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Does It Have A Transportation Infrastructure Increasing Regional Economic Growth In Indonesia? (Spatial *Spillover Effect Analysis*)

Ahmad Sandi Nurmansyah* & Uka Wikarya

Master of Economic Planning and Development Policy, Faculty of Economics and Business, University of Indonesia, Depok, Indonesia

Abstract

This study aims to analyze the effect of transportation infrastructure on economic growth in 33 provinces in Indonesia by using spatial panel data. Spatial panel data combines spatial (spatial) and time (panel) dimensions in its analysis. Spatial panel data can accommodate heterogeneity between provinces and spatial autocorrelation in the model. The model used in this study is *the Spatial Durbin Model* (SDM), which includes the effect of spatial interaction between the dependent and independent variables and the lag of the independent variable. The study results show that transportation infrastructure, including capital accumulation, labor, length of national roads, ship visits to ports, and airport loading and unloading, positively and significantly affects economic growth in a province and its neighboring provinces through spatial interactions. However, the increase in capital accumulation and the length of national roads in neighboring provinces has a negative and significant effect on economic growth in a province. This research recommends several policies to enhance the development of transportation infrastructure in Indonesia, such as encouraging cooperation between the government and the private sector, increasing the availability and quality of the workforce, and improving the existing transportation infrastructure. Transportation infrastructure development must focus on connectivity, quality, capacity, equity, and inclusiveness between islands and regions to increase collaboration, efficiency, reliability, and prosperity in the regional economy.

Keywords: Transportation Infrastructure; Regional Economic Growth; Spatial Panel Data; Spatial Durbin Model.

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1. Introduction

Economic growth is the leading indicator in measuring the welfare of a country or region. Hamid & Ato in Akadun (2000; 1) states that several factors can affect economic growth, namely investment, technological development, and improving the quality of labor following market demand. (Djadjuli, 2018) . Kuznets (1966) adds that increasing inventory, technological developments, and the effective and efficient use of technology also contribute to economic growth. (Raharti et al., 2020) . One essential factor in supporting economic growth is adequate infrastructure. Infrastructure can support the mobility and distribution of goods and services between regions. Transport infrastructure, in particular, plays an essential role in increasing productivity, distribution, and regional integration. Transportation infrastructure also has an impact on the growth and acceleration of the development of a region through trade, market expansion, and creation of competition, which will ultimately increase the economic welfare of the community (Biomantara & Herdiansyah, 2019; Yusyahbella et al., 2019). Thus, economic growth is influenced by various factors, including transportation infrastructure which has a strategic role in national development.Innovative and quality transportation infrastructure can reduce costs and improve trade efficiency, promote economic growth by enhancing global competitiveness and integration, and promote sustainable development, economic prosperity, and regional competitiveness by facilitating the movement of people and goods, connecting less developed regions with more developed areas, and attract investment and business (Daniswara & Ikhsan, 2022; Kadyraliev et al., 2022). However, the transportation infrastructure in Indonesia still needs to improve, such as low quality, limited capacity, high costs, and inequality between regions (Palilu, 2018). According to data from the World Economic Forum (WEF) in the Global Competitive Report (2017-2018), Indonesia is ranked 52nd out of 137 countries in infrastructure development (Frita et al., 2022). The World Economic Forum report (2016) shows that Indonesia is also below Singapore, Malaysia, and Thailand in the quality of transportation infrastructure based on five assessments (Sitorus & Sitorus, 2017). That impacts

* Corresponding author.
E-mail address: sandinurmansyah10@gmail.com

high transportation costs, regional price disparities, and low productivity and efficiency.

To overcome these problems, increasing the quantity and quality of transportation infrastructure in Indonesia is necessary. This increase can be done in various ways, such as building new infrastructure, repairing old infrastructure, developing technology, increasing cooperation between parties, and increasing budget allocations. This increase is expected to have a positive impact on the Indonesian economy, such as reducing production costs, increasing the quality of goods and services, increasing company productivity and profitability, increasing export and import markets, and increasing income and social welfare (Amri, 2019; Ompusunggu, 2018).

Improving transportation infrastructure will not only have a positive impact on the region concerned but also on other areas that are connected or adjacent to it. That is called the spillover effect or spillover from transportation infrastructure between regions. This spillover effect can be in the form of increasing economic growth, increasing investment, increasing human resources, increasing technological progress, or increasing the balance of development between regions. This spillover effect indicates the existence of dependence or spatial interaction between regions in regional economic development.

Various factors, such as geographical distance, regional characteristics, socio-economic-cultural relations, government policies, or other factors, can influence spatial interactions between regions. Spatial interactions between regions can be positive or negative. Positive spatial interaction means that the economic growth of a region will increase the economic growth of other regions that are connected or adjacent to it. Negative spatial interaction means that the economic growth of a region will reduce the economic growth of other regions that are connected or adjacent to it.

Spatial interactions between regions can be measured using spatial econometric models. The spatial econometric model is a model that accommodates heterogeneity between regions and spatial autocorrelation in its analysis. Heterogeneity between regions means that each region has different characteristics that can affect the dependent or independent variables in the model. Spatial autocorrelation means that the value of the dependent or independent variable in an area is affected by the value of the dependent or independent variable in other areas that are connected or adjacent to it.

Spatial econometric models can be divided into three main types, namely spatial lag models (SLM), spatial error models (SEM), and Durbin spatial models (SDM). The SLM model is a model that includes spatial autocorrelation on the dependent variable in the model. The SEM model is a model that includes spatial autocorrelation of the error term in the model. The SDM model is a model that includes spatial autocorrelation of the dependent and independent variables in the model. These models can be used to estimate the spillover effect of transportation infrastructure on regional economic growth.

Research on the effect of transportation infrastructure on regional economic growth using spatial econometric models has been carried out in many countries worldwide. Most of these studies aim to examine the economic benefits of transportation investment and find rational investment patterns. The results of the study show that there is a positive relationship between transportation investment and regional economic growth. However, the research results also show differences between studies in terms of the definition of public capital, the type of panel data, the type of spatial econometric model, the size of the sample area, the period of analysis, or other factors.

Research on the effect of transportation infrastructure on regional economic growth using spatial econometric models in Indonesia still needs to be completed. This research attempts to fill this gap by using spatial panel data from 34 provinces in Indonesia during the 2010-2019 period. This spatial panel data combines spatial (spatial) and time (panel) dimensions in its analysis. This spatial panel data can accommodate heterogeneity between provinces and spatial autocorrelation in the model.

This study uses spatial panel data to analyze and determine the spillover impact of transportation infrastructure on regional economic growth in Indonesia. This study also aims to analyze and find out other factors that influence regional economic growth in Indonesia using spatial panel data. This research is expected to contribute ideas to knowledge in regional economics and become a reference for the government in planning and designing policies for developing transportation infrastructure in Indonesia.

2. Methods

This study uses a quantitative research approach and type with panel data design. Panel data is data that contains elements of cross-section and time series. The cross-section element is data consisting of several observation units at a specific time. The time series element is data consisting of one observation unit several times. Panel data is used to examine the effect of transportation infrastructure on economic growth in 33 provinces in Indonesia during the 2009-

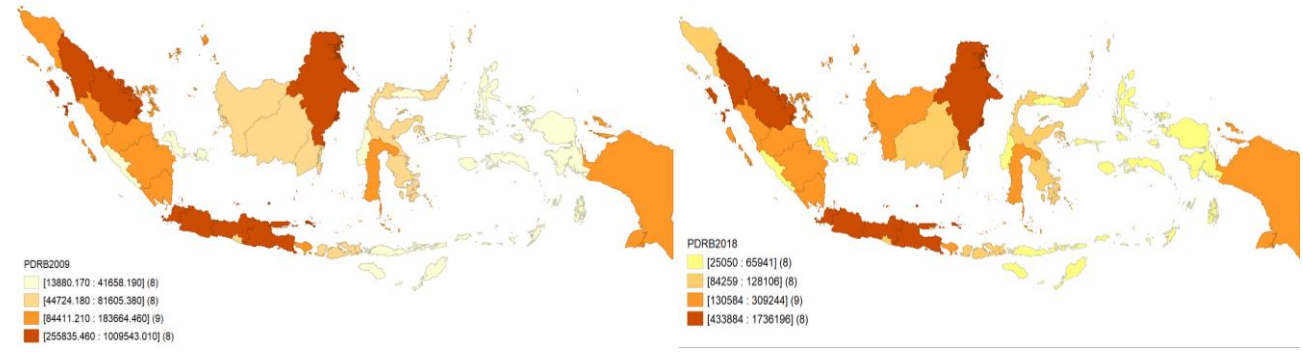
2018 period. The data source used in this study is secondary data obtained from the Central Bureau of Statistics and Indonesian transportation statistics.

The data analysis technique used in this study is Durbin spatial modeling (SDM) using R, 2020 software. SDM is a linear regression model that adds the effect of spatial interaction between the dependent and independent variables. Spatial interaction describes a relationship or connection between a region and other regions. A spatial weighting matrix (W) is used to calculate spatial interactions, which is made based on the criteria of adjacency or intersection between regions. This study uses the queen contiguity criterion, which states that two regions are neighbors if they are side by side or their corners meet. Before HR analysis, a spatial dependency test was performed on the dependent and independent variables using the Lagrange Multiplier (LM) test, Robust-LM, Cross-sectional Dependency (CD) measurement, and Moran's Index.

3. Result and Discussions

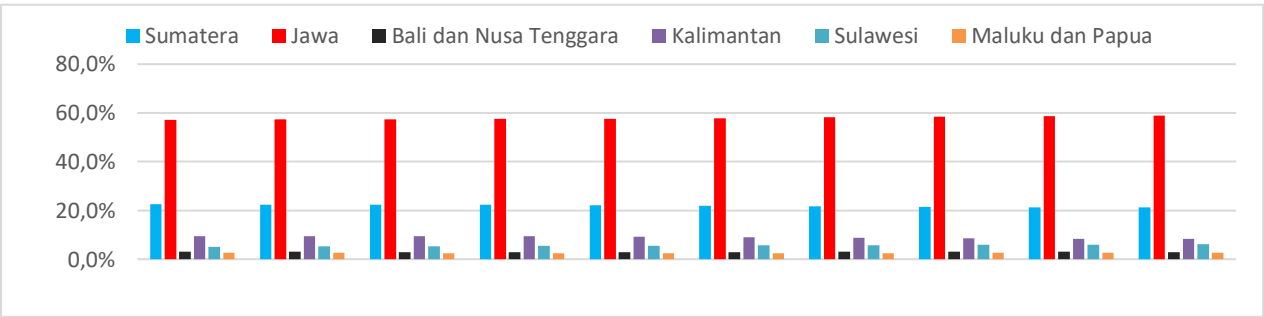
This study aims to analyze the effect of transportation infrastructure on economic growth in 33 provinces in Indonesia. The data used in this research is secondary data obtained from the Central Bureau of Statistics and Indonesian transportation statistics during the 2009-2018 period. The data includes Gross Regional Domestic Product (GDP) as the dependent variable and accumulation of capital, labor, length of national roads, ship visits to ports, and airport loading and unloading as independent variables.

From the data obtained in Figure 1. and Figure 2. it can be seen that GRDP in Indonesia has experienced positive growth for ten years. Provinces on the island of Java dominate the GRDP contribution to the Indonesian economy, especially DKI Jakarta, which has the highest GRDP value. Various factors, such as strategic geographical location, investment inflows, the number of workers, and the availability of adequate infrastructure, can influence this. Investment in Indonesia has also increased yearly, especially in the provinces of West Java and DKI Jakarta. This investment can increase capital accumulation, one of the economy's essential production factors.



Source: BPS, 2019 (processed by GeoDa)

Figure 1. Map of the 2009 & 2018 Gross Regional Domestic Product Distribution (GDP) in Indonesia (in billions of rupiah)



Source: BPS, 2019 (processed)

Figure 2. Percentage Of Gross Regional Domestic Production (GRDP) At Constant Prices Per Island In 2009-2018 In Indonesia

Transportation infrastructure is an essential indicator in supporting economic activity. The transportation infrastructure used in this study is national roads, ports, and airports. National roads are a means of land transportation that connects between regions. The length of national roads in Indonesia has increased over the past ten years, with steady road quality being more dominant than before. The port is a means of sea transportation that plays a role in trade between islands and countries. Ship visits and loading and unloading of goods can measure port activity. Provinces with a strategic geographical location between trade routes have higher port activity. The airport is a means of air transportation that plays a role in the mobility of passengers and goods. Airport activity can be measured by the arrival of aircraft and the loading and unloading of goods. Provinces that have significant and busy airports have higher airport activity.

Before estimating the spatial panel regression model, a spatial autocorrelation or spatial dependency test is performed to determine whether or not there is a spatial relationship in the panel data. The tests used are the Lagrange Multiplier (LM) test, Robust-LM, Cross-sectional Dependency (CD), and Moran's Index. The test results in Table 1. show that the GRDP panel data has spatial dependence, meaning that economic growth in a province is affected by economic growth in neighboring provinces. In addition, the test results also show that the variables capital stock, labor, port infrastructure, and the proportion of industry have spatial relationships with neighboring provinces.

Table 1 Spatial Autocorrelation Test

Breusch-Pagan LM Test	Chisq =1 747 , 7 df=528	p-value < 2.2e-16
Order a Test CD	z = 1 5.699	

After knowing that spatial dependencies exist in the panel data, the spatial panel regression model is estimated using R, 2020 software. The Spatial Autoregressive Model (SAR) and Spatial Durbin Model (SDM) are used. SAR is a linear regression model that includes the effect of spatial interaction between the dependent and independent variables. SDM is a linear regression model that includes the effect of spatial interaction between the dependent and independent variables and the lag of the independent variable. The estimation results show that the SAR model with a fixed effect is better than the SAR model with random effects based on the Hausman test. In addition, the estimation results also show that the SDM model is better to use than the SAR model based on the R-squared value. The estimation results of the SAR model in Table 2 shows that all independent variables positively and significantly influence regional economic growth, both directly and indirectly.

Table 2. Results of Testing the Spatial Lag Model on Economic Growth

Variable	**Estimation Results**		
	Pooled	**Spatial Fixed Effects**	**Spatial Random Effects**
Capital Stock (X1)	0.4333***	0.0891***	0.0785***
	(19566)	(4.171)	(3.242)
Labor (X2)	0.1894***	0.3682***	0.5400***
	(9.588)	(5.703)	(8.836)
Infos. Port (X3)	0.0078	0.0178***	0.0259***
	(1.336)	(2.896)	(3.689)
Airport Infrs (X4)	0.0274**	0.0477***	0.0626***
	*(3.081)	(7,408)	(8.652)
Infos. Street (X5)	0.1871***	0.0588***	0.0750***
	(7.003)	(2.737)	(3.062)
In industry (X 6)	0.2345***	0.3211***	0.4073***
	(17.592)	(14.031)	(17.854)
Intercepts	2.9444***		0.8433***
	(16116)		(2.596)
lambdas (λ)	-0.005***	0.1042***	0.0242
	(-5.845)	(11.227)	(1.611)
r2	0.9515 _	0.99 84	
Hausman Spatial Model Test	Chisq = 41. 62, p-value = 0.000		

4. Ket. ** statistically significant at the 5% level,*** statistically significant at the 1% level, brackets denote z-statistics, processed (software R,2020)

The estimation results of the SDM model in Table 3 shows that all independent variables have a positive and significant effect on GRDP. That means that an increase in the accumulation of capital, labor, the length of national roads, ship

visits to ports, and loading and unloading at airports will increase economic growth in a province. In addition, the estimation results also show that the spatial interaction between the dependent and independent variables has a positive and significant effect on GRDP. That means that a province's economic growth will increase in neighboring provinces. However, the estimation results also show that the lag of the capital stock and road infrastructure variables has a negative and significant effect on GRDP. That means that an increase in capital accumulation and the length of national roads in neighboring provinces will reduce economic growth in a province.

Table 3. Results of Testing the Durbin Spatial Model on Economic Growth

Variable	Estimation Results	Variable	Estimation Results
Capital Stock (X1)	0.0 678* ** (3.148)	Capital Stock _SL	0.0 673 *** (3 . 775)
Labor (X2)	0. 3709 *** (5469)	Labor_SL	- 0.0 393 (-1.256)
Infos. Port (X3)	0.0 109* (1.719)	Inf. Port_SL	0.0 097* * (2.362)
Airport Infrs (X4)	0.0 419 *** (6.252)	Inf. Airport_SL	0.0 071 * (1,734)
Infos. Street (X5)	0.0 794* ** (3,634)	Inf. Jalan_SL	-0.0 325 *** (- 2,621)
Industrial (X6)	0.262*** (10.208)	Industri_SL	0.0344** (2,306)
lambdas (λ)		0. 079 *** (4,254)	
Logs. Likelihood		540,606	
r2		0.9 986	
AIC		- 799.21	
BIC		- 808.65	

Ket. ** statistically significant at the 5% level,*** statistically significant at the 1% level, brackets represent z-statistics, processed (software R, 2020)

The model estimation results show that the capital production factor from physical capital has a significant positive impact on the model. These results indicate that investment in a province provides economic growth and benefits neighboring provinces or the surrounding areas. That is based on the benefits of the investment that creates economic growth because the influx of investors will undoubtedly provide new business systems/processes, management practices, and technology, especially when investment inflows will become links to export markets and international supply chains. Per the Word Bank report (2018) that investment by foreign companies has created growth in domestic industries, such as the electronics sector in China, the textile and clothing industry in Bangladesh, and software in Costa Rica.

The model estimation results also show that the factor of human resource availability seen in the workforce has a significant positive impact but spatial interactions have a negligible effect. That shows that investment and labor in the exogenous growth model are the main drivers of economic growth in Indonesia and the level of technological progress in the region. However, labor does not necessarily increase economic growth in neighboring provinces. That can occur due to migration or transfer of skilled workers to growth centers or areas that have been developed. The higher the output or economy of a region, it will have an impact on the density of economic activity or activities that require input factors, namely labor in moving the wheels of the economy.

The estimation results of the model also show that transportation infrastructure consisting of the length of national roads, ship visits to ports, and airport loading and unloading has a positive and significant impact on driving economic growth in Indonesia. However, there are differences in effect between the types of transportation infrastructure used. The length of the national road harms the indirect effect, which shows that the farther a region is from the center of growth, the longer the road that must be provided will deplete the capital stock allocated for other productive investments. Ship visits to ports positively influence the indirect effect, which shows that the closer an area is to a growth center, the greater the economic flow from the growth center to the surrounding areas, which will increase income in its economy. Airport loading and unloading positively influence direct and indirect effects, which shows that airport infrastructure

can access geographically isolated areas and mobilize high-value commodities with a high degree of time sensitivity.

The estimation results of the model also show that regional characteristics, which are proxied by the proportion of the manufacturing industry, have a positive and significant impact on driving economic growth in Indonesia. That is because each region has differences in natural resources that make it have a superior sector compared to other regions. Sjoholm's research (1999) states that the characteristics of districts and cities in a region are better able to describe the economic productivity of a region than a province because, at the district level, the industrial structure has been diversified to increase productivity in a region directly. Characteristics of a region can occur due to the concentration of the manufacturing industry into a strategic sector in creating and encouraging other sectors to carry out production.

Based on the results of the estimation of the spatial model presented in Table 4, it can be seen that all independent variables have a positive and significant influence on regional economic growth, both directly and indirectly. That shows that investment in transportation infrastructure in a province not only increases its economic growth but also provides positive benefits to its neighboring provinces through increased capacity, efficiency, reliability, access, and economies of scale. This finding is in line with several previous studies which stated that transportation infrastructure has an essential role in driving regional economic growth (Munnell, 1992; Holtz-Eakin, 1994; Cohen & Paul, 2004; Cantos et al., 2005; Berechman et al., 2006; Ozbay et al., 2007).

Table 4. Effects of the Durbin Spatial Model on Economic Growth

Variable	Immediate Effect (*Direct effect*)	Indirect Effects (*Indirect effects*)	Total Effect (*total effect*)
Capital Stock (X1)	0.0 679 ***	0.00 57 **	0.0 737 ***
	(3. 141)	(2,414)	(3. 131)
Labor (X2)	0.3718 *** _	0.0 312 ***	0.4030 *** _
	(5562)	(3.208)	(5521)
Infos. Port (X3)	0.0 110*	0.000 9	0.0 119*
	(1671)	(1,534)	(1671)
Airport Infrs (X4)	0.0 420 ***	0.00 35 ***	0.0 4555 ***
	(6. 220)	(3,374)	(6. 200)
Infos. Street (X5)	0.0 796 ***	0.0 066 **	0.08 62 ***
	(3,384)	(2. 537)	(3.379)
Industrial (X6)	0.2627***	0.0221***	0.2848***
	(9,637)	(3,587)	(9,433)

Ket. ** statistically significant at 5% level,*** statistically significant at 1% level, processed (software R)

This study's results align with several previous studies which found a positive effect of transportation infrastructure on economic growth. For example, Calderon and Serven (2004) found that infrastructure improvements have increased productivity and long-term economic growth. IFAD (2012) found that better-quality roads can promote social and economic development by increasing mobility and access to resources and markets. Rodrigue (2020) found that transportation infrastructure can provide direct and indirect benefits to the regional economy, such as reducing transportation costs, increasing access to education and health, and increasing economies of scale.

The results of this study also provide policy implications for the government and related stakeholders in planning and implementing transportation infrastructure development. Transportation infrastructure development must pay attention to inter-island and inter-regional connectivity to build collaboration within the region and between each surrounding region. Transportation infrastructure development must also pay attention to aspects of quality and capacity to increase efficiency and reliability in connecting production with consumers. The development of transportation infrastructure must also pay attention to the aspects of equity and inclusivity in order to reduce price disparities and income gaps between regions. Thus, the development of transportation infrastructure can be essential in driving high and sustainable economic growth and social welfare.

5. Conclusions

This study uses spatial panel data to examine the effect of transportation infrastructure on economic growth in 33 provinces in Indonesia. The study results show that transportation infrastructure, including capital accumulation, labor, length of national roads, ship visits to ports, and airport loading and unloading, has a positive and significant effect on economic growth in a province and its neighboring provinces through spatial interactions. However, the increase in

capital accumulation and the length of national roads in neighboring provinces has a negative and significant effect on economic growth in a province. Therefore, this study recommends several policies to enhance the development of transportation infrastructure in Indonesia, such as encouraging cooperation between the government and the private sector, increasing the availability and quality of the workforce, and improving the existing transportation infrastructure. Transportation infrastructure development must pay attention to connectivity, quality, capacity, equity, and inclusiveness between islands and regions to increase collaboration, efficiency, reliability, and prosperity in the regional economy.

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