

Revealing The Spatial Matter in Indonesia's Economic Growth Model: A Cross-Province Analysis

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Abstract

Research Originality: This research integrates spatial econometric modeling to analyze the determinants of Indonesia's economic growth, highlighting the influence of spatial dependence on neighboring regions. It uses spatial models to provide insights into Indonesia's growth dynamics from a geographically interdependent perspective.

Research Objectives: Examine the key factors driving Indonesia's economic growth by incorporating internal regional elements and external spatial influences from neighboring provinces.

Research Method: This study employs a spatial econometric approach to analyze Indonesia's economic growth across 34 provinces from 2015 to 2024.

Empirical Results: The empirical analysis confirms the presence of spatial dependence in regional economic growth, with neighboring provinces influencing one another. Foreign Direct Investment (FDI), Domestic Direct Investment (DDI), and population significantly impact growth directly and through spillovers. However, road infrastructure has an insignificant effect.

Implications: This research emphasizes the importance of provincial collaboration on investment, infrastructure, and trade. While population growth matters, skill enhancement is crucial for development. Policymakers should prioritize high-quality infrastructure and leverage spatial data to promote balanced growth and reduce regional disparities.

Keywords:

domestic direct investment; foreign direct investment; economic growth; spatial model

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INTRODUCTION

Economic growth has long been a fundamental theme in development economics, serving as a key measure of national progress and improvements in welfare (Ng et al., 2019; Dragoi, 2020). Classical and neoclassical growth theories, including the Harrod-Domar and Solow-Swan models, highlight capital accumulation, labor force expansion, and technological advancements as the primary drivers of growth (Solow, 1956; Missaglia & Vaggi, 2025). However, these traditional frameworks often conceptualize growth as an isolated process occurring independently within specific regions, failing to account for the impact of geographical proximity and spatial connections. Such perspectives are particularly limiting in countries like Indonesia, which is marked by significant geographic diversity and uneven regional development.

Indonesia's economic geography demonstrates enduring spatial disparities. Economic activities are predominantly concentrated in Java, and select regions of Sumatra, while many provinces in the eastern part of the country, particularly Maluku and Papua, experience considerable lag in development. Despite the government's efforts to promote decentralization and equalize infrastructure, regional growth remains uneven. Previous studies on Indonesia's economic growth have primarily focused on various factors, including investment (Yuliana et al., 2019), human capital and labor (Bawono, 2021), and infrastructure (Ng et al., 2019; Brueckner, 2021). However, many of these analyses utilize classical econometric models that fail to account for spatial dependence—the notion that economic dynamics in one province can influence growth in its neighboring regions. Overlooking these interactions risks producing biased estimates and providing an incomplete understanding of how growth disseminates spatially across the nation.

Recent advancements in spatial econometrics offer a robust theoretical and methodological framework for exploring interdependencies among regions. Spatial dependence indicates that regional growth is influenced not only by local characteristics but also by the dynamics of neighboring regions, facilitated by mechanisms such as trade integration, investment diffusion, labor migration, and infrastructure connectivity (Anselin, 2022; Proost & Thisse, 2019; Zhang et al., 2022). Empirical studies from various countries demonstrate that these spatial linkages can produce both positive spillovers by fostering regional synergy and negative spillovers by exacerbating core-periphery inequalities (Elhorst, 2017; Suryowati et al., 2021). However, in Indonesia, spatial analysis remains underutilized in the examination of economic growth, highlighting a significant conceptual and empirical disconnect between spatial growth theory and regional policy implementation.

In response to this identified gap, the present study embarks on a comprehensive exploration of the spatial dimension of Indonesia's economic growth across its 34 provinces, spanning the years 2015 to 2024. Employing a sophisticated spatial economics framework, it delves into the intricate relationship among foreign direct investment (FDI), domestic direct investment (DDI), population trends, and infrastructure development. By utilizing the Spatial Autoregressive (SAR), Spatial Error (FEM), and Spatial Durbin Model (SDM), the study illuminates how these factors interact and reveals their profound impact on economic performance not only within individual provinces but also across neighboring

regions. This nuanced approach allows for a deeper understanding of the region's economic landscape, capturing the dynamic interactions that shape growth in this diverse archipelago.

The originality of this research is evident in three pivotal aspects. First, it introduces a spatially explicit modeling framework to analyze Indonesia's economic growth, advancing beyond traditional non-spatial approaches. Second, it employs the Spatial Model to capture both direct and indirect (spillover) effects, thereby providing a more nuanced approach that encompasses Indonesia's recent era of decentralization and infrastructure development and offers updated empirical insights into how regional interconnectivity influences growth outcomes. This study makes a significant contribution to the ongoing academic discourse on regional development by incorporating spatial dependence into economic growth modeling in Indonesia. It demonstrates that economic growth is not an isolated event but rather an interconnected phenomenon across different geographical areas. The findings underscore the importance of regional collaboration, cross-provincial investment strategies, and the necessity for spatially informed policy planning to promote inclusive and balanced national development. Additionally, this study investigates the spatial determinants and interdependencies of economic growth in Indonesia, with a specific focus on integrating the spatial linkages among provinces into the growth model to provide a comprehensive analysis of these dynamics.

METHODS

This study adopts a positivist approach, analyzing empirical data based on secondary sources. Secondary data is obtained from the official website of the Central Statistics Agency and other recognized institutions. The dataset comprises spatial panel data from 34 provinces in Indonesia, covering the period from 2015 to 2024. The analysis employs descriptive and inferential statistical methods, including spatial econometric models. A spatial panel model is used to examine how both spatial and non-spatial factors influence economic growth across regions in Indonesia. Spatial panel data is particularly relevant because it includes a spatial dimension based on geographic locations (Elhorst, 2017).

The spatial panel data model aims to reveal spatial dependencies within an econometric framework. Spatial econometrics encompasses a range of techniques that address spatial issues, such as spatial autocorrelation and heterogeneity, in regression models that utilize data collected from spatially defined points (Anselin, 2022). According to Elhorst (2017) Two challenges arise when panel data incorporates a spatial component: 1) spatial relationships may develop between observational units within each period, and 2) parameters may not be homogeneous, varying across different locations. Traditional panel regression struggles to capture these spatial effects, as it primarily focuses on different intercepts without accounting for variations between spatial units. Consequently, important variables may be omitted from the model or incorrectly specified.

This study employs a spatial econometric panel-data approach to analyze the determinants of Indonesia's economic growth, accounting for spatial dependence across provinces. The use of spatial models allows the estimation of both direct (within-province) and indirect (spillover) effects. Let $i = 1, 2, \dots, N$ represent the province, and $t = 1, 2, \dots, T$ denote the time period, where $N = 34$ and $T = 10$ (2015-2024). The dependent variable

is economic growth (*GROWTH*), while the independent variables include Foreign Direct Investment (*FDI*), Domestic Direct Investment (*DDI*), Population (*POP*), and Infrastructure (*INFRAS*). The general form of a spatial panel data model can be expressed as:

$$y_t = \rho W y_t + X_t \beta + W X_t \theta + \mu + \varepsilon_t$$

Where y_t is an $N \times 1$ vector of the dependent variable (economic growth), X_t is an $N \times K$ matrix of independent variables, W is the spatial weight matrix (defining spatial linkages among provinces), ρ is the spatial autoregressive coefficient capturing endogenous spatial dependence, θ measures the exogenous spatial spillover effects, β is a vector of parameters for the independent variables μ is the province-specific fixed effect, and ε_t is the error term.

The Spatial Autoregressive Model assumes that spatial dependence occurs in the dependent variable itself. Thus, the growth rate of a province depends not only on its own characteristics but also on the growth rates of neighboring provinces:

$$GROWTH_{it} = \rho \sum_{j=1}^N w_{ij} GROWTH_{jt} + \beta_1 \ln FDI_{it} + \beta_2 \ln DDI_{it} + \beta_3 \ln POP_{it} + \beta_4 \ln INFRAS_{it} + \mu_i + \varepsilon_{it}$$

where w_{ij} represents the spatial weight between province i and j (with $w_{ii} = 0$), ρ measures how strongly the economic growth of neighboring provinces influences that of province i , and ε_{it} is the idiosyncratic error term assumed to be normally distributed.

The Spatial Error Model assumes that spatial dependence arises in the error term rather than in the dependent variable. In this case, spatial correlation reflects unobserved factors (e.g., policies, institutional quality, or geographic conditions) that are spatially correlated:

$$GROWTH_{it} = \beta_1 \ln FDI_{it} + \beta_2 \ln DDI_{it} + \beta_3 \ln POP_{it} + \beta_4 \ln INFRAS_{it} + \mu_i + u_{it}$$

$$u_{it} = \lambda \sum_{j=1}^N w_{ij} u_{jt} + \varepsilon_{it}$$

where u_{it} represents the spatially correlated error term, λ captures the degree of spatial correlation among error terms across provinces, and ε_{it} is a random disturbance term. A significant value of λ indicates the presence of spatial error dependence, meaning that omitted or unobserved shocks in one region are transmitted spatially to others.

The Spatial Durbin Model extends the SAR model by including spatially lagged explanatory variables. This model captures both endogenous (dependent variable) and exogenous (independent variable) spatial effects, allowing the estimation of direct and indirect (spillover) impacts simultaneously:

$$GROWTH_{it} = \rho \sum_{j=1}^N w_{ij} GROWTH_{jt} + \beta_1 \ln FDI_{it} + \beta_2 \ln DDI_{it} + \beta_3 \ln POP_{it} + \beta_4 \ln INFRAS_{it} + \theta_1 \sum_{j=1}^N w_{ij} \ln FDI_{jt} + \theta_2 \sum_{j=1}^N w_{ij} \ln DDI_{jt} + \theta_3 \sum_{j=1}^N w_{ij} \ln POP_{jt} + \theta_4 \sum_{j=1}^N w_{ij} \ln INFRAS_{jt} + \mu_i + \varepsilon_{it}$$

Where θ_k (for $k = 1, 2, 3, 4$) captures the spatial spillover effects of each independent variable from neighboring provinces, and ρ continues to represent the endogenous spatial dependence in economic growth.

RESULTS AND DISCUSSION

The models are estimated using the Maximum Likelihood Estimation (MLE) technique, which allows for fixed and random effects in spatial panel data. The estimation results from three spatial panel data models, namely the Spatial Autoregressive Model (SAR), the Spatial Error Model (SEM), and the Spatial Durbin Model (SDM), are summarized in Table 1. Optimal model selection is based on Akaike's Information Criterion (AIC). The model with the lowest AIC is considered the best fit for the data. AIC balances the trade-off between the model's goodness-of-fit and its simplicity, addressing both the risks of overfitting and underfitting (Burnham & Anderson, 2002). Among these models, the Spatial Durbin Model (SDM) demonstrates superior performance, as evidenced by the lowest Akaike Information Criterion (AIC) of -888.67. This result indicates that Indonesia's provincial economic growth exhibits significant spatial dependence, along with direct and indirect (spillover) effects of investment, population, and infrastructure on Indonesia's provincial economic growth from 2015 to 2024.

Table 1. The Empirical Result of Three Models

Parameter	SAR-FE	SDM-FE	SEM-FE
Main			
<i>lnFDI</i>	0.0369 (0.000)	0.0313 (0.000)	0.0307 (0.000)
<i>lnDDI</i>	0.0348 (0.000)	0.0161 (0.001)	0.0232 (0.000)
<i>lnPOP</i>	0.0509 (0.020)	0.0713 (0.096)	0.0285 (0.062)
<i>lnINFRAS</i>	0.0153 (0.595)	-0.0081 (0.771)	0.0165 (0.565)
Wx (θ)			
<i>lnFDI</i>		0.0226 (0.002)	
<i>lnDDI</i>		0.0389 (0.000)	
<i>lnPOP</i>		0.0563 (0.204)	
<i>lnINFRAS</i>		-0.0277 (0.494)	
Spatial			
<i>Rho</i>	0.5697 (0.000)	0.4772 (0.000)	
<i>Lambda</i>			0.6468 (0.000)
R-sq	0.7622	0.6335	0.8123
Log-likelihood	431.0101	454.3349	395.8262
AIC	-850.0202	-888.6698	-779.6523

Note: the figure in the bracket () denotes a p-value

$$\begin{aligned}
 GROWTH_{it} = & 0.4772 \sum_{j=1}^{34} w_{ij} GROWTH_{jt} + 0.0313 \ln FDI_{it} + 0.00161 \ln DDI_{it} + 0.0713 \ln POP_{it} \\
 & - 0.0081 \ln INFRAS_{it} + 0.0226 \sum_{j=1}^{34} w_{ij} \ln FDI_{jt} + 0.0389 \sum_{j=1}^{34} w_{ij} \ln DDI_{jt} \\
 & + 0.0563 \sum_{j=1}^N w_{ij} \ln POP_{jt} + 0.0277 \sum_{j=1}^N w_{ij} \ln INFRAS_{jt} + \mu_i + e_{it}
 \end{aligned}$$

This equation quantifies how both internal factors and spatial interactions drive economic growth across Indonesia's provinces. The findings from the Spatial Durbin Model (SDM) reveal that the variables Foreign Direct Investment (FDI), Domestic Direct Investment (DDI), and population (POP) significantly influence economic growth in Indonesia; however, road infrastructure (INFRAS) does not. Furthermore, the analysis indicates the presence of spatial dependence, reflecting both the indigenous interaction effect, which suggests spatial autoregression among the dependent and independent variables that also impact economic growth in Indonesia.

The coefficient of FDI is positive, confirming that foreign investment is a major driver of regional economic growth in Indonesia. The findings of this analysis indicate that Foreign Direct Investment (FDI) serves as a positive catalyst for economic growth in Indonesia. This result suggests that foreign investment directly stimulates economic development within the region. This finding aligns with empirical evidence from Yuliana et al. (2019), Fan & Hao (2020), and Ullah et al. (2022), who demonstrate that FDI enhances productivity, innovation diffusion, and labor demand in both domestic and neighboring markets. The result also corresponds with Ato-Mensah & Long (2021) and Bakour et al. (2022), who emphasize that foreign investment contributes to technology transfer and industrial clustering, two mechanisms highly relevant in Indonesia's manufacturing regions, such as Java and Sumatra. However, the positive FDI effect contrasts with studies like Susilo (2018) and Acquah & Ibrahim (2020), which suggest that FDI may have a limited impact in economies lacking absorptive capacity. The divergence underscores that Indonesia's improved investment climate and decentralized policy reforms have strengthened the country's ability to internalize the benefits of foreign capital. Furthermore, the significant spatial lag of FDI in the SDM model indicates that FDI inflows not only enhance local growth but also generate positive spillover effects on neighboring provinces.

DDI also positively affects economic growth, indicating that domestic investors play a complementary role to foreign investors in driving economic performance. These findings corroborate Nizam's (2022) findings on resilience. Likewise, Bakari & Bouchoucha (2021) find that well-regulated domestic investments stimulate employment and regional consumption, leading to broader growth externalities. The positive interregional diffusion of DDI found here provides strong evidence for the spatially networked nature of Indonesia's domestic economy. Additionally, spatial variables that influence economic growth in Indonesia exhibit exogenous interactions. Exogenous interactions also positively impact provincial economic growth. This indicates that the interrelated nature of these

factors significantly affects economic performance across provinces in Indonesia. The significant spillover coefficient indicates that domestic investment in one province fosters growth in neighboring provinces, likely through interprovincial trade linkages, regional production networks, and supply-chain integration.

The population variable also shows a positive coefficient, highlighting the role of human capital and demographic dynamics in sustaining regional growth. A large population enhances labor supply and market size, which, in turn, stimulates industrial and commercial activities. This finding is consistent with Paul and Adoji (2022), Romli et al. (2022), and Khursanaliev (2023), who report that population growth positively affects economic development when accompanied by rising productivity and educational attainment. In Indonesia, population dynamics significantly contribute to enhancing economic development throughout the country. A larger population provides a larger labor supply, thereby bolstering growth in labor-intensive sectors. These results further support the Neoclassical Theory, which highlights the significance of investment in driving economic growth. Furthermore, the significant spatial spillover coefficient suggests that demographic advantages extend beyond provincial boundaries, thereby strengthening labor mobility and interregional trade, consistent with Jamir (2022) and Bidemi et al. (2018).

Unlike other variables, the coefficient of infrastructure investment is insignificant. This result suggests that road infrastructure has not yet yielded direct or spillover benefits to economic growth in the observed period. This finding contrasts with Ng et al. (2019) and Donaldson (2018), who emphasize the positive contribution of transport infrastructure to reducing trade costs and enhancing accessibility. However, it aligns with Sharif and Tauqir (2021) and Mejia et al. (2020), who highlight that infrastructure can have diminished or even negative effects when environmental degradation, poor maintenance, or unbalanced regional distribution are present. In Indonesia, the observed insignificance may stem from a spatial mismatch between infrastructure expansion and productive economic activity, or from the long-term nature of infrastructure benefits that are not immediately captured in short-run data. The insignificant spillover coefficient reveals that road infrastructure in one province does not foster growth in neighboring provinces. The insignificant and negative coefficient for infrastructure also implies that physical infrastructure effects are localized and may not generate immediate or positive spillovers. The Summary of empirical results from the Spatial Durbin Model (SDM) is summarized in Table 2.

The spatial autoregressive parameter in the SDM model indicates strong interprovincial dependence in economic growth, suggesting that the performance of one province has a measurable impact on its neighbors. This pattern is consistent with the “spatial diffusion” hypothesis (Proost & Thisse, 2019; Zhang & Xie, 2019), which posits that regional growth tends to cluster geographically due to market access and labor migration, and that regional economies in Indonesia function as interconnected systems rather than isolated entities. Provinces such as East Java, Central Java, and Jakarta likely serve as growth poles, transmitting economic impulses across spatial networks, a phenomenon consistent with regional growth pole theory (Perroux, 1950) and recent spatial growth studies in China (Xiao & Wang, 2022) and the EU (Yeboah & Baffour, 2023).

Table 2. Summary of Empirical Insights

Variable	Coefficient (SDM)	Spatial Spillover (θ)	Interpretation
FDI	+0.0313***	+0.0226***	Strong local and regional growth effect
DDI	+0.0161***	+0.0389***	Local investment stimulates neighbors
POP	+0.0713*	+0.0563	Labor-driven spillover effects
INFRAS	-0.0081 (ns)	-0.0277 (ns)	Weak, possibly long-term effects
ρ (rho)	0.4772***	—	Endogenous spatial dependence confirmed
FDI	+0.0313***	+0.0226***	Strong local and regional growth effect

From a theoretical standpoint, these findings bridge the gap between neoclassical growth theory and spatial economics. While the Solow-Swan model (Solow, 1956) and Harrod-Domar model highlight internal factors such as capital and labor, this study empirically demonstrates that these forces are geographically interdependent. The incorporation of spatial models extends traditional theory by validating that regional economic growth depends not only on endogenous accumulation but also on spatially transmitted externalities. Compared with the international literature, the evidence aligns with Elhorst (2017) and Anselin (2022), who argue that neglecting spatial interdependence leads to biased estimates in regional growth models. The empirical results from Indonesia thus enrich the global discourse on spatial econometrics in developing economies, providing one of the few national-level applications of spatial models in Southeast Asia.

The findings suggest that Indonesia's policymakers should transition from regionally segmented development planning to a more spatially integrated growth framework. By enhancing interprovincial cooperation, they can leverage the spatially contagious nature of economic growth, fostering cooperation among neighboring provinces to amplify overall growth. Furthermore, balanced investment strategies should direct Foreign Direct Investment (FDI) and Domestic Direct Investment (DDI) to both core regions and peripheral provinces linked by regional trade corridors. Additionally, implementing human capital and mobility policies that utilize population dynamics through education, skill development, and labor mobility can help magnify spatial spillovers. Finally, a sustainable infrastructure strategy should emphasize connectivity, quality, and environmental sustainability to ensure long-term benefits.

This research provides robust empirical evidence that spatial interdependence is a crucial, yet often neglected, determinant of Indonesia's economic growth. The results contribute to the growing literature that emphasizes the spatial connectedness and mutual reinforcement of regional economies. By empirically integrating spatial econometric techniques into Indonesia's growth model, this study not only fills a methodological gap but also advances conceptual understanding of how economic growth propagates across space in a geographically diverse archipelago.

CONCLUSION

The empirical findings of this study underscore the pivotal role of spatial interdependence in influencing the dynamics of Indonesia's economic growth. The notable spatial effect identified in the Spatial Durbin Model (SDM) reveals that regional economic activities extend beyond administrative boundaries and are intricately interconnected across provinces. Consequently, policies aimed at stimulating growth must transcend provincial autonomy and embrace a nationally coordinated approach to development.

There are several policy recommendations proposed. First, the central government should promote collaboration among provinces, particularly in key corridors like Java and Sumatra, through interprovincial economic councils that align policies and support lagging areas. Second, Policies should enhance interconnected regional ecosystems via cluster-based incentives and cross-border special economic zones. Indonesia's investment agencies should focus on value-chain investments in logistics, manufacturing, and agribusiness to optimize positive spillovers. Third, key policies should focus on improving labor mobility, infrastructure, and education tailored to local needs while promoting inclusive urbanization to boost productivity and reduce inequalities. Fourth, Indonesia should shift from prioritizing quantity to enhancing connectivity and efficiency by focusing on interprovincial projects, integrating environmental sustainability, and creating a spatial performance index. This strategy can drive productivity gains through better connectivity. Fifth, by aligning economic and spatial policies, Indonesia can foster a regional economy that drives growth, reduces inequality, and boosts competitiveness.

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