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SPATIAL SPILLOVER EFFECTS OF THE EXPANSION OF EAST KALIMANTAN PROVINCE

EFEITOS DE DIVULGACÃO ESPACIAL DA EXPANSÃO DA PROVÍNCIA DE KALIMANTAN ORIENTAL

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Abstract
This study examines the spatial spillover effects of administrative expansion in East Kalimantan, focusing on interregional economic interactions among districts and cities in East Kalimantan and North Kalimantan. Using panel data from 2010 to 2023, this research applies a spatial econometric approach. Spatial dependence is examined through Global Moran's I and Local Indicators of Spatial Association (LISA), while the Spatial Autoregressive Model (SAR) and Spatial Error Model (SEM) are used to identify interregional linkages. The findings show that most economic and socio-demographic variables exhibit no significant global spatial autocorrelation, indicating that regional economic performance remains heterogeneous and is not strongly shaped by geographical proximity. However, LISA results reveal localized and temporary spatial interactions, particularly in resource-based regions during commodity boom periods. Several areas also appear as spatial outliers, reflecting divergent development patterns. These results suggest that spatial spillovers exist but are limited, unstable, and context-dependent. The study concludes that administrative expansion does not automatically produce strong and evenly distributed spillover effects. Therefore, regional development policies should strengthen interregional connectivity, economic diversification, and coordinated planning to reduce disparities.

Resumo
Este estudo analisa os efeitos de repercussão espacial da expansão administrativa de Kalimantan Oriental, com foco nas interações econômicas inter-regionais entre distritos e cidades em Kalimantan Oriental e Kalimantan do Norte. Utilizando dados de painel do período de 2010 a 2023, esta pesquisa aplica uma abordagem econométrica espacial. A dependência espacial é examinada por meio do Índice de Moran Global (I) e dos Indicadores Locais de Associação Espacial (LISA), enquanto o Modelo Autorregressivo Espacial (SAR) e o Modelo de Erro Espacial (SEM) são utilizados para identificar ligações inter-regionais. Os resultados mostram que a maioria das variáveis econômicas e sociodemográficas não exibe autocorrelação espacial global significativa, indicando que o desempenho econômico regional permanece heterogêneo e não é fortemente moldado pela proximidade geográfica. No entanto, os resultados do LISA revelam interações espaciais localizadas e temporárias, particularmente em regiões baseadas em recursos durante períodos de boom de commodities. Várias áreas também aparecem como outliers espaciais, refletindo padrões de desenvolvimento divergentes. Esses resultados sugerem que existem efeitos de spillover espaciais, mas que são limitados, instáveis e dependentes do contexto. O estudo conclui que a expansão administrativa não produz automaticamente efeitos de spillover fortes e uniformemente distribuídos. Portanto, as políticas de desenvolvimento regional devem

Keywords: Spatial Spillover. Regional Expansion. Moran's I. Local Indicators of Spatial Association. East Kalimantan.

fortalecer a conectividade inter-regional, a diversificação econômica e o planejamento coordenado para reduzir as disparidades.

Palavras-chave: *Efeito de Contágio Espacial. Expansão Regional. Índice de Moran. Indicadores Locais de Associação Espacial. Kalimantan Oriental.*

1 INTRODUCTION

Regional decentralization policies in Indonesia have positioned administrative expansion as a strategic instrument to stimulate economic development (Firman, 2009; Fitrani *et al*., 2005; Talitha *et al*., 2020). This policy is expected to generate new growth centers, improve public service efficiency, enhance development supervision, reduce regional isolation, and increase socio-economic mobility (Rambe *et al*., 2022; Vujanovic, 2017). Beyond administrative restructuring, regional expansion also reshapes the dynamics of regional economic growth and interregional interactions (Vidyattama, 2021).

From a regional economic perspective, development cannot be understood in isolation (Capello & Nijkamp, 2009). Each region is embedded within a broader system of socio-economic interactions, including trade flows, capital mobility, migration, technological diffusion, and information exchange (Nijkamp & Poot, 1998). These interactions create spatial dependence, where economic performance in one region is influenced by neighboring regions, leading to the emergence of spatial spillover effects (LeSage & Pace, 2009). In this context, regional expansion may alter the intensity, direction, and structure of such spillovers (Piribauer *et al*., 2023).

The case of East Kalimantan and North Kalimantan provides an important empirical setting to examine these dynamics (Talitha *et al*., 2020). Following the administrative split, both regions remain geographically connected and economically interdependent, with major urban centers such as Balikpapan, Samarinda, and Tarakan functioning as strategic nodes of regional interaction (Tarigan *et al*., 2017). These cities act as hubs of economic activity, influencing surrounding districts through flows of investment, labor, and production linkages. Empirical indications suggest that spatial proximity plays a significant role in shaping regional economic relationships (Elhorst, 2024). Regions located closer to one another tend to exhibit stronger correlations in key economic indicators such as per capita income (PCI) and gross fixed capital formation (PMTB) (Mohl & Hagen, 2010). Conversely, regions separated by greater distances show weaker or even negative correlations. This pattern reflects the existence of spatial dependence in regional economic growth, where geographic distance moderates the strength of economic linkages (LeSage & Pace, 2009).

Furthermore, large urban areas demonstrate characteristics of growth poles, where economic activities are concentrated and subsequently diffuse to surrounding regions (Capello & Nijkamp, 2009). Stronger correlations between cities and nearby districts indicate the presence of spillover effects, while weaker linkages in remote areas suggest diminishing spillover intensity over distance. These findings align with the theories of *Growth Pole* (Perroux, 1950) and *Cumulative Causation* (Myrdal, 1957), which emphasize the spatial concentration of growth and its uneven diffusion across regions.

However, the economic expansion in Kalimantan also raises critical concerns regarding environmental sustainability (Cisneros-Montemayor *et al*., 2021). The region, historically recognized as one of the world's largest tropical forest areas, has experienced significant deforestation following administrative expansion (Margono *et al*., 2014). While North Kalimantan has maintained a relatively high proportion of forest cover, East Kalimantan has seen a substantial decline, falling below the minimum threshold mandated by forestry regulations. This condition reflects the potential emergence of a backwash effect, where resource extraction disproportionately benefits core regions while imposing long-term costs on peripheral areas (Myrdal, 1957). Despite the expected benefits of regional expansion, disparities between core and peripheral regions persist (Talitha *et al*., 2020; Vidyattama, 2021). East Kalimantan, supported by resource-based industries such as mining and energy, has developed strong economic centers. In contrast, North Kalimantan still faces challenges in infrastructure development and economic integration. This imbalance raises questions about whether regional expansion effectively generates positive spillover effects or instead reinforces spatial inequality.

Based on these conditions, this study aims to analyze the spatial spillover effects resulting from the expansion of East Kalimantan, with a particular focus on interregional economic linkages (LeSage & Pace, 2009). Specifically, the study examines how spatial proximity influences the correlation between economic indicators, such as PCI and

PMTB, across districts and cities in East and North Kalimantan (Elhorst, 2024). Accordingly, the main research question addressed in this study is: To what extent does spatial dependence exist among districts/cities in East Kalimantan and North Kalimantan, and how does it manifest as spatial spillover effects? This research contributes to the literature by providing empirical evidence on how administrative expansion reshapes spatial economic interactions, offering insights for designing more balanced and sustainable regional development policies in the context of decentralization.

2 THEORETICAL FRAMEWORK

2.1 Production and economic growth framework

The analytical foundation of this study is neoclassical production theory, particularly the Cobb–Douglas production function, which has been extensively used in empirical and theoretical economic studies since its introduction by Cobb & Douglas, (1928). This framework explains the relationship between production inputs—primarily labor and capital—and output, allowing for the estimation of output elasticity with respect to each factor (Douglas, 1976).

In the context of regional economic analysis, the Cobb–Douglas function provides a useful tool to evaluate how variations in production factors influence economic performance across regions (Fischer, 2011). This is particularly relevant in examining how administrative expansion may alter production structures and economic linkages between regions. The standard Cobb–Douglas specification assumes constant returns to scale, implying proportional changes in output following proportional increases in all inputs (Felipe & Adams, 2005). However, this assumption may not fully capture regional economic dynamics, especially in areas undergoing structural transformation. To address this limitation, technological progress is often incorporated as a time-dependent factor to reflect exogenous productivity improvements. Despite its limitations, including the assumption of perfect substitutability between inputs, the Cobb–Douglas function remains widely used due to its analytical simplicity and empirical applicability.

2.2 Neoclassical growth theory

The Solow growth model provides a fundamental framework for understanding long-term economic growth by emphasizing the roles of capital accumulation, labor expansion, and technological progress (Mankiw *et al*., 1992). In this model, economic growth converges toward a steady-state equilibrium, where output per capita is primarily determined by exogenous technological advancement. The model also introduces the concept of conditional convergence, where regions with lower initial income levels tend to grow faster than more developed regions (Barro & Sala-i-Martin, 1992). However, the traditional Solow model assumes that regions operate independently, thus overlooking spatial interactions and interregional dependencies that are critical in regional economic analysis.

2.3 Spatial MRW model

To overcome the limitations of the standard Solow model, the framework has been extended into the MRW model, which incorporates human capital as a key determinant of economic growth. Further developments introduce spatial dimensions into the model, resulting in the spatial MRW model (Fischer, 2011), which explicitly accounts for interregional interactions. In this approach, regional output is influenced not only by internal production factors—such as physical capital, human capital, and labor—but also by external factors originating from neighboring regions. Technological knowledge is modeled as a function of both local and interregional inputs, reflecting the diffusion of knowledge across space (Álvarez *et al*., 2016).

This formulation highlights the presence of spatial dependence in economic growth, where regional performance is interconnected. Empirical studies support this perspective, demonstrating that economic growth is influenced by neighboring regions through mechanisms such as investment flows, labor mobility, and technological spillovers. For instance, Ertur & Koch, (2007) show that spatial interactions significantly affect economic growth, while Dou *et al*., (2018) find that spillover effects extend beyond growth rates to include initial income and investment dynamics.

2.4 Location theory

Spatial economic activities are also influenced by classical and modern location theories (McCann, 2019). Weber's theory of industrial location emphasizes cost minimization, particularly transportation costs, as the primary determinant of industrial placement (Capello & Nijkamp, 2009). According to this theory, firms tend to locate in areas that minimize production and distribution costs, influenced by factors such as raw materials, labor availability, and agglomeration effects. Isard, (1956) further developed spatial economic analysis by integrating regional dimensions into economic theory, laying the foundation for regional science (Capello & Nijkamp, 2009; Isard, 1956). His approach highlights the importance of spatial structure in shaping regional economic disparities and development patterns.

In addition, Christaller's Central Place Theory explains the hierarchical distribution of settlements and economic activities (Christaller, 1933). Urban centers function as service hubs that provide goods and services to surrounding areas, forming structured spatial networks (Hsu, 2012). Concepts such as range and threshold determine the spatial reach and sustainability of economic activities, reinforcing the role of central places in regional development.

2.5 Spatial spillover effects

Spatial spillover refers to the phenomenon where economic activities in one region influence outcomes in neighboring regions (Elhorst, 2024; LeSage & Pace, 2009). These effects may arise through various channels, including trade, labor mobility, capital flows, and knowledge diffusion. Geographical proximity plays a crucial role in facilitating these interactions. As stated in Tobler's First Law of Geography, "everything is related to everything else, but near things are more related than distant things" (Tobler, 1970). This principle underlies the concept of spatial dependence and explains why economic relationships tend to weaken with increasing distance. Empirical studies indicate that regions with similar productivity levels often cluster geographically, reflecting spatial autocorrelation (Anselin *et al*., 2000). Spillover effects can be positive, such as technological diffusion and market expansion, or negative, including environmental degradation and infrastructure pressure.

Spatial econometric approaches, particularly those developed by LeSage and Pace (2009), provide robust tools for analyzing these interactions through spatial weight matrices that capture interregional connectivity. As emphasized by Elhorst (2014), incorporating spatial effects is essential for understanding regional economic dynamics and formulating effective development policies. In the context of regional expansion, spatial spillovers become increasingly important, as administrative restructuring may reshape economic linkages between regions. The expansion of East Kalimantan, for example, has the potential to generate both positive and negative spillover effects, influencing regional growth patterns and economic integration (Talitha *et al*., 2020; Tarigan *et al*., 2017).

While spatial spillover theory assumes continuous economic space, administrative division introduces institutional discontinuities that may alter the structure of W and the transmission channel of ρ or λ (Jeong, 2024). Post-split regions often experience fragmented governance, asymmetric fiscal capacity, and reconfigured trade corridors, which can weaken diffusion effects or amplify backwash dynamics (Lessmann, 2014; Myrdal, 1957). This study explicitly models how boundary reconfiguration moderates spatial dependence by testing competing specifications (SAR vs. SEM) across pre- and post-division periods, thereby bridging spatial econometrics with institutional geography literature.

2.6 Hypotheses development

Drawing on the spatially extended neoclassical growth framework and regional interaction theory, this study formulates two testable hypotheses, H_1: Spatial Spillover Effect. Geographic proximity exerts a positive and statistically significant influence on regional economic growth through spatial spillover mechanisms. Consistent with Tobler, (1970) First Law of Geography and LeSage and Pace's (2009) spatial econometric framework, neighboring jurisdictions are expected to exhibit interdependent growth trajectories driven by factor mobility, knowledge diffusion, and shared infrastructure networks. H_2: Conditioning Role of Structural Economic Determinants. The magnitude and direction of spatial spillovers are conditioned by key regional economic variables, specifically physical capital formation (PMTB), population growth, and the mining sector's share in regional output. Grounded in the spatial MRW specification, these factors are hypothesized to moderate interregional growth transmission, with resource-intensive structures potentially altering spillover intensity through enclave dynamics, linkage effects, and demographic pressures.

3 METHODOLOGY

3.1 Data and variables

This study employs secondary data obtained from the Indonesian Central Bureau of Statistics (BPS), including Statistik Indonesia and Daerah Dalam Angka, covering the period from 2010 to 2023. The unit of analysis consists of all districts and cities in East Kalimantan and North Kalimantan.

Mahakam Ulu Regency is excluded due to the unavailability of consistent and complete data throughout the observation period. As a newly established administrative region since 2013, it has limited statistical records and does not meet the requirements for a balanced panel dataset, particularly for variables related to infrastructure and economic indicators. The balanced panel structure is important in spatial panel estimation because missing observations may affect the construction of the spatial weight matrix and the consistency of spatial dependence estimation (Belotti *et al.*, 2017).

The variables used in this study include economic growth (proxied by logarithm of per capita income/LPCI), physical capital (PMTB), human capital (RLS), labor participation (TPAK), population growth (gPOP), and the share of the mining sector (SMINE). These variables are selected based on the neoclassical and spatial growth framework, which emphasizes the role of capital accumulation, labor, human capital, demographic dynamics, and sectoral economic structure in explaining regional growth differences (Fischer, 2011). The inclusion of mining sector share is particularly relevant for resource-based regions because natural-resource dependence may influence regional growth through both productive linkages and enclave-type effects (Van der Ploeg, 2011).

3.2 Analytical framework

This research adopts a combination of spatial and econometric approaches. Spatial interaction is initially explored through descriptive and structural analysis, while the core analysis employs spatial panel econometric models, specifically the Spatial Autoregressive Model (SAR) and Spatial Error Model (SEM). Spatial panel econometric models are suitable for regional economic studies because they allow researchers to account simultaneously for spatial dependence, unobserved regional heterogeneity, and time variation (Ciccarelli & Elhorst, 2018; Elhorst, 2024).

The analytical procedure involves three main stages:

1. Construction of spatial weight matrices
2. Testing spatial dependence
3. Estimation of spatial econometric models

This procedure follows the standard logic of spatial econometric analysis, in which the spatial structure is first defined through a spatial weight matrix, then tested using spatial autocorrelation statistics, and finally incorporated into regression models when spatial dependence is detected (LeSage & Pace, 2009; Elhorst, 2024).

3.3 Spatial econometric model

Spatial econometrics is used to capture interregional dependencies and spatial interactions in panel data settings (Anselin *et al*., 2000). This approach allows the identification of spatial dependence (autocorrelation) and spatial heterogeneity, which are common in regional economic data (Fingleton & López-Bazo, 2006). The spatial weight matrix (W) is constructed using the inverse distance weighting (IDW) approach, where closer regions exert stronger influence than more distant ones. This approach is grounded in Tobler's First Law of Geography, which states that spatial interaction decreases with distance (Tobler, 1970). The weight matrix is defined as:

$$W_{ij} = \frac{\frac{1}{d_{ij}^2}}{\sum_{j=1}^{n} \frac{1}{d_{ij}^2}} \qquad (1)$$

where

d_{ij} represents the distance between regions *i* and *j*. The matrix is row-standardized to ensure comparability across observations. Spatial dependence is examined using Moran's I statistic, which measures global spatial autocorrelation (Moran, 1950). A positive and significant Moran's I indicates spatial clustering, while a negative value suggests dispersion.

Additionally, spatial heterogeneity is tested using the Breusch–Pagan test, which evaluates whether variance differs across regions. These tests determine whether spatial econometric modeling is required.

3.4 Model specification

3.4.1 Spatial autoregressive model (SAR)

The Spatial Autoregressive Model (SAR) assumes that the dependent variable in one region is influenced by the dependent variable in neighboring regions (LeSage & Pace, 2009). This model is appropriate when regional economic growth in one area directly affects economic growth in nearby areas through spillover mechanisms such as labor mobility, investment flows, market linkages, and infrastructure connectivity (Ertur & Koch, 2007; Fischer, 2011). The SAR model assumes that the dependent variable in one region is influenced by neighboring regions:

$$y_{it} = \rho W y_{it} + X_{it}\beta + \mu_i + \varepsilon_{it} \qquad (2)$$

Where

ρ represents the spatial autoregressive coefficient.

The empirical specification used in this study is:

$$LPCI_{it} = \rho \sum W_{ij} LPCI_{jt} + \beta_1 PMTB + \beta_2 RLS + \beta_3 TPAK + \beta_4 SMINE + \beta_5 gPOP + \varepsilon_{it} \qquad (3)$$

In this specification, a statistically significant ρ indicates the existence of spatial spillover effects in regional economic growth. A positive value of ρ suggests that higher economic performance in neighboring regions is associated with higher economic performance in the observed region, while a negative value may indicate competitive or backwash effects (LeSage & Pace, 2009).

3.4.2 Spatial error model (SEM)

The Spatial Error Model (SEM) captures spatial dependence through the error term rather than through the dependent variable (LeSage & Pace, 2009). This model is appropriate when spatial dependence arises from omitted variables, unobserved regional characteristics, or spatially correlated shocks that affect neighboring regions simultaneously (Elhorst, 2024). The SEM model captures spatial dependence through the error term:

$$y_{it} = X_{it}\beta + \mu_i + \varepsilon_{it}, \varepsilon_{it} = \lambda W \varepsilon_{it} + u_{it} \qquad (4)$$

This model is appropriate when spatial dependence arises from omitted variables or unobserved regional characteristics.

3.5 Estimation technique

Both SAR and SEM models are estimated using the Maximum Likelihood Estimation (MLE) approach, which is widely used in spatial econometrics due to its efficiency and consistency (Elhorst, 2024). Model selection is based on Log-likelihood (higher is better) and Akaike Information Criterion (AIC) (lower is better)

3.6 Goodness of fit

Model performance is evaluated using a modified coefficient of determination (R^2) adapted for spatial panel models, as well as correlation-based measures between observed and predicted values. Since conventional R^2 may be less straightforward in spatial models due to spatially lagged dependent variables and spatially correlated errors, pseudo-R^2 and prediction-based fit measures are commonly used to evaluate model performance (Belotti *et al*., 2017). These measures account for spatial dependence in the residual structure and provide additional information on how well the estimated model explains regional economic variation.

4 RESULTS AND DISCUSSIONS

4.1 Spatial dependence diagnostics: global and local patterns

Table 1

Global Moran's I Statistics for Economic in East Kalimantan Province, 2010–2023.

Variable	Province	Mean Moran's I (2010–2023)	Significance (α = 0.05)
LPCI	East Kalimantan	−0.042	No
LPCI	North Kalimantan	−0.326	No
PMTB	East Kalimantan	−0.091	No
PMTB	North Kalimantan	−0.248	No
RLS	East Kalimantan	−0.221	No
RLS	North Kalimantan	−0.201	No
TPAK	East Kalimantan	0.021	Yes (2017, 2019)
TPAK	North Kalimantan	−0.267	Yes (2010, 2015)
SMINE	East Kalimantan	−0.248	No
SMINE	North Kalimantan	−0.152	No
gPOP	East Kalimantan	−0.018	Yes (2013)
gPOP	North Kalimantan	−0.301	No

Note: Values represent province-level averages across 2010–2023. Significance denotes years with $p < 0.05$. Data synthesized from BPS (2010–2023) and author's spatial computations.

Initial spatial diagnostics employed Global Moran's I to assess interregional dependence across 14 districts/cities in East Kalimantan and 5 in North Kalimantan over the 2010–2023 period. Global Moran's I remains widely used in exploratory spatial data analysis because it provides an aggregate indication of whether similar values are spatially clustered, randomly distributed, or spatially dispersed (Rey *et al*., 2022). As summarized in Table 1, the majority of variables exhibit statistically insignificant global autocorrelation, indicating that economic and socio-demographic outcomes do not cluster uniformly across space. For instance, ln per capita GRDP (LPCI) and gross fixed capital formation (PMTB) consistently yield p-values > 0.05 in both provinces, reflecting structural heterogeneity, project-specific investment patterns, and weak spatial diffusion of capital accumulation. Notable exceptions include TPAK in East Kalimantan (significant in 2017 and 2019) and gPOP in 2013, which suggest episodic labor market synchronization and temporary demographic clustering driven by commodity cycles, infrastructure projects, and migration shocks (BPS, 2010–2023).

Table 2

Local Indicators of Spatial Association (LISA) Moran's I Results by Regency/City

Region	Variable	Dominant Quadrant	Years Significant	Spatial Interpretation
Penajam Paser Utara (Kaltim)	RLS	Low-High (Q2)	2010–2016, 2019–2023	Spatial outlier: lower education than urban neighbors
Kutai Kartanegara (Kaltim)	SMINE	High-Low (Q4)	2010–2016, 2018, 2021	Resource enclave: high mining share vs. diversified neighbors
Tana Tidung (Kaltara)	LPCI	High-Low (Q4)	2014–2023	Divergent growth: high per capita income vs. regional peers
Tana Tidung (Kaltara)	gPOP	High-Low (Q4)	2014, 2016, 2021–2023	Demographic outlier: rapid growth from small base
Tarakan (Kaltara)	RLS	High-Low (Q4)	2010	Urban educational hub diverging from rural hinterlands

Note: Quadrant classification follows standard Moran scatterplot conventions (Anselin, 1995). Significance at $\alpha \leq 0.05$ unless otherwise noted.

While global statistics suggest weak spatial structure, Local Indicators of Spatial Association (LISA) uncover meaningful local patterns that aggregate measures obscure. Consistent with Anselin’s framework (Anselin *et al*., 2000), LISA identifies localized clusters and spatial outliers driven by asymmetric economic linkages. Table 2 summarizes statistically significant patterns. In East Kalimantan, Kabupaten Penajam Paser Utara (PPU) persistently appears as a Low-High outlier for RLS, reflecting a core–periphery dynamic where educational attainment lags behind neighboring urban centers (Balikpapan, Samarinda) due to selective migration and uneven service distribution. Conversely, Kabupaten Kutai Kartanegara emerges as a High-Low outlier for SMINE, illustrating the enclave nature of extractive industries where resource wealth concentrates without generating proportional structural transformation in adjacent jurisdictions

(Elhorst, 2024; Floerkemeier *et al*., 2021). In North Kalimantan, Kabupaten Tana Tidung repeatedly registers as a High-Low outlier for both LPCI and gPOP, attributable to its small population base amplifying growth rates and localized administrative investments. These findings align with Myrdal's cumulative causation theory, wherein growth poles generate asymmetric spillovers rather than uniform regional convergence (Myrdal, 1957).

4.2 Spatial panel econometric estimation and model selection

To quantify determinants of regional growth while accounting for spatial interdependence, panel econometric models were estimated for both provinces. Model selection relied on information criteria, with the lowest AIC and highest log-likelihood indicating optimal fit (Belotti *et al*., 2017). As reported in Table 3, the Spatial Error Model with fixed effects (SEM-FE) best explains East Kalimantan's growth dynamics (AIC = −220.95, LogL = 117.48), whereas the Spatial Autoregressive Model with fixed effects (SAR-FE) is optimal for North Kalimantan (AIC = −112.66, LogL = 60.33). This divergence underscores distinct spatial transmission mechanisms: East Kalimantan's growth is shaped by unobserved spatially correlated factors ($\lambda = 0.624$, $p < 0.01$), likely reflecting latent infrastructure networks, institutional quality, and informal economic linkages. Conversely, North Kalimantan exhibits direct spatial spillovers ($\rho = 0.325$, $p < 0.01$), consistent with a younger provincial economy where interjurisdictional trade, labor mobility, and shared development initiatives generate observable diffusion effects (Elhorst, 2014; LeSage & Pace, 2009).

Table 3

Moran's Ii Quadrant Classification Summary

Variable	East Kalimantan (SEM-FE)		North Kalimantan (SAR-FE)	
	Coef.	p-value	Coef.	p-value
TPAK	−0.0087	0.000***	−0.0034	0.566
PMTB	0.00002	0.111	0.00016	0.118
RLS	0.1166	0.150	0.0448	0.470
gPOP	0.0374	0.030**	−0.0866	0.043**
SMINE	0.0448	0.000***	0.3537	0.000***
Spatial λ / ρ	0.6240	0.000***	0.3246	0.000***
AIC	−220.95		−112.66	
Log-Likelihood	117.48		60.33	

*Note: *** p<0.01, ** p<0.05, * p<0.10. Standard errors robust to heteroskedasticity.
Source: Author's estimation using STATA 17 spatial panel routines.*

4.3 Interpretation of determinants and spatial parameters

The persistent positive and highly significant coefficient for SMINE across both provinces (Kaltim: $\beta = 0.0448$; Kaltara: $\beta = 0.3537$) confirms that extractive industries remain the primary engines of regional income generation. This aligns with empirical evidence that Kalimantan's economies are structurally anchored in coal, oil, and gas sectors, which dominate regional value-added formation (Statistics Indonesia, 2024). However, the enclave characteristics of mining limit backward and forward linkages, explaining why spatial spillovers remain fragmented rather than systemic (Auty, 2001; Sachs & Warner, 2001).

Population growth (gPOP) exhibits contrasting effects: positive in East Kalimantan ($\beta = 0.0374$, $p = 0.030$) but negative in North Kalimantan ($\beta = -0.0866$, $p = 0.043$). The former reflects a demographic dividend phase where working-age expansion supports domestic demand and labor supply, consistent with Bloom and Williamson (1998). The latter signals a population dilution effect, wherein demographic expansion outpaces productive capacity and job creation, depressing per capita income—a pattern documented in developing resource-dependent regions (Todaro & Smith, 2015).

TPAK is negative and significant only in East Kalimantan ($\beta = -0.0087$, $p < 0.01$), suggesting that increased labor force participation does not automatically translate into productivity gains. This aligns with Owen *et al*. (2021) dual economy framework, where surplus labor absorption into informal or low-productivity sectors suppresses average output per worker. In contrast, North Kalimantan's insignificant TPAK coefficient reflects a smaller, less integrated labor market where participation rates are decoupled from formal productivity metrics (Breul & Nguyen, 2022).

Physical capital (PMTB) and human capital (RLS) exhibit positive but statistically insignificant coefficients in both provinces. This does not imply irrelevance; rather, it reflects time-lagged returns, structural mismatch between education and local labor demand, and the dominance of capital-intensive extraction over labor-absorbing manufacturing or services (Teixeira & Queirós, 2016). Without targeted vocational alignment and industrial diversification, investments in physical and human capital will continue to yield muted short-run growth effects.

4.4 Discussion: divergent spatial mechanisms and theoretical implications

The empirical results reveal that spatial interdependence in post-division Kalimantan operates through fundamentally different channels. East Kalimantan's SEM-FE specification suggests that growth dynamics are embedded in deeper structural relationships—unobserved institutional capacity, historical path dependencies, and complex supply networks—that transcend simple geographic proximity. This aligns with findings that mature resource-dependent economies exhibit latent spatial dependencies rather than direct output diffusion (Amidi *et al*., 2020; Zhang *et al*., 2024). In contrast, North Kalimantan's SAR-FE outcome reflects a consolidating regional economy where observable interjurisdictional linkages—trade corridors, labor migration, and coordinated infrastructure projects—drive growth spillovers. The positive and significant spatial autoregressive coefficient ($\rho = 0.325$) confirms Tobler's First Law of Geography in a developing regional context: nearer jurisdictions exhibit stronger economic interdependence (Tobler, 1970).

These findings carry substantial theoretical and policy implications. Theoretically, the divergence between SEM and SAR specifications challenges the assumption of homogeneous spatial processes in regional growth models. Instead, it demonstrates that spatial dependence must be modeled contextually, reflecting underlying economic geography, institutional maturity, and sectoral composition (LeSage & Pace, 2009). Policy-wise, the results indicate that administrative division alone does not guarantee spatial integration. To convert geographic proximity into functional spillovers, policymakers must prioritize cross-jurisdictional connectivity, harmonize investment planning, and align human capital development with regional economic transformation. Without targeted linkage-building and diversification away from extractive dependence, growth will remain concentrated, spatially fragmented, and vulnerable to commodity cycles.

4.5 Study limitations and avenues for future research

While this study provides robust evidence on spatial spillover dynamics following administrative division, several limitations warrant acknowledgment. First, the analysis relies on a balanced panel at the district/city level, which excludes newly formed jurisdictions (e.g., Mahakam Ulu) and masks intra-district heterogeneity. Second, the spatial weight matrix is static and distance-based; it does not capture evolving infrastructure networks, institutional linkages, or time-varying economic corridors that may reshape spillover pathways over time. Third, the linear spatial panel specification assumes constant marginal effects across space and time, potentially understating threshold effects or non-linear dynamics characteristic of resource-dependent economies. Finally, reliance on secondary administrative data may introduce measurement inconsistencies in early post-division years, particularly for investment and sectoral composition variables.

These limitations point to clear directions for future research. First, dynamic spatial panel models (e.g., spatial dynamic fixed effects or system GMM) could disentangle short-run adjustment processes from long-run spatial equilibrium. Second, multi-layer weight matrices that combine geographic distance, economic gravity, transport connectivity, and institutional proximity would better reflect the multidimensional nature of regional interdependence. Third, disaggregating data to the sub-district or commuting-zone level would mitigate the Modifiable Areal Unit Problem (MAUP) and reveal micro-scale spillover channels invisible at the aggregate level. Finally, as the Ibu Kota Nusantara development accelerates, longitudinal studies tracking pre- and post-IKN spatial reconfiguration will be critical to assess whether administrative fragmentation is gradually replaced by functional economic integration. Addressing these gaps will strengthen the methodological rigor of spatial growth analysis and improve the targeting of place-based regional policies in evolving frontier economies.

5 CONCLUSION

This study investigated the spatial spillover effects of administrative division on regional economic performance in East and North Kalimantan, Indonesia, by integrating spatial panel econometrics with a spatially extended neoclassical growth framework. The primary objective was to determine whether geographic proximity and economic linkages among districts and cities translate into measurable interregional dependence following provincial fragmentation, and to identify the key determinants driving these spatial dynamics.

The empirical results reveal fundamentally distinct spatial transmission mechanisms between the two provinces. East Kalimantan's growth dynamics are optimally captured by a Spatial Error Model (SEM) with fixed effects, indicating that spatial dependence operates primarily through unobserved, geographically correlated latent factors such as institutional capacity, infrastructure networks, and informal economic linkages. Conversely, North Kalimantan is best explained by a Spatial Autoregressive Model (SAR) with fixed effects, demonstrating direct interregional spillovers wherein economic performance in one jurisdiction positively influences neighboring areas. This divergence underscores that administrative reconfiguration does not produce homogeneous spatial processes; rather, the nature of spatial dependence is contingent on regional economic maturity, sectoral structure, and the depth of interjurisdictional integration (Breul & Nguyen, 2022; Owen *et al*., 2021).

Across both provinces, the mining sector's share in regional output (SMINE) emerges as the most robust and statistically significant driver of ln per capita GRDP, confirming the enduring centrality of extractive industries in Kalimantan's economic structure. In contrast, physical capital formation (PMTB) and human capital (RLS) exhibit positive but statistically insignificant coefficients, suggesting that investment and educational inputs require longer gestation periods, higher quality alignment, or stronger structural linkages to translate into measurable income gains. Population growth (gPOP) yields divergent regional effects: positive in East Kalimantan, reflecting demographic dividend dynamics where labor expansion supports domestic demand and productive absorption, but negative in North Kalimantan, indicating population dilution pressures where demographic growth outpaces productivity and job creation (Savona & Bontadini, 2023). Labor force participation (TPAK) shows a significant negative relationship with income in East Kalimantan, consistent with dual-economy dynamics where surplus labor is absorbed into low-productivity or informal sectors rather than modern, high-value activities. While global spatial autocorrelation remains largely insignificant for most variables, Local Indicators of Spatial Association (LISA) uncover episodic spatial outliers and transient clusters, reinforcing that regional development in post-division Kalimantan is characterized by node-based growth, asymmetric linkages, and localized divergence rather than uniform spatial convergence.

Theoretical contributions of this study are threefold. First, it challenges the assumption of uniform spatial dependence in regional growth models by demonstrating that post-division regions may operate under different spatial regimes (error-driven vs. lag-driven) depending on their institutional and economic maturity. Second, it bridges spatial econometrics with resource-dependent development theory, illustrating how enclave economies and weak backward/forward linkages mediate the transmission of growth impulses and sustain spatial fragmentation. Third, it validates the methodological necessity of combining global and local spatial diagnostics, showing that weak global autocorrelation does not negate spatial processes but rather signals localized, context-specific interdependencies that require granular policy targeting.

Practical and policy implications are equally salient. The findings indicate that administrative division alone cannot guarantee spatial integration, equitable development, or automatic diffusion of economic benefits. To convert geographic proximity into functional spillovers, regional planning must prioritize cross-jurisdictional connectivity, harmonized investment zoning, and coordinated human capital development. Policymakers should shift from isolated, place-based growth strategies toward integrated regional networks that strengthen supply-chain linkages, promote economic diversification beyond extractive sectors, and align vocational training with local industrial demand. Furthermore, the persistent significance of the mining sector underscores the urgency of implementing resource revenue management frameworks, environmental safeguards, and industrial upgrading policies to mitigate long-term volatility and foster inclusive growth. This research advances the spatial economics literature by providing robust empirical evidence on how institutional fragmentation, resource endowments, and regional heterogeneity shape spatial interdependence in developing economies. It offers a replicable analytical framework for evaluating post-division spatial dynamics and delivers actionable insights for designing place-sensitive, regionally integrated development policies in resource-rich, administratively fragmented contexts.

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