2023 period it was recorded that the largest investment realization in Indonesia was in West Java Province in 2023, which was 210.6 trillion rupiah. Meanwhile, the availability of infrastructure outside Java in general still has several challenges compared to Java. Some of the main challenges are budget limitations, where the budget allocation for infrastructure development outside Java is often smaller than that of Java. In addition, the factor of area and geographical conditions outside Java is generally wider and has more diverse geographical conditions, so infrastructure development becomes more complex and expensive.

Analysis of the influence of investment has a positive and significant effect on economic growth. This result is in line with studies conducted by several previous literature confirming that investment has an important effect on economic growth, such as by Xiaojuan [51]. His research showed that foreign capital has a positive impact on the transformation of economic growth patterns and improving the quality of economic growth in China. Meanwhile, Isma et al. [52] and Juliansyah et al. [53] concluded that investment has a positive and significant impact on economic growth in Aceh Province and is one of the main factors contributing to the province's human development progress [54]. Furthermore, Harrod and Domar [55] stated that investment has an important role in the economic growth process, namely by creating income and increasing the production capacity of the economy through increasing capital stock. Thus, the availability of adequate infrastructure and the amount of investment that comes in have an impact on economic growth in a region.

The results of the mediation influence analysis, it can be concluded that investment does not mediate the influence of road infrastructure on economic growth in Indonesia. Based on research by Sumadiasa et al. [56], investment is not a mediating variable in the influence of road infrastructure development on GRDP growth in Bali Province in 1993-2014. In this study, road infrastructure has not provided significant results because road conditions in Bali Province are not evenly distributed. Roads are built focusing on urban areas while rural areas are still lagging behind, the imbalance in development between districts in Bali still experiences inequality as a result of uneven infrastructure, and the lack of complete infrastructure including transportation and road facilities in supporting economic activities is still considered inadequate causing investors to be more interested in investing in South Bali only, so that several districts such as Bangli Regency have difficulty getting investors.

Meanwhile, investment can mediate the influence of electricity and telecommunications infrastructure on economic growth in Indonesia. The partial mediation effect occurs in the electricity and telecommunications infrastructure variables because the electricity and telecommunications infrastructure variables affect economic growth both directly and indirectly through the investment variable. These results confirm the findings of Miao [57] and Pradhan et al. [8], explained that in general, the entry of foreign direct investment can promote a country's economic growth with its internal mechanisms being the process flow, management experience, advanced telecommunications infrastructure network, and others brought by foreign direct investment. Massive investment in various power generation projects especially widespread power grid infrastructure will help overcome the power crisis in Pakistan [58]. On the other hand, investment in energy infrastructure can improve social welfare for basic living needs for several important energy resources, such as gas, electricity, etc. [59]. Another study conducted by Yang et al. [60] proved that investment in energy infrastructure (electricity) was able to mediate the influence of energy infrastructure networks (electricity) on economic growth in China in the period 2000-2014.

From the results of the analysis, it is known that investment is a partial mediation of the influence of infrastructure on economic growth in Indonesia [10,17]. This fact shows that

investment can act as a bridge between two other variables (infrastructure and economic growth). This means that investment is not only influenced by infrastructure but also independently influences economic growth. As is known, infrastructure can encourage investment in a region such as good infrastructure (roads, ports, airports, etc.) facilitating the mobility of goods and services, thus attracting investors to invest. On the other hand, investment is also called a driver of economic growth through various channels, such as job creation. With the entry of new investment, it will create jobs, increase people's income, and encourage consumption. In addition, investment often brings new technology that increases productivity and efficiency. As a result, there is a reciprocal influence, where good infrastructure attracts investment, and large investment can encourage further infrastructure development.

Conclusions

This study analyzes the effect of infrastructure, represented by roads, electricity, and telecommunications, on economic growth in Indonesia, with investment as a mediating variable. It utilizes panel data from 34 provinces in Indonesia during the period from 2014 to 2023. The statistical test results show that infrastructure has a significant effect on investment. This study also demonstrates that both infrastructure and investment significantly impact economic growth. The mediation test results conclude that investment is able to partially mediate the effect of infrastructure on economic growth.

This finding has important implications for the economy, as infrastructure and investment can be effective strategies to boost economic growth in Indonesia. Focusing on one type of infrastructure alone will not yield optimal results. A better approach is to build infrastructure that is integrated and tailored to the needs and potential of each region. Thus, infrastructure development can make a significant contribution to economic growth. For this reason, government policies such as building integrated industrial estates equipped with complete infrastructure will attract investors to invest. In addition, simplifying licensing procedures and providing one-stop services will facilitate investors in setting up businesses.

This study is not without its shortcomings, as some variables that may affect economic growth, such as political conditions and the level of corruption, have not been included in the analysis. Furthermore, this study is limited to data from 34 provinces in Indonesia over a period of only 10 years, so generalization of the results to other countries or longer time spans should be approached with caution. Future research can include other important variables with wider area coverage and longer time periods, using the Error Correction Model (ECM) or Autoregressive Distributed Lag (ARDL) approach to provide a more comprehensive picture of the effect of infrastructure on economic growth.

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