

# Analysis of human capital for infrastructure development relation to industrialization in Indonesia



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## ABSTRACT

This research aims to analyze the value-added between infrastructure and industrialisation in Indonesia and both as critical aspect that supports the achievement of 9 Sustainable Development Goals (SDG). SDG 9 focuses on building durable infrastructure, promoting inclusive and sustainable industrialisation, and encouraging innovation. This research focuses on analyze the impact of infrastructure on the level of industrialisation, taking into account the modulation by human capital. Data analysis was conducted using Stata version 16 software with the aim of testing the direct impact of variables as well as testing the indirect impact through the application of the Sobel test. The Sobel test aims to analyse the dataset from 1990-2022. This research specifically explores the Indonesian context as a case study, identifying infrastructure variables that are significant in shaping the level of industrialisation in the country. In addition, this research involves an in-depth analysis of the role of human capital in moderating the impact of infrastructure on the level of industrialisation. The significance of this research lies in its potential to address critical knowledge gaps in understanding the complex interplay between infrastructure development, industrialization, and economic growth in Indonesia. The implication of the study that investment on infrastructure for industrialization can absorb labor.

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## 1. Introduction

A country's economic growth is a complex domain that is closely related to various factors, and in an effort to drive industrial progress, infrastructure development is a key element that cannot be ignored (Todorović & Kalinović, 2022). As Indonesia strives to accelerate its economic growth, attention to infrastructure development is becoming increasingly important, as a foundation for improving competitiveness and achieving higher levels of industrialization (Nawir et al., 2023). However, to holistically understand the impact of infrastructure development on the industrialisation process, we need to detail the linking role of human capital management. The apparent delay in the process of economic development in Indonesia includes several aspects that require serious attention (Amalia et al., 2023). Inadequate infrastructure issues, especially in the transport and energy sectors, also contribute to the delay in economic development (Rabe et al., 2020). Inadequate infrastructure can hinder the distribution of goods and services, increase logistics costs, and slow the growth of related sectors (Mbedzi & Kapingura, 2023).

Infrastructure development in this context does not only refer to physical aspects such as the construction of roads, ports and bridges, but also includes non-physical dimensions, including improvements in the quality of human resources (Peng, 2023). Through this research, we aim to delve

deeper into the impact of infrastructure development on industrialisation, taking into account the important mediating role of human resource management. An in-depth analysis of how infrastructure development can affect the growth of the industrial sector is the main basis of this research framework (Mačiulytė-šniukienė et al., 2022). A thorough understanding of the linkages between infrastructure development, finance and human capital is expected to provide valuable insights for economic policy formulation in Indonesia (Priyanta & Zulkarnain, 2023). By focusing on this complex relationship, this research also aims to contribute conceptual and empirical thoughts to the scientific literature related to economic development (Ghura et al., 2017).

Industrialisation in Indonesia has been one of the main focuses in an effort to strengthen the country's economic structure (Zalva et al., 2023). This process of industrialisation started since the beginning of Indonesia's independence, but gained greater momentum in the last few decades (Aswicahyono & Hill, 2016). Along with significant economic growth, the Indonesian government has endeavoured to boost the industrial sector as the backbone of the national economy (Harahap et al., 2023). Financial development plays an important role not only in project realisation, but also in relation to overall economic well-being (Hunjra et al., 2022). The availability of good financial services can open up access to capital for businesses and development projects, which in turn can increase productivity and economic growth (Magazzino & Santeramo, 2023). In addition, financial development also has a direct impact on people's welfare (Click & Dobbins, 2020). Active engagement in financial services can provide access to banking, insurance, and investment products, which in turn can improve the financial stability of individuals and families.

Given that investments in infrastructure development and maintenance require skilled labour, sustainable infrastructure development policies should seriously integrate human resource aspects for project effectiveness and sustainability (Hayes et al., 2023). Therefore, necessary measures include the provision of appropriate skills training and educational upgrading to enable the workforce to meet the demands of increasingly complex infrastructure projects (Irianto et al., 2022). Thus, it can not only have a positive impact on economic growth, but also play a role in poverty alleviation efforts through the creation of quality jobs and overall economic empowerment of the community (Erlando et al., 2020). Human resources are a critical element in the dynamics of an organisation or society, involving individuals who bring expertise, knowledge, skills and potential to achieve common goals (Lionel et al., 2023). In the context of business and management, human resources also refer to aspects such as productivity, motivation, and job satisfaction that can affect the overall performance of the company (Ariani, 2023). Therefore, human resource management is key in creating a productive, innovative and sustainable work environment (Piwovar-Sulej, 2020).

Based on theoretical framework, researchers can establish a robust foundation for comprehending the interrelations among various variables and associated phenomena. Moreover, this study identifies research gaps, such as the inadequate understanding of the role of human capital management in linking infrastructure development with industrialization, as well as the lack of comprehensive analysis considering both physical and human aspects in infrastructure development. While previous studies have acknowledged the importance of infrastructure development for economic growth, this study uniquely emphasizes the crucial role of human capital management in mediating the relationship between infrastructure development and industrialization. By highlighting this aspect, the study adds depth to the understanding of how infrastructure investments can translate into economic progress by focusing on the development and utilization of human resources. The research expansion involves further exploration of the impact of technology on infrastructure development, deeper understanding of environmental and social aspects, involvement of the private sector in infrastructure projects, as well as evaluation of the performance of built infrastructure to strengthen understanding of the relationship between infrastructure development, industrialization, and economic growth in Indonesia. Thus, through this research, we hope to achieve a deeper understanding of the dynamics of Indonesia's economic growth, especially in achieving higher levels of industrialisation. Through this understanding, we hope to identify opportunities and challenges that Indonesia may face in achieving sustainable and inclusive economic growth.

## 2. Literature Review

### 2.1. Relationship between Infrastructure and Industrialization

Theoretically, the availability of adequate and efficient infrastructure not only improves people's quality of life but also promotes rapid industrialisation. Infrastructure and industrialisation are two

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interrelated and important concepts in a country's development. Infrastructure development in Indonesia is essential to drive economic growth and improve the standard of living of the Indonesian people. Infrastructure development, such as telecommunication infrastructure, transport network infrastructure, and public-private partnerships, plays an important role in achieving inclusive economic growth, reducing inequality, and addressing unemployment (Gati & Khoirunnurrofik, 2023). Development economists view physical infrastructure as a prerequisite for industrialisation and economic development, where physical infrastructure generally consists of two parts as follows: economic infrastructure such as telecommunications, roads, irrigation and electricity, and social infrastructure such as water supply, sewerage systems, hospitals and schools (Murphy et al., 1989). Therefore, infrastructure and industrialisation go hand in hand in achieving sustainable development in any economy (Prakash, 2018).

Endogenous economic growth theory by Romer (1986), Lucar Jr (1988) and Barro (1990) emphasises the importance of investment in human capital, innovation and technology to drive economic growth. Infrastructure is considered a supporting factor that facilitates technology transfer, communication, and distribution of production. Optimal infrastructure will trigger economic growth, while conversely, economic growth will increase the need for infrastructure. For example, transport systems provide facilities for the mobility of people and goods, which contributes to boosting trade and production activities. The existence of an efficient transport and trade infrastructure network has a positive impact on strengthening trade in an integrated space. Reduced transport costs may have varying impacts depending on the sector in question in the context of market expansion and transaction volumes (Azarnert, 2016). Reduced transport costs for industrial goods may result in convergence in growth rates among trading economies. Conversely, a reduction in transport costs for non-industrial goods may play a role in further increasing divergence between countries.

An efficient system, supported by high demand, spurred by local product diversity, leads to market expansion and fosters the growth of inter-regional trade. This creates an attraction for firms interested in sustainable profits. On the other hand, infrastructure that supports inter-regional trade generates centripetal forces that magnify disparities associated with differences in capital intensity. Therefore, customised infrastructure is the starting point for successful regionalization (Yang & Hamaguchi, 2013). It overcomes limitations resulting from unfavourable economic geography, stimulates mobility factors in the growth cycle, attracts efficient agents, and facilitates interregional competition through cross-regional exchanges. Theoretically, infrastructure development in African regions can influence the industrialisation process through a number of channels and mechanisms. For example, there are several mechanisms that explain how the spread of Information and Communication Technology (ICT) affects industrial development. One of the main mechanisms is through the creation of new firms. ICT deployment is consistently associated with the emergence of new businesses, especially in the manufacturing and services sectors (Aboal & Tacsir, 2018). Startups generally specialise in the production of useful technologies, especially those related to the use of computers and the internet. With the introduction of Information and Communication Technology (ICT), the possibility of new services emerging in the primary sector can influence industrialisation, especially through its impact on employment. In addition to efforts to help Indonesian manufacturers access digital inputs more effectively, the Indonesian government can also leverage digital technologies to improve public administration support for the industrialisation process. Digitalisation has the potential to improve the efficiency and productivity of services related (Chenic et al (2023) to manufacturing, such as customs administration, general logistics, and so on, thereby supporting the development of the industrial sector.

## 2.2. Empirical Evidence of Relationship between Infrastructure and Industrialization

Empirically, several studies have proven the relationship between infrastructure and industrialisation. The development and utilisation of Information and Communication Technology (ICT) has been shown to be positively correlated with industry productivity levels (Chancellor, 2023; Maciulyte-Sniukiene & Butkus, 2020). Based on empirical studies, investments and advancements in ICT directly affect productivity, although the effects can be felt after a certain period (Mahmood et al., 2021). Furthermore, the impact of ICT development on productivity shows greater magnitude in countries with higher productivity levels compared to countries with lower productivity levels (Antonioli et al., 2018). ICT infrastructure development has been found to have a positive and significant influence on manufacturing output in middle-income countries. This relationship has been observed in the case of North African countries (Kocsis & Xiong, 2022). According to Prasetyo &

Rini (2023) ICT has a positive and significant effect on Indonesian industrialisation. By applying the Generalised Moments (GMM) method, it is presented that Information and Communication Technology (ICT) has a positive and meaningful impact on the industrialisation process (Ježić et al., 2022).

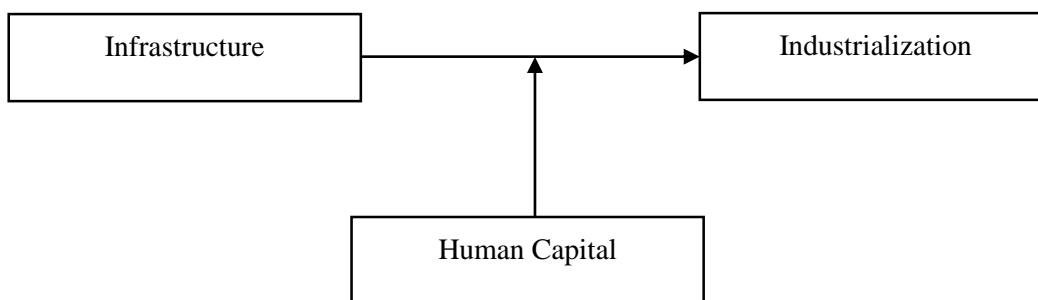
The marginal impact on manufacturing productivity, as measured by total capital, by electricity and transport infrastructure is estimated to be relatively comparable (Chen & Lin, 2021). Furthermore, there are no specific references to studies that have conducted regression analyses of total factor productivity levels considering electricity generation capacity in 112 countries over the period 1970 to 2000. Countries were classified into five groups based on the income levels set by the World Bank. The findings showed a positive and significant relationship between energy infrastructure and total factor productivity. Overall, the results support the view that investment in infrastructure can provide impetus to the industrialisation process at the expected level in developing countries. Investment in energy infrastructure has a positive and significant effect on total factor productivity, driving industrialisation in developing countries to the desired level (Telatar, 2015). The effect of infrastructure on productivity in the manufacturing sector has been the focus of research for a number of scholars. Arshed et al (2022) revealed the results of their study that showed a positive and significant impact of infrastructure, such as roads, telecommunications, and electricity supply, on manufacturing sector productivity. Khanna & Sharma (2021) argue public infrastructure, which includes electricity, energy, telephones, roads, railways, and ports, exerts a positive and significant influence on productivity growth in the manufacturing sector.

Overall, while the significant role of infrastructure development in accelerating manufacturing sector performance has been recognised in the literature, some findings suggest that infrastructure can also have a negative impact on the industrialisation process. The literature shows that the relationship between infrastructure and industrialisation in panel samples in Indonesia suffers from significant limitations. In addition, most studies use a single infrastructure index, which hinders our ability to evaluate the impact of various infrastructure indicators on industrialisation. Furthermore, none of these studies attempted to analyse the indirect relationship between infrastructure and industrialisation through human capital development and financial aspects. The main objective of this study is to fill the gap in the literature related to analysing the impact of infrastructure development on the industrialisation process. Indonesia's ability to establish a competitive industrial sector and promote closer industrial linkages is hampered by the lack of quality infrastructure, including in the aspects of energy, transport, and communication, which leads to higher transaction and production costs. Therefore, increased investment in the infrastructure sector, especially energy, is crucial. In order to achieve this goal, development finance is an instrument that governments can rely on to strengthen these investments to improve the competitiveness of the industrial sector. In addition, to capture the long-term impact of infrastructure development on the industrialisation process, emphasis needs to be placed on developing human resources with the capacity to care for and maintain the infrastructure. financial development and human resource development are considered important factors explaining performance differences among developing countries, particularly in the industrial sector, it is necessary to determine their role in the context of the relationship between development and industrialisation.

### 3. Method

The dependent variable of this study is industrialisation. In this study, it is proxied by manufacturing value added (MVA) and industrial value added per capita (IVAK). Studies using similar measures include (Wolde, 2022b; Wolde, 2022a). An interesting independent variable in this study is infrastructure development. Study from Herdiansah & Pangestuty (2022) and Naufal et al (2023) infrastructure development is proxied by Indonesia's infrastructure development index. This index is a composite index of infrastructure that includes a composite index of transport (Transport), a composite index of electricity (Electricity), a composite index of information technology and information and communication technology (ICT) and a composite index of water and sanitation (WSS). Priyanta & Zulkarnain (2023) argue that infrastructure development is essential for structural transformation in Indonesia. Therefore, the control variables used in this study are. Other control variables also used are foreign direct investment (FDI) inflows, trade openness, economic growth (GDPK), and human capital (Hc).

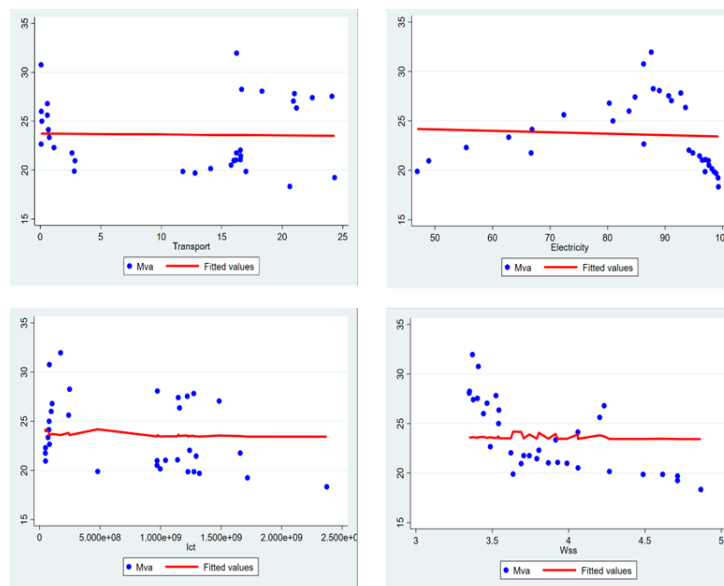
Faizah et al (2021) stated that ICT infrastructure, including mobile phone ownership, internet accessibility, and the number of Base Transceiver Stations (BTS), contributed significantly to economic growth in Indonesia. In contrast, it shows that infrastructure spending on education and health has a negative influence on poverty reduction, while road infrastructure spending has no significant impact on poverty reduction (Arma et al., 2018). In this case, they argue that import trade, economic growth and financial sector development drive industrialization. Silajdzic & Mehic (2015) for their part argue that industrialisation through value addition driven by FDI has a positive impact on economic growth. From these literatures, FDI, trade, domestic credit, GDP are expected to have a positive sign in positive in this study. Bustaman et al (2022) aggregation of institutions as a composite index stated that institutional quality has a positive effect on industrialisation in Indonesia. Margiansyah (2017) Governance and human resources play an important role in improving industrialisation in Indonesia. The same result is expected in this study. Human capital is expected to have a positive sign in this study that showed on Figure 1.



Source: Author

Figure 1. The relation between infrastructure and industrialization.

The infrastructure variable is obtained from the data base, the rule of law is taken from the Worldwide Governance indicators of the World Bank and the remaining variables are obtained from the Worldwide Governance indicators of the World Bank. The data range from 1990 to 2022 for the country of Indonesia is largely based in part on the availability of data on the retained variables. Figure 2 presents the adjusted two-way scatter plot of infrastructure development in Indonesia.



Source: Author Calculation

Figure 2. Scatter plot of Pattern infrastructure development on industrialisation

Figure 2 shows the same pattern of an insignificant positive effect of infrastructure development on industrialisation. However, there is co-movement between economic variables both domestically as a result of national policies and internally as a result of globalisation and economic integration. This study, we used secondary data related to infrastructure, industrialisation and human capital, which were obtained through the official website of the Worldwide Governance Indicators of the World Bank. Given the time series nature of the data, we categorised it as time series data and conducted the analysis using Stata 16 and Sobel Test. Utilizing secondary data offers cost and time efficiencies,

larger sample sizes, longitudinal analysis capabilities, enhanced reliability, comparability across studies, and access to advanced statistical tools like Stata for complex analyses, thereby providing comprehensive insights across various research domains. This research methodology applies the estimation method using hypothesis testing to test the effect of the variables involved. Hypothesis testing is a method used to test the significance level of the relationship between variables in a study (Tyagi & Watanabe, 2023). Therefore, this study will test the direct effect of infrastructure on industrialisation, as well as the indirect effect by including human capital as a mediating variable.

#### 4. Results and Discussion

Descriptive statistical analysis in this study describes the values that reflect the characteristics of each research variable. The statistical parameters described involve the maximum value (maximum) and minimum value (minimum), average, and standard deviation. Table 1 shows that MVA has the highest value of 31.953 and the lowest value of 18.336, MVA has the average value of 23.627 and a standard deviation of 18.336. IVAK has the highest value of 48.061 and the lowest value of 38.238, with an average value of 42.813 and a standard deviation of 3.010. Transportation has the highest value of 24.320 and the lowest value of 0.075, with an average value of 11.748 and a standard deviation of 8.692. Electricity has the highest value of 99.270 and the lowest value of 46.900, with an average value of 85.436 and a standard deviation of 1,500. ICT has the highest value of 2.372.396,832 and the lowest value of 48.000.067, with an average value of 798.543.476 and a standard deviation of 636.814.794. WSS has the highest value of 4.866 and the lowest value of 3.348, with an average value of 3.854 and a standard deviation of 0.445. All these variables (MVA, IVAK, Transport, Electricity and ICT) has huge gape, it means that there has not been equitable development on these indicators.

**Table 1.** Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
MVA	23.627	3.623	18.336	31.953
IVAK	42.813	3.010	38.238	48.061
Transport	11.748	8.692	0.075	24.320
Electricity	85.436	1.500	46.900	99.270
ICT	798.543.476	636.814.794	48.000.067	2.372.396.832
WSS	3.854	0.445	3.348	4.866
FDI	9.269.032.284	9.551.256.520	-4.550.355.286	25.120.732.060
Trade	52.827	11.917	32.972	96.186
GDPK	2.146.409	1.425.928	459.192	4.787.999
HC	2.228	0.154	1.895	2.417

Source: data processed

In this study, all research models were found to not pass the multicollinearity test. However, issues related to heteroskedasticity and autocorrelation were detected in the research models. To address these problems, the researcher used a robust standard error approach. This was done to adjust the standard error for regression models with heteroskedasticity and autocorrelation issues, allowing statistical conclusions to be drawn and the regression models to be used. Additionally, the researcher encountered issues with the normality test conducted. The normality problem was addressed by converting the data for the ICT variable into natural logarithm form to reduce excessive data fluctuations. Table 2 shows the transportation system does not affect industrialization, whether proxied by MVA or IVAK. The absence of an effect is attributed to the fact that industrialization is mostly located in large cities. When the transportation system is functioning well, there is no discernible impact on industrialization. Contrary to previous studies Fagega & Gonzales-Aregall (2017); Kharel & Singh (2022) and Fretz et al (2022) revealing that more kilometers of highways lead to a decrease in industrial employment in nearby areas, while ports have a positive effect on industrial employment. Industrialization, measured by MVA, is not influenced by the reliability of electricity. However, when measured by IVAK, electricity negatively influences industrialization. Unreliable electricity can significantly limit industrial production, especially in developing countries where electricity supply is still unreliable and self-generation is costly. Smaller companies are more affected by unreliable electricity because they may have limited resources to invest in alternative resources or backup systems. The cost of generating electricity itself can be much higher for small companies,

making it more challenging for them to purchase reliable power. Smaller companies may have less bargaining power or influence to demand better electricity services from the government or utility providers. Limited access to reliable electricity can disrupt the production process and lead to more frequent disruptions, causing disproportionate productivity losses for smaller companies (Poczter, 2017).

**Table 2.** Result of Regression

Variables		MVA (1)	IVAK (2)	HC (3)
HC	Coef	27.560	39.941	
	Std error	(7.67)**	(9.54)**	
Transport	Coef	0.108	0.090	0.001
	Std error	(0.09)	(0.077)	(0.002)
Electricity	Coef	0.033	-0.166	0.007
	Std error	(0.06)	(0.074)*	(0.001)**
LnICT	Coef	-0.487	-0.254	0.035
	Std error	(0.41)	(0.437)	(0.015)*
WSS	Coef	4.338	4.522	-0.076
	Std error	(1.11)**	(1.502)**	(0.015)
FDI	Coef	0.001	0.002	
	Std error	(0.001)	(0.003)	
Trade	Coef	-0.045	0.089	
	Std error	(0.03)	(0.040)*	
GDPK	Coef	-0.006	-0.003	
	Std error	(0.01)**	(0.001)**	
C	Coef	-35.122	-43.337	1.172
	Std error	(19.47)	(21.136)	(0.220)**
R-Square		0.873	0.821	0.960

Note: \* The correlation is significant at the level 0.05 and \*\* The correlation is significant at the 0.01.

Other findings indicate that the Information and Communication Technology composite index (ICT) does not have an impact on industrialization, whether proxied by MVA or IVAK. This is due to several reasons, including the lack of supportive policies and regulations promoting the integration and utilization of ICT in various economic sectors. Insufficient investment in ICT infrastructure, including broadband connectivity, crucial for the effective utilization of ICT tools and services. Limited digital literacy and skills among the population hinder their ability to fully leverage the benefits of ICT for economic growth. Unequal access to ICT resources, especially in rural and remote areas, leads to a digital divide that hampers inclusive economic development. Inadequate availability and affordability of ICT services, such as internet access and mobile connectivity, restrict the reach and impact of ICT on economic activities. These barriers highlight the need for a comprehensive strategy addressing policies, infrastructure, skill development, and accessibility to unlock the full potential of ICT to drive industrialization. The Water and Sanitation composite index (WSS) influences industrialization, whether proxied by MVA or IVAK. Research has shown that water quality and sanitation facilities significantly impact sustainable human development and public health. In rapidly industrializing areas, the availability and management of water resources become crucial. The presence of untreated industrial and urban waste can degrade water quality, affecting surface and groundwater sources. Additionally, water quality indices have been developed as tools to assess and monitor water quality, helping minimize contamination and prevent health hazards. Water play a pivotal role in the existence in the human life. water quality index is assessing the overall quality of water based on location, time and some parameters of water. water quality index is important tool for assessing the quality water on the surface. Therefore, ensuring a high composite water and sanitation index is crucial for sustainable industrialization and overall societal well-being. These results support previous research by Patel et al (2020) and Sravani et al (2023) revealed that the composite water and sanitation index impacts increased industrialization. Sravani et al (2023) highlighted the water quality index observed at various stations shows that some places are not fits for drinking S-1, S-2 and S-3 are below 100 are very poor and S4-S12 sites are more polluted and unfit for drinking. testing of mediation effects described through  $P > t$ , if it is less than 0.05, it is interpreted as the mediating variable capable of intervening in the influence of the independent variable on the dependent variable.

However, if  $P > t$  exceeds 0.05, it means the mediating variable is unable to intervene in the influence of the independent variable on the dependent variable.

**Table 3.** Result of Sobel Test

	<b>T-Statistic</b>	<b>P&gt;t</b>
<b>Dependen : MVA</b>		
Transport	0.49522844	0.62043888
Electricity	3.19666528	0.00139026
LnICT	2.02693064	0.04035562
WSS	-2.93097343	0.00337902
<b>Dependen : IVAK</b>		
Transport	0.49647351	0.61956038
Electricity	3.59362102	0.00032611
LnICT	2.03827124	0.04152281
WSS	-3.22780891	0.00124742

Source: data processed

Table 3 the Sobel test results indicate that human resources cannot mediate the influence of transportation on industrialization. However, human resources can act as a mediator for the influence of electricity reliability, ICT, and WSS on industrialization. Overall, human resources play a mediating role in the influence of infrastructure development on industrialization. The presence of adequate human resources is crucial for the successful implementation and utilization of infrastructure projects, which, in turn, promotes industrialization (Pestaria et al., 2022). Francisco & Tanaka (2019) argue that good infrastructure is essential for human resource development. Health infrastructure will improve public health outcomes, and educational infrastructure will enhance the quality of education. Meanwhile, the model proposed by Romer (1986) suggests that there is an increase in gains by assuming that human resources have a significant positive influence on output at the industrial level. Skilled and healthy individuals are expected to carry out manufacturing and other industrial operations. Additionally, certain infrastructures such as information and communication technology (ICT) infrastructure require highly skilled labor to ensure effective functioning in industrial operations. Therefore, human resources, as a mediator, facilitate the relationship between infrastructure development and industrialization by ensuring effective infrastructure utilization and promoting sustainable development.

## 5. Conclusion

This research examines the impact of infrastructure development on industrialization in Indonesia, focusing on the mediating role of financial development and human resources. Using Stata software version 16 and Sobel tests, the study analyzes data from 1990 to 2022. Results indicate that while human resources do not mediate the influence of transportation on industrialization, they do play a mediating role in the impact of electricity reliability, ICT, and water supply and sanitation on industrialization. The findings suggest that a well-functioning transportation system does not significantly impact industrialization, primarily due to the concentration of industrial activities in large cities. Emphasis on human resource development, especially in the ICT sector, is crucial, requiring investments in education aligned with industry needs. Further recommendations include enhancing infrastructure development in the health sector. Future research should explore country-level analyses and consider additional policy-modulating variables and sector-specific industrial studies to inform more effective policy strategies. Policymakers are advised to invest in infrastructure for industrialization, with careful consideration of the simultaneous development of the financial sector and human resources to absorb industrial jobs.

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