

Research Paper

# Spatial Dynamics and Regional Spillover Effects of Manufacturing GDP Growth in Indonesia

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## Abstract

This study examines the spatial dynamics and regional spillover effects of manufacturing GDP growth across provinces in Indonesia during the period 2019–2023. Regional disparities and uneven industrial development remain critical challenges in achieving inclusive and sustainable economic growth, particularly in the context of spatial inequality and structural transformation. Using an Exploratory Spatial Data Analysis (ESDA) approach, including Global Moran's I, LISA Cluster Map, and spatial visualization, this study identifies patterns of spatial dependence and regional clustering. The results reveal consistent positive spatial autocorrelation, indicating that manufacturing growth is spatially interdependent rather than randomly distributed. The analysis identifies three phases of spatial dynamics: pre-disruption integration, spatial decoupling during economic shocks, and post-pandemic re-convergence. A High–High cluster in Sulawesi indicates the emergence of a new growth pole driven by agglomeration forces and spatial spillover effects, while persistent Low–Low clusters in Papua reflect the presence of spatial low-growth traps. These findings highlight the importance of spatially integrated industrial policies, strengthening interregional connectivity, and addressing structural disparities to support more inclusive and sustainable development. This study contributes to the achievement of SDG 8 and SDG by providing empirical evidence on spatial inequality and regional growth dynamics in Indonesia.

**Keywords:** Spatial Economics; Regional Spillover; Core-Periphery Regions; Manufacturing Industry.

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### 1. Introduction

The manufacturing industry is the foundation of a country, serving as the main instrument and driver of a strong economy (L. Wang & You, 2023). Integrated and coordinated regional development is an important component in realizing high-quality development (Annoni et al., 2019; Shi et al., 2025). This is reflected in the synergy between urban and rural areas through coordination between the real economy and the property sector, as well as between the manufacturing industry and the modern service sector, which play an important role in maintaining supply effectiveness and promoting stable economic growth (Li & Li, 2026; Shi et al., 2025; Song et al., 2023).

Industrial agglomeration is considered capable of increasing resource management efficiency and reducing production costs, while also driving economic growth in core areas and triggering the development of peripheral areas (Mukhlis et al., 2019; Z. Wang et al., 2025). The results of a study by Sinaga et al (2022) found that the combination of industrial agglomeration and technological innovation contributes significantly to improving the quality of economic development in urban areas. Although many studies have examined industrial agglomeration in general, the specific influence of resource-based industrial agglomeration on regional economic development is still relatively rarely discussed.

Companies and industrial sectors gain various advantages when located in areas with concentrated economic activity, through the utilization of positive spatial externalities, also known as economies of agglomeration (Puga, 2010). This concept of agglomeration economics has been identified in various contexts, as demonstrated by the positive relationship between the size and density of cities or industrial areas and the rate of new business formation, increases in total factor productivity, wage increases, and innovation development (Ahlfeldt & Pietrostefani, 2019; Jordaan & Garduño-Rivera, 2024).

New Economic Geography (NEG) theory states that the distribution of economic activity is not neutral to space, but is shaped by the interaction between agglomeration and dispersion forces that determine the location of production activities between regions (Ehnts & Trautwein, 2012; Gori & Panicià, 2015; Nijkamp et al., 2024). Manufacturing industries tend to concentrate in certain regions when economies of scale, market proximity, and input-output linkages result in increased productivity and spatial efficiency (Thapliyal et al., 2025; Xiufan et al., 2024; H. Zhu et al., 2025). Conversely, differences in transportation costs, infrastructure limitations, and variations in regional economic capacity can drive growth disparities between regions (Shi et al., 2025; W. Zhu & Yang, 2024). Regional economic growth is understood as an interconnected spatial process, in which the performance of a region is influenced by the dynamics of the surrounding regions through spatial spillover mechanisms (Furková - & Chochołatá, 2016; Sinaga et al., 2022).

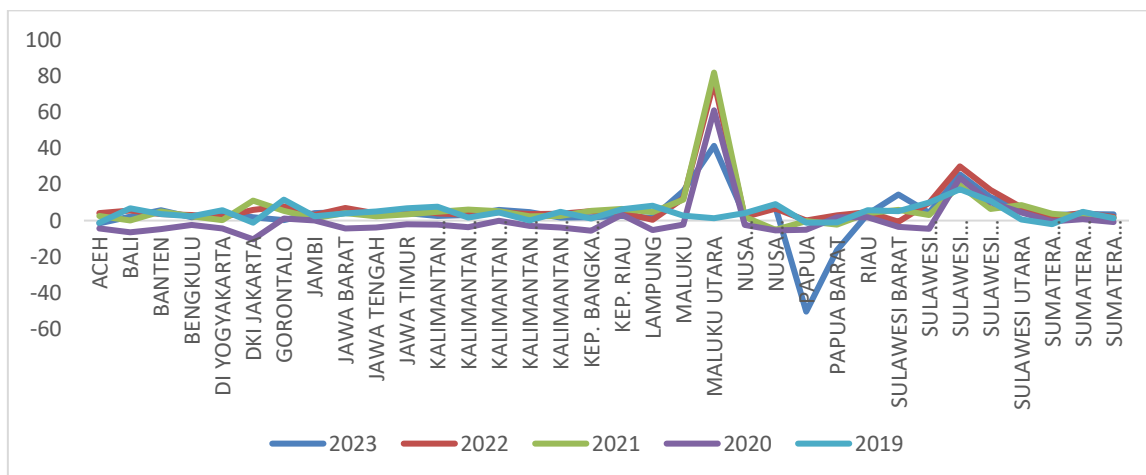


Figure 1. Dynamics of Indonesia's Manufacturing Industry Growth Rate 2019-2023

Source: Compiled by the authors based on the data from "Laju Pertumbuhan PDB Industri Manufaktur, 2023" by Badan Pusat Statistik Indonesia. Retrieved from: <https://www.bps.go.id/id/statistics-table/2/MTIxNiMy/laju-pertumbuhan-pdb-industri-manufaktur.html> (Date of access: 15 February 2026)

The growth of the Gross Domestic Product (GDP) of the manufacturing sector between provinces in Indonesia during the 2019–2023 period shows very diverse dynamics, both temporally and spatially. The

data shows quite sharp fluctuations in growth between years, especially in 2020, which was marked by economic contraction in most provinces due to global economic disruption. Most regions experienced negative growth in that year, such as DKI Jakarta (-10.36), Bali (-6.41), Banten (-4.67), and West Java (-4.36), indicating the high sensitivity of the manufacturing sector to external shocks.

Entering the post-2020 recovery period, manufacturing sector growth showed a significant rebound in many provinces. This can be seen from the increase in growth rates in 2021–2023, especially in regions with strong industrial bases and natural resources. Some provinces even showed very high growth, such as North Maluku, which recorded extreme growth in the 2020–2023 period (60.98 to 81.83 percent), Central Sulawesi, which consistently grew at a high rate (17.30–29.90 percent), and Southeast Sulawesi, which showed a sustained positive growth trend. This phenomenon indicates the emergence of new growth centres in eastern Indonesia, driven by resource-based industrialization and investment in the processing sector.

Conversely, there are also regions that have experienced slowdown or negative growth in recent years, such as Papua, which experienced a sharp contraction in 2023 (-50.35), and West Papua (-16.47). This disparity in growth between regions shows that the dynamics of the manufacturing industry in Indonesia are not homogeneous, but rather exhibit strong spatial variations. Differences in regional economic structures, levels of industrialization, and access to infrastructure and markets are factors contributing to these variations.

Although studies on regional growth in Indonesia have developed, most research still focuses on aggregate economic inequality or non-spatial sectoral analyzed. Studies using the New Economic Geography (NEG) perspective generally emphasize theoretical aspects of agglomeration but rarely examine how spatial interregional linkages manifest in the distribution of industrial growth at the provincial level. Empirical evidence on the evolution of spatial clustering patterns of manufacturing industries, particularly during periods of economic disruption and recovery, remains limited in the Indonesian context.

Addressing these gaps, this study therefore aims to analyse the spatial dynamics and interregional spillover effects of manufacturing GDP growth across provinces in Indonesia using an Exploratory Spatial Data Analysis (ESDA) approach. The analysis focuses on identifying spatial autocorrelation patterns, examining the formation of regional growth clusters, and exploring the implications of spatial interactions for regional development. Furthermore, this study contributes to the Sustainable Development Goals (SDGs), particularly SDG 8 (Decent Work and Economic Growth) and SDG 9 (Industry, Innovation, and Infrastructure), by providing insights into spatial inequality and the emergence of new growth centers in Indonesia. This study also provides an empirical contribution by demonstrating how spatial clustering and interregional linkages evolve during periods of economic disruption and recovery, thereby enriching the application of the New Economic Geography framework in the context of developing countries.

## 2. Methods

This study adopts the Exploratory Spatial Data Analysis (ESDA) approach as used by (Santoso et al., 2019a, 2025) to examine the geographical patterns of economic activity in the manufacturing sector in Indonesia. ESDA is employed to identify spatial patterns, interregional dependencies, and potential spillover effects in manufacturing GDP growth across provinces. The use of spatial analysis is essential, as regional economic performance is inherently interdependent and influenced by geographical proximity and spatial interactions.

This study utilizes provincial-level panel data in Indonesia for the period 2019–2023, covering all provinces. The main variable analyzed is the growth rate of manufacturing GDP in each province. The data are obtained from official publications of the Central Statistics Agency (BPS) and processed in spatial format using GeoDa software.

The ESDA framework is applied to explore the spatial distribution of manufacturing growth, detect the presence of spatial autocorrelation, and identify the formation of regional growth clusters. In this study, spatial relationships between regions are explicitly modelled using a spatial weight matrix, which defines the structure of interregional interactions.

The spatial weight matrix is constructed using a queen contiguity approach, where provinces sharing common borders or vertices are considered neighbors. This specification is widely adopted in regional spatial analysis as it captures adjacency-based spatial interactions and reflects potential economic linkages arising from geographical proximity. The matrix is row-standardized to ensure comparability across regions and to avoid bias due to differences in the number of neighboring provinces.

The use of ESDA in this study is intended as an exploratory analytical framework to identify spatial dependence and clustering patterns prior to the application of more advanced spatial econometric techniques. While ESDA does not provide estimates of causal relationships or quantify the magnitude of spillover effects, it offers robust initial evidence on the structure and dynamics of spatial interactions. Therefore, the findings should be interpreted as indicative of spatial processes rather than definitive causal inference.

To measure global spatial dependence, this study employs the Global Moran’s I statistic, which evaluates the degree of similarity between a region’s value and those of its neighboring regions. The statistics are defined as follows:

$$I = \frac{n \sum_i \sum_j w_{ij} (y_i - \mu)(y_j - \mu)}{\sum_i \sum_j w_{ij} \sum_i (y_i - \mu)^2} \dots\dots\dots(1)$$

$y_i$  is the growth rate of the manufacturing GDP of province-i,  $w_{ij}$  is the element of the spatial weight matrix,  $\mu$  is the mean of the variable, and  $n$  is the number of observation areas. A positive Moran’s I value indicates a clustered pattern, a negative value indicates a dispersed pattern, while a value close to zero indicates a random distribution (Moran, 1950).

To complement global analysis, Local Indicators of Spatial Association (LISA) are employed to identify local spatial clusters and spatial outliers. LISA enables the classification of regions into High–High (HH), Low–Low (LL), High–Low (HL), and Low–High (LH) clusters, reflecting different forms of spatial association (Anselin, 1995). In addition, statistical significance is assessed using permutation tests to ensure that the identified spatial patterns are not due to random variation. This strengthens the robustness of the spatial analysis and enhances the reliability of the findings. Therefore, ESDA is employed as a preliminary analytical framework to identify spatial patterns before advancing toward more complex spatial econometric modelling.

### 3. Results and Discussions

The 2023 manufacturing industry GDP growth map shows an uneven spatial distribution across provinces in Indonesia. Regions with high growth are concentrated in eastern Indonesia, particularly Sulawesi and Maluku, while most other regions fall into the moderate growth category. Meanwhile, several provinces in the east show low growth. This pattern indicates significant spatial variation and suggests the presence of regional clustering driven by interregional economic interactions and potential spillover effects.

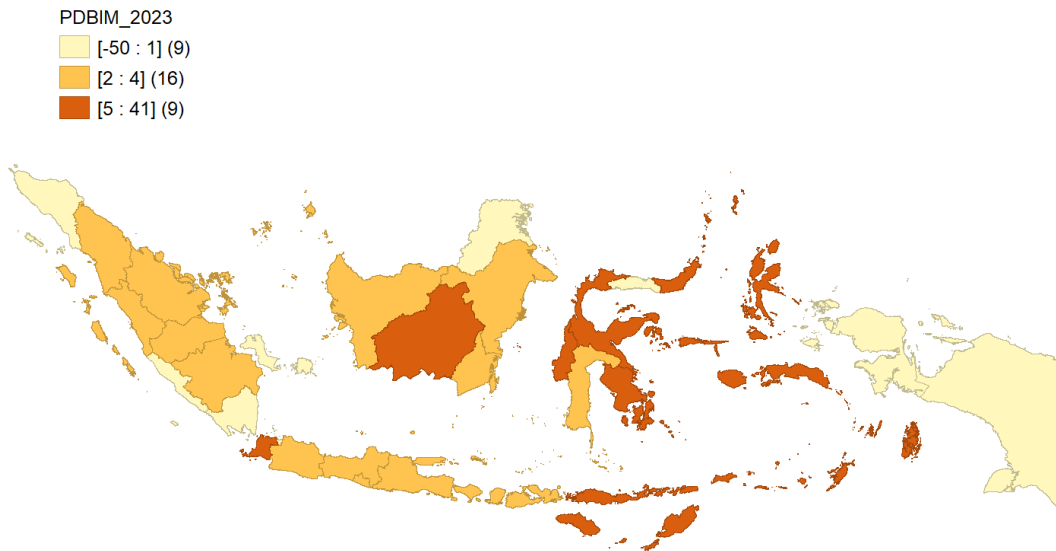


Figure 2. The Spatial Distribution of Indonesian Manufacturing Industries, 2023

Sulawesi can be identified as an emerging growth pole driven by resource-based industrialization, particularly in downstream processing industries such as nickel and mineral-based manufacturing. From the perspective of New Economic Geography, this reflects strong agglomeration forces where increasing returns to scale, market proximity, and input-output linkages attract further industrial concentration. This finding reinforces the argument that industrial growth in Indonesia is not spatially isolated, but embedded within a network of regional economic interactions shaped by agglomeration forces and spatial spillover mechanisms.

This concentration generates positive spatial spillover effects, allowing neighboring regions to benefit through economic diffusion, labor mobility, and interregional trade linkages. The formation of a High–High cluster in Sulawesi indicates not only localized growth but also a broader process of regional integration, where economic expansion in one province stimulates growth in surrounding areas.

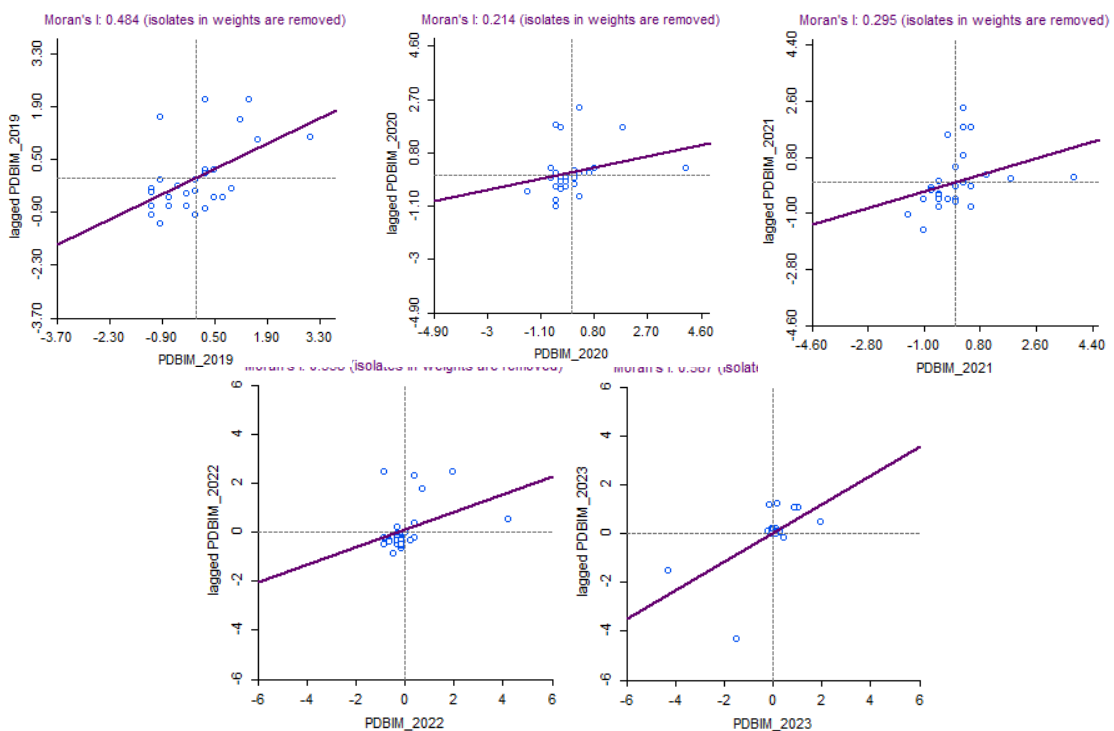


Figure 3. Global Moran's I Scatter Plots for Indonesia's Manufacturing Industry Growth Rate 2019-2023

Figure 3 shows the results of the Global Moran's I Scatter Plot analysis for the GDP growth rate of the manufacturing sector between provinces in Indonesia during the 2019–2023 period. The Moran's I

values for each year show a positive spatial autocorrelation trend, indicating that manufacturing industry growth between regions does not occur randomly but is influenced by geographical interactions between provinces. The Moran's I value decreased in 2020, indicating a weakening of spatial linkages due to economic disruptions, but gradually increased again in the 2021–2023 period, reaching 0.587 in 2023.

The pattern of change in Moran's I values during the 2019–2023 period shows three main phases, namely spatial integration, spatial decoupling, and spatial re-convergence.

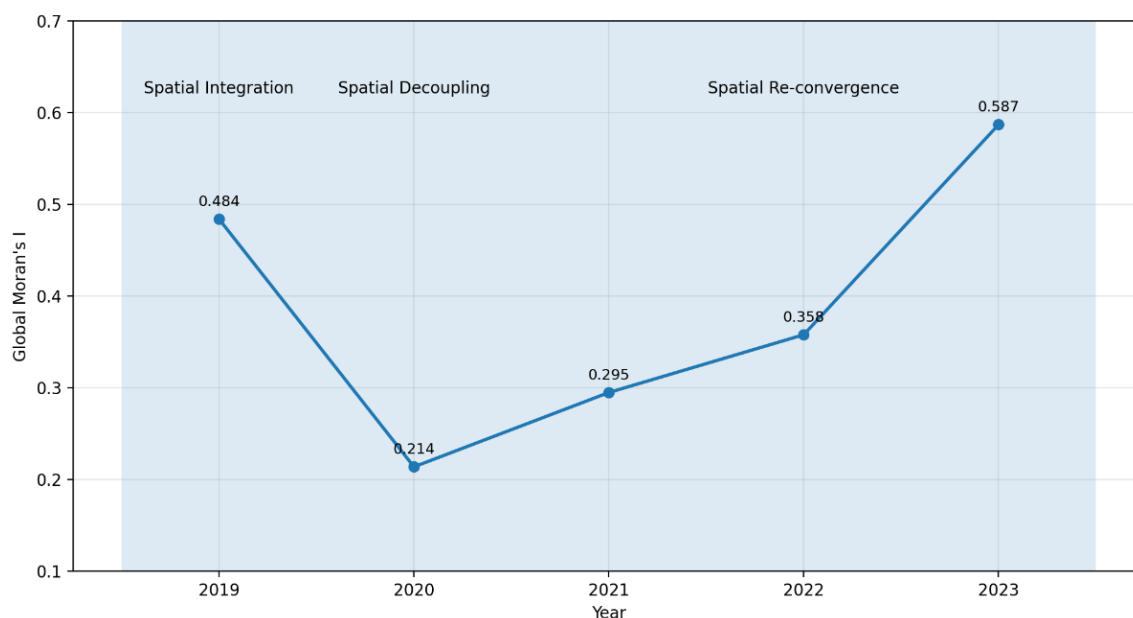


Figure 4. Spatial Dynamics of Manufacturing Growth in Indonesia (Global Moran's I, 2019–2023)

Moran's I value of 0.484 in 2019 shows that before the global economic disruption, manufacturing industry growth had formed a relatively strong spatial interconnection pattern. The sharp decline in Moran's I value to 0.214 in 2020 is an important signal indicating spatial decoupling, namely the weakening of inter-regional growth linkages (Lu et al., 2020). The increase in Moran's I to 0.295 in 2021 and 0.358 in 2022 indicates the beginning of the spatial reconnection process (Annoni et al., 2019). The sharp increase in Moran's I to 0.587 in 2023 indicates a phase of spatial re-convergence, which is a condition where economic growth is again geographically concentrated with a stronger level of interconnection compared to the period before the economic disruption (Furková - & Chocholatá, 2016). This phenomenon is often referred to in regional economics as the restructuring of spatial growth patterns, namely changes in the configuration of growth centers due to economic shocks followed by the consolidation of more competitive regions (Arbia et al., 2003; Le Gallo & Dall'erba, 2008).

From a theoretical perspective, the temporal variation in Moran's I reflects a dynamic restructuring of Indonesia's spatial economic system. The decline in spatial autocorrelation during 2020 indicates a disruption of interregional linkages due to external economic shocks, while the subsequent increase suggests a process of spatial re-convergence. This confirms that regional growth in Indonesia is inherently spatial and aligns with the framework of New Economic Geography.

Despite the national recovery, regional growth disparities have widened in the wake of the pandemic. Based on Figure 5 and Figure 6, the distribution of data through boxplots shows the emergence of extreme outliers at the top, indicating provinces with growth far exceeding the national average.

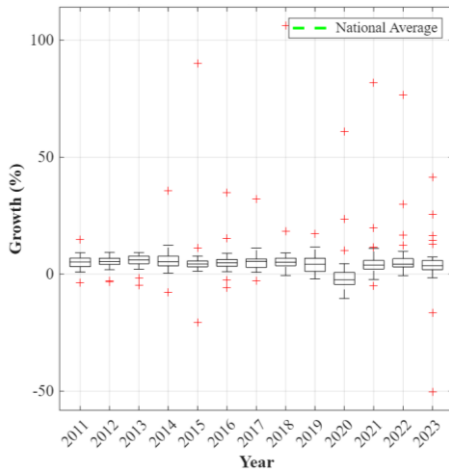


Figure 5. Distribution Across Provinces

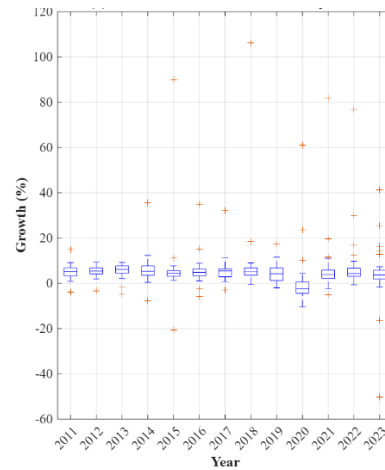


Figure 6. Distribution of Growth Rates by Year

From the perspective of New Economic Geography, this condition reflects a spatial low-growth trap characterized by weak agglomeration forces, high transportation costs, and limited market accessibility. These structural constraints reduce the attractiveness of the region for industrial investment and hinder the formation of productive economic linkages, reinforcing long-term regional disparities.

The persistence of low growth traps continues to overshadow peripheral regions such as Papua. Figure 7 shows Papua's growth chart, which experienced a sharp contraction to -50.35% in 2023. Cumulatively, Figure 8 visualizes a clear divergence in trajectories; while the provinces in Sulawesi are skyrocketing, the Papua region remains on a low or even negative growth path in the long term. This condition reflects the existence of a spatial low-growth trap due to weak economic connectivity and regional integration. These findings confirm that the reconfiguration of Indonesia's manufacturing industry geography requires policies that strengthen inter-regional connectivity to ensure that the transformation process not only creates new growth centers but also reduces increasingly selective spatial disparities.

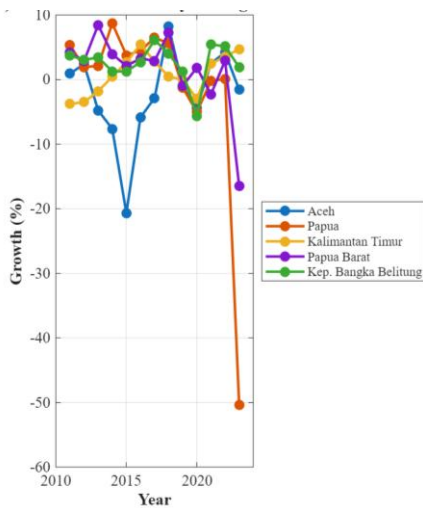


Figure 7. Bottom 5 Provinces by Average Growth

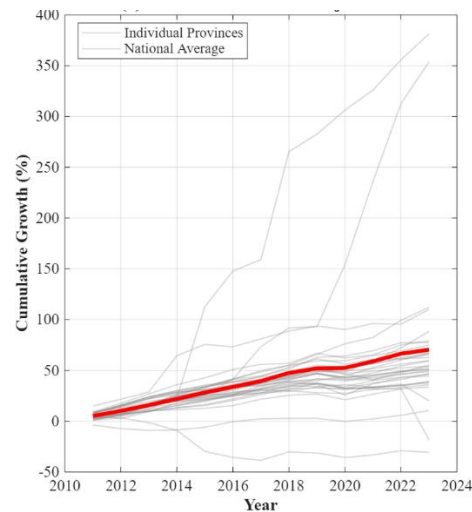


Figure 8. Cumulative Growth Trajectories

The LISA (Local Indicators of Spatial Association) map shows the pattern of local spatial autocorrelation of manufacturing sector GDP growth between provinces in Indonesia in 2023. Figure 9 shows the identification of significant spatial clustering, indicating that manufacturing industry growth does not occur randomly, but forms specific geographical clusters. The LISA Cluster Map results show the existence of a High-High cluster in the Sulawesi region, indicating a center of manufacturing industry growth with positive spillover effects between regions.

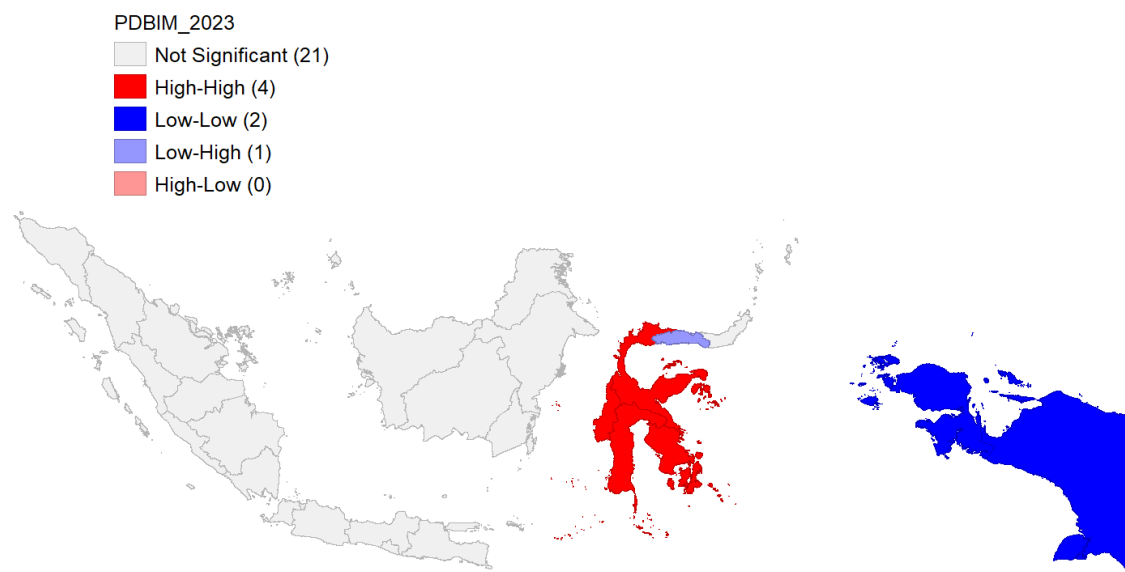


Figure 9. LISA Cluster Map of Manufacturing Growth in Indonesia 2023

This pattern is consistent with research findings showing that the concentration of economic activity and industrial agglomeration can generate spatial spillover effects through production linkages and regional economic networks (Kim et al., 2021; H. Wang et al., 2023). The existence of High-High clusters reflects the process of strengthening interactions between regions, where the growth of one region can drive the growth of surrounding regions through economic diffusion and regional agglomeration mechanisms (Bermejo Carbonell & Werner, 2018; Ertur & Koch, 2007; Lu et al., 2020). This clustering pattern provides empirical evidence of localized spatial dependence, where regions with similar economic performance tend to be geographically concentrated due to strong interregional linkages.

The Low-Low cluster in the Papua region reflects areas with low growth that are close to each other, indicating a spatial low-growth trap. This condition can be explained through the concept of a regional development trap, where peripheral regions experience structural limitations that make it difficult to escape the low-growth path due to weak economic connectivity and limited regional spillover effects (Davies et al., 2024). This phenomenon is also related to the concept of spatial lock-in, which is a situation where an underdeveloped regional economic structure reinforces the persistence of disparities between regions (Roessler, 2024). These findings confirm that manufacturing growth in Indonesia forms an uneven spatial pattern and is influenced by geographical interactions between provinces.

Spatial analysis shows that Indonesia is undergoing an industrial spatial transition, namely a shift in the geography of manufacturing industry growth from a centralized structure to a more multipolar pattern. This transition process often emerges as a response to changes in economic structure and regional dynamics that result in more balanced or geographically unbalanced development patterns (Deng et al., 2022). This spatial dynamic, from the perspective of New Economic Geography, shows that there is a restructuring of industrial geography influenced by economic agglomeration processes and regional spillover effects. The shift in growth centers from core regions to new regions reflects changes in the patterns of spatial interconnections between regions that are dynamic and evolutionary in nature. This transformation indicates that Indonesia's industrial development is evolving toward a more spatially differentiated structure, shaped by the interaction between emerging and lagging regions.

This is in line with the findings of recent studies on regional convergence dynamics, which show that changes in the value of spatial autocorrelation over time can reflect the process of spatial re-convergence, in which interactions between regions strengthen again after experiencing economic disruption (Ehnts & Trautwein, 2012; Gori & Panicià, 2015; Krugman, 1995; Santoso et al., 2019b).

Figure 10 and the descriptive statistics in table 1 show the fluctuating dynamics of Manufacturing Industry GDP Growth between regions during the 2019–2023 period.

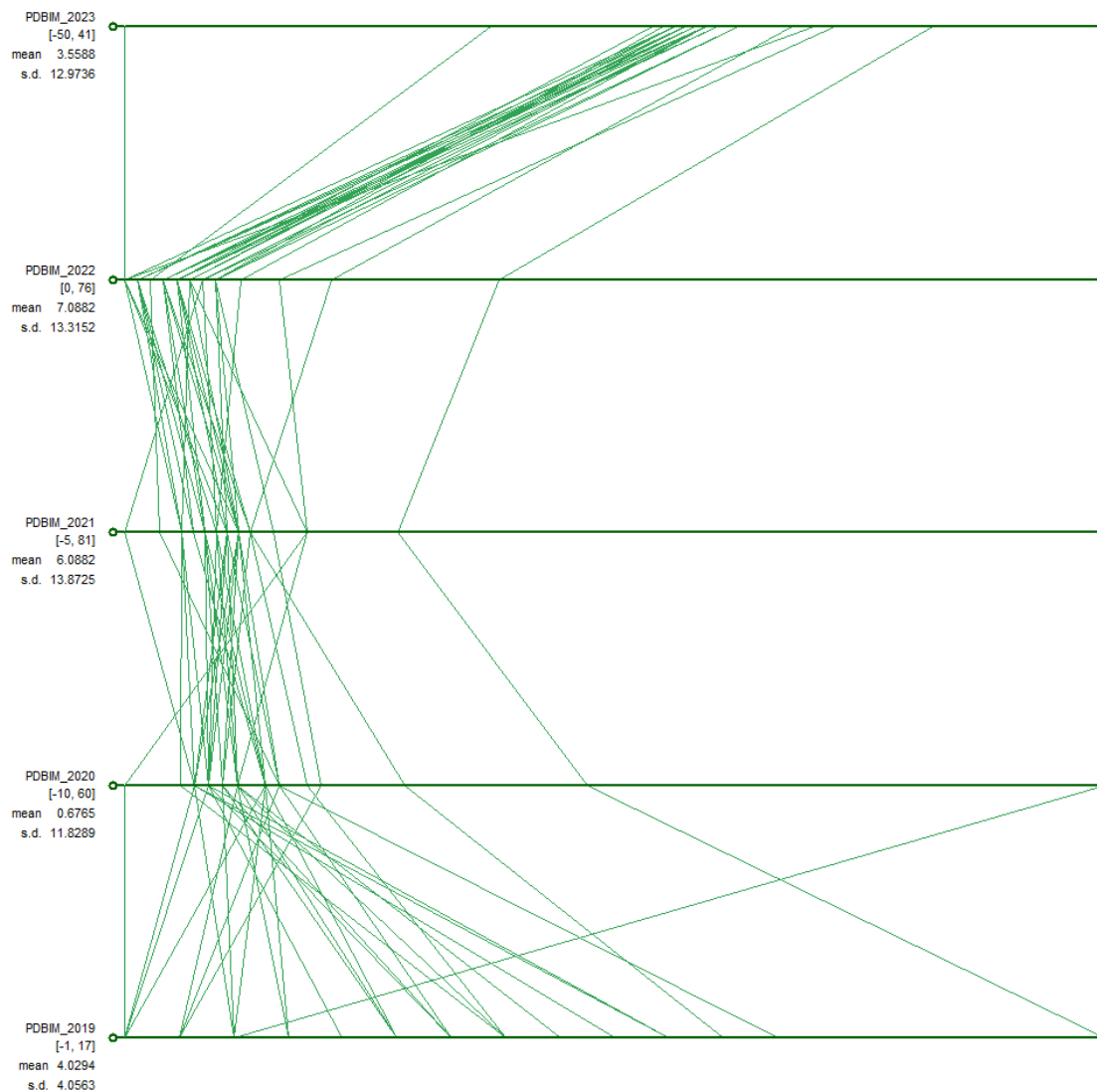


Figure 10. Parallel Coordinate Plot of Manufacturing Industry GDP Growth 2019–2023

The Parallel Coordinate Plot shows that the rate of manufacturing industry GDP growth between provinces during the 2019–2023 period is heterogeneous and dynamic. The number of intersecting lines indicates changes in the relative positions between regions over time, especially in the 2020 period, which shows an increase in growth variation. This pattern indicates regional growth restructuring and reinforces the finding that the dynamics of the manufacturing industry in Indonesia are influenced by changes in the spatial structure between regions. This further suggests that regional economic performance is dynamic and influenced by shifting spatial interactions over time.

Tabel 1. Statistik trajectory plot

Year	Mean	Standard Deviation	Interpretation
2019	4.0294	4.0563	Relatively small variation
2020	0.6765	11.8289	Sharp decline + increased variation
2021	6.0882	13.8725	Strong recovery
2022	7.0882	13.3152	Average peak
2023	3.5588	12.9736	Decline Again

The average growth of the manufacturing industry's GDP experienced a sharp decline in 2020 from 4.0294 to 0.6765, indicating an economic shock. In the 2021–2022 period, there was an increase in the average to 7.0882, indicating a phase of economic recovery. A further decline in 2023 to 3.5588 indicates a slowdown in growth. On the other hand, an increase in standard deviation from 4.0563 in 2019 to above 12 in the period after 2020 shows that the disparity in industrial growth between regions is increasing.

This confirms that post-disruption recovery has been uneven and spatially selective, reinforcing the persistence of regional disparities.

Overall, the findings of this study demonstrate that manufacturing industry growth in Indonesia is inherently spatial and shaped by interregional dependencies. Strengthening interregional connectivity and implementing spatially integrated industrial policies are essential to reduce regional disparities and support inclusive economic growth. These efforts are particularly relevant in achieving SDG 8 and SDG 9.

## **Conclusion**

The findings of this study indicate that the growth of the manufacturing industry in Indonesia is undergoing a fundamental spatial transformation. The emergence of new growth clusters in Sulawesi and the persistence of low-growth areas in Papua signal a shift in the core periphery structure of the national economy. The observed spatial autocorrelation dynamics confirm that regional growth is not independent but is shaped by geographical interactions and interregional spillover effects. This study provides empirical evidence that the geography of Indonesia's manufacturing industry is being reconfigured towards a more multipolar structure, while simultaneously revealing the persistence of spatial inequality. These findings contribute to the literature by demonstrating how spatial dynamics and clustering patterns evolve during periods of economic disruption and recovery, particularly within the framework of New Economic Geography. From a policy perspective, the results highlight the importance of adopting spatially integrated industrial development strategies. Strengthening interregional connectivity, promoting balanced industrial expansion, and addressing structural constraints in lagging regions are essential to ensure that industrial transformation leads to more inclusive and equitable growth. In the context of sustainable development, these efforts are crucial in supporting the achievement of SDG 8 (Decent Work and Economic Growth) and SDG 9 (Industry, Innovation, and Infrastructure), particularly in reducing regional disparities and fostering sustainable industrialization across Indonesia.

## **Limitations**

This study has several limitations that should be acknowledged. First, the analysis relies on the Exploratory Spatial Data Analysis (ESDA) approach, which is inherently exploratory in nature. While ESDA is effective in identifying spatial patterns and dependencies, it does not provide estimates of causal relationships or quantify the magnitude of spillover effects. Therefore, the findings of this study should be interpreted as indicative of spatial processes rather than definitive causal inference. Second, the relatively short observation period (2019–2023) may limit the ability to capture long-term spatial dynamics and structural transformations in the manufacturing sector. The period analyzed is also influenced by significant external shocks, which may affect the stability of observed spatial patterns. Third, the spatial weight matrix is constructed based on geographical proximity, which may not fully capture the complexity of interregional economic interactions. In practice, economic linkages between regions are also shaped by trade networks, infrastructure connectivity, and institutional factors that are not explicitly modeled in this study. Future research is therefore recommended to apply spatial econometric models, such as the panel Spatial Durbin Model (SDM), to quantify spillover effects and examine causal relationships more rigorously. In addition, extending the temporal scope and incorporating additional variables related to economic structure, infrastructure, and connectivity would provide a more comprehensive understanding of the spatial transformation of industrial development in Indonesia.

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