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An Analysis of the Effects of Spatial Dependence on Economic Growth Among Regencies and Cities in Java

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Abstract

Java is inarguably essential for Indonesia's economy with its 59% contribution to the country's GDP. However, behind the tremendous participation lies high regional disparity, poverty, and unemployment, which have become challenges to its economic development. This research aims to analyze the role of spatial dependence on regional economic growth in 119 regencies and cities in Java during the 2015-2019 period. Exploratory Spatial Data Analysis (ESDA) and Spatial Durbin Model (SDM) were used to analyze the determinants of the spatial dependence and its impact on regional economic growth. The travel time among regions was utilized for the spatial weight matrix. The existence of spatial dependence in inter-regional economic growth can be identified from all models. The positive value of Moran's I in the ESDA analysis indicates that the spatial pattern of the growth is clustering. The lambda parameter in the SDM estimation indicates the occurrence of backwash spillover in the effect of the spatial dependence on economic growth. The direct effects of initial per capita income, physical capital investment, road infrastructure, population growth, and education are significant on economic growth. Furthermore, the spillover effect of initial per capita income and education is also significant on the inter-regional economic growth.

Keywords: Economic growth, spatial dependence, spillover effect, Exploratory Spatial Data Analysis (ESDA), Spatial Durbin Model (SDM)
JEL classification: C31, O18, R11, R12, R58

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1. INTRODUCTION

The economic growth model continues to develop along the emergence of recently proposed various analyses. The economic growth model has evolved from the neoclassical model, which initially focused on supply-side analysis, to the demand-side model. Furthermore, the development of the neoclassical model has incorporated spatial analysis (Harris, 2011). The role of spatial analysis in the neoclassical model of Solow (1956) has been questioned since the concept of long-term supply-side growth determined by consumption, capital growth, labor, and technological progress has acquired many criticisms as it does not consider the existence of spatial dependence between regions (Cheshire & Malecki, 2003). However, a region cannot function as an independent unit and disregard other regions. Interregional socio-economic interactions occur through various economic activities such as trade, capital flows, migration, technology diffusion, and information exchange (Aspiansyah & Damayanti, 2019; Nijkamp & Poot, 1998; Rustiadi et al., 2009). The presence of non-natural factors and regional economic clusters can lead to inter-regional associations and obtain parameters containing spatial lag (Nurjanna et al., 2020). Hence, in the study of interregional economic growth, disregarding spatial dependence can lead to biased or misleading conclusions because the spatial lag from the model is omitted (Anselin, 1988).

In the analysis of inter-regional economic growth incorporating spatial connectivity, one of the important steps is determining the weight of the relationship between the regions being studied, which is known as spatial weight matrix (Lesage & Fischer, 2008). This study applies travel time as spatial weight matrix. In its development, spatial connectivity of spatial dependence among regions are not limited by geographical characteristics (physical spatial weight), as proposed by Anselin (1988) and LeSage & Pace (2009), such as contiguity and distance. Instead, it also considers economic spatial weights (Nurjanna et al., 2020). Since the inter-regional spatial dependence are not hindered by distances and administrative boundaries alone, but rather various needs in economic activities caused by regional heterogeneity (Sapena & Ruiz, 2019; J. Wang, 2017), so travel time among regions is used for spatial weight matrix in this study. There are uncommon spatial weight matrices that have been applied; they are travel cost (Mustajab, 2009), population characteristic (Case et al., 1993), and travel time (Lesage & Fischer, 2008; Mustajab, 2009).

The existence of spatial dependence in inter-regional economic growth from numerous previous research proves the importance of considering spatial dependence for inter-regional economic growth analysis. In the context of multi-national dependence, Ertur & Koch (2007) and Fischer (2011) found the impact of such dependence on the economic growth of 91 countries from 1960 to 1995 and of 198 regions from 22 European countries from 1995 to 2004. Then, Sun et al. (2017) and Wang et al. (2021) also found the significant role of spatial dependence on economic growth among prefectures (from 1992 to 2010) and provinces (from 2009 to 2017) in China. In the Indonesian context, there are several researchers who have found the existence of spatial dependence in inter-regional economic growth; they are Aspiansyah & Damayanti (2019) at provincial level, Nurjanna et al. (2020) at cross-regional level in Sulawesi, Miranti & Mendez (2022), Day & Lewis (2013), Ervina & Jaya (2018), Aritenang (2014), and Santos-Marquez et al. (2022) across regions in national level, Wibisono & Kuncoro (2015), Rummaya et al. (2005), Laksono et al. (2018) across regions in East Java.

According to the past findings and past statistical economic data, Java is one of the Indonesian islands appealing for research in terms of its economic growth spatial connectivity. Then, there are no previous studies that uses regencies and cities in Java as observation units. Some previous studies conducted analyses only on provincial level, or at least on inter-regional level in one province. Thus, it is important to analyze the effects of the spatial dependence on economic growth in Java with considerations on all regions such as regencies and cities (Pravitasari et al., 2021). However spatial dependence between regions are hindered not only by distances and administrative boundaries but also by various needs in economic activities caused by regional heterogeneity (Sapena & Ruiz, 2019; Wang, 2017).

Java is the most populous island not only in Indonesia but also in the world. In fact, according to *Population Census of 2020*, Java is the home to 56,10% (151,59 million people) of Indonesia's total population (270,2 million people) (Statistics Indonesia, 2021a). Therefore, the centrality of Java to Indonesia as a whole is undeniable. For instance, it contributes approximately 59% of Indonesia's Gross Regional Domestic Product (GRDP) (*Statistics Indonesia*, 2020). According to Simon (1990), large population will induces greater scale of production and market, and thus increasing output and efficiency. Then, there is straight comparison between the population and the total GRDP in Java. Regardless of Java's contribution to the Indonesia's economic performance, the development within this island is persistently uneven among its regencies and cities (Pravitasari et al., 2021; Rustiadi et al., 2010). Most of Java's GRDP comes from its metropolitan areas. According to Rahadini (2018) and Pravitasari et al. (2021), there are six metropolitan areas which serve as the central of its economic activity; they are *Jabodetabek*, *Bandung Raya*, *Kedungsempur*, *Kartamantul*, *Gerbangkertosusila*, and *Solo Raya*. Table 1 shows that the six metropolitan areas contribute 64% on GRDP, despite its meager coverage of 10,32%. In addition, spatial concentrations can also be found in most developing countries where population and industrial distribution are concentrated in large cities, such as Bangkok, New Delhi, Sao Paulo which marking a spatial system based on capital and labor accumulation in the urban agglomeration (Kuncoro, 2002). Hence, regional differences have been clearly noticeable not only between Java and outside Java, but also among regions within Java (Rahadini, 2018).

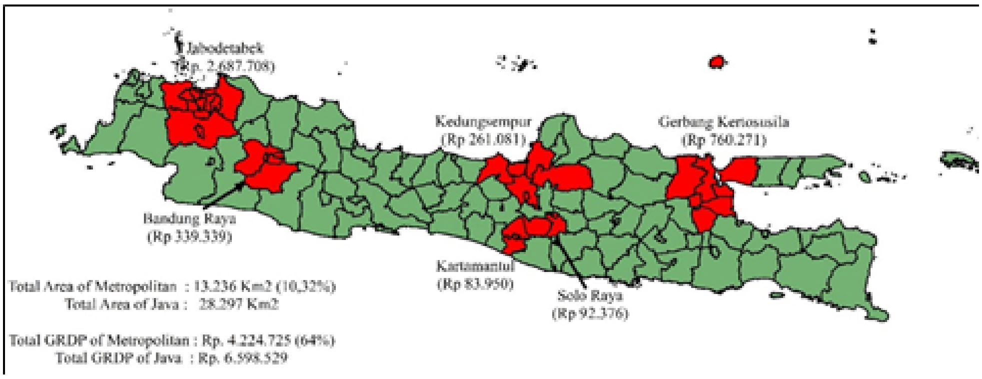

Figure 1. Regions and GRDP *at Constant Price* (in billion Rupiah) of Java's Metropolitan
Source: Statistics Indonesia (processed by the authors)

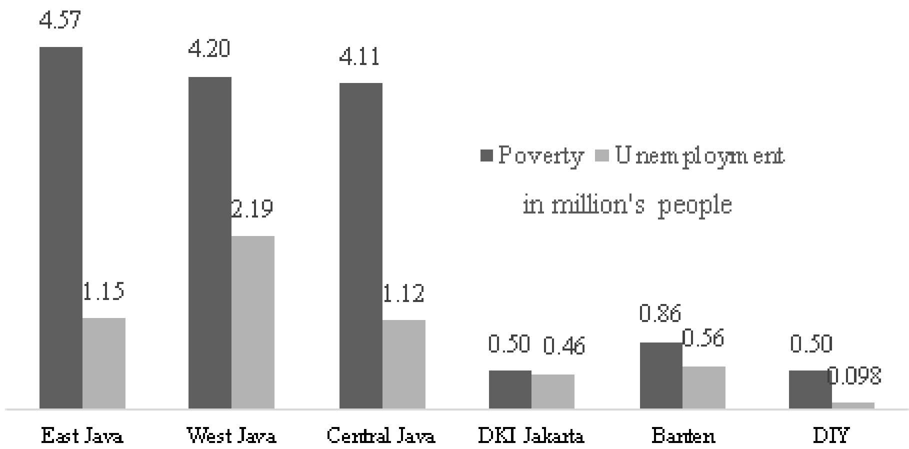

Figure 2. Poverty and Unemployment rate in Javanese provinces
Source: Statistics Indonesia (processed by the authors)

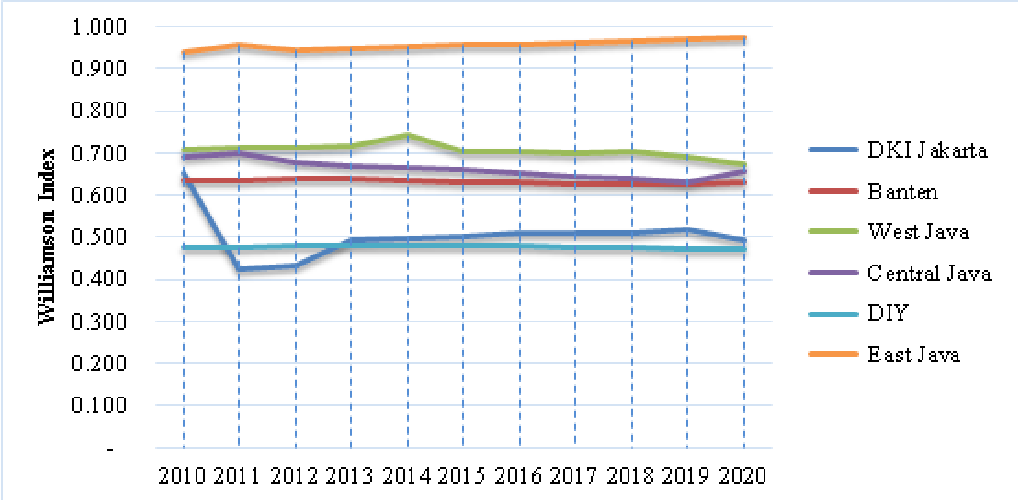

Figure 3. The comparison of the Provincial Williamson Index in Java During the 2010-2020 period

Source: Processed by the authors

The large population in Java is a socioeconomic problem. Java is the home of 53,57% (14,75 million out of 27,54 million) of Indonesian poor population. Three of its provinces are the highest in terms of poverty; they are East Java (4,57 million), West Java (4,2 million), and Central Java (4,11 million). In addition, from 8,75 million of unemployed people in Indonesia, 63,78% (5,58 million people) live in Java. West Java (2,19 million people), East Java (1,15 million people), and Central Java (1,12 million people) are the three provinces with the highest poverty rate (Statistics Indonesia, 2021). Figure 2 shows the details. Therefore, reducing socioeconomic problem like poverty and unemployment in Java is so strategic and influential because accelerating its reduction rate will certainly influence the nation as a whole (Hidayat et al., 2021).

Indonesian government reduces inequalities and enhances economic activities in Java by increasing inter-regional accessibility, such as by constructing the *Trans Jawa Toll Road*. According to Haughton & Khandker (2009), the determinant factor for poverty is the low accessibility, which is one of the spatial factor of inter-regional easy access. The target of *Trans Jawa Toll* is connecting regions from western Java (Merak Port) to the eastern Java (Banyuwangi Port), which covers the distance of 1,056.38 kilometers. The inter-regional connection can increase efficiency and facilitate distribution of goods and services. Such connection is also expected to expand and enhance production networks and supply chains of goods and services between regions. Then, it will increase productivity and competitiveness in trade and investment flows in various regions, which lead to higher economic growth (Asian Development Bank., 2012; Banerjee et al., 2020; Chen & He, 2014).

Although the 2010-2020 Williamson Index indicate reductions in economic disparity rates between regencies and cities in Javanese provinces, the resulting values are still considered high (Table 1). The high inequality of the Williamson Index is indicated by the average value of more than 0,5 (Williamson, 1965). The high economic activity in Java is taken over by the large economic, agglomerated regions, and surrounding regions which are less than 100 kilometers in distance. Regions which are far (i.e., more than 100 kilometers) from economic growth poles are potentially stagnant (Firman, 2017). Otherwise, it is a different pattern from the increasing connectivity and accessibility in Java. Nevertheless, the fact remains that the economic gap between developed regions and less-developed regions is still wide, becoming an important topic in terms Java's development (Pravitasari et al., 2021). Spatial connectivity is supposed to have contributed to the equal distribution of inter-regional economic growth with the help of spillover effects (Capello, 2009). Hence, this study aims to analyze the determinants and role of spatial dependence on economic growth in Javanese regencies and cities, as well as to find solutions for the said socioeconomic problems. Spatial dependence should play a role in regional economic growth and disparity. All Javanese regencies and cities are included in this study.

2. RESEARCH METHOD

2.1. Data

This study generates data from 119 regencies and cities in Java as cross-section data. The selection of the 2015-2019 period was made due to the pre-global crisis and the decline in economic growth as the consequences of the Covid-19 pandemic. One of the prominent matters in the analysis of regional economic growth, according to Lesage & Fischer (2008), is describing variables included in the research. This study uses the Mankiw-Romer-Weil (MRW Model), which was initiated by Mankiw et al. (1992). This model was derived from the neo-classical model with an addition of a factor, i.e., human capital. This, the MRW Model was used to describe all variables in this study. According to the Model, per-capita regional income growth is the main explanatory and dependent variable. Previous studies that used the same model are those by Aspiansyah & Damayanti (2019), Fischer (2011), Nurjanna et al. (2020), and Sun et al. (2017). There are at least two advantages of using the MRW model.MRW Model can detect the existence of convergence in regional economic growth according to the assumption of diminishing return to capital in rich regions and the catching-up process of poor regions (Mankiw, 2010). According to Mankiw et al. (1992) and Fischer (2011), the β parameter of the initial per capita income is the indicator of the existence of convergence. This model can be extended according to the necessity of the analysis., Moreover, based on the purposes of this study, MRW Model adopts spatial effect and becomes MRW Spatial Model (Ertur & Koch, 2007; Fischer, 2011). MRW Spatial Model's problem statement is similar to the problem statement of this study, which is the direct effect from the region itself and the indirect effect of spatial spillover from other regions. Therefore, the economic growth of a region is not only affected by initial per capita income, physical capital investment, human capital, population growth, and total factor productivity from the region itself but also influenced by the initial per capita income, physical capital investment, human capital, population growth, total factor productivity, and economic growth of other regions. All variables and their operational definitions can be seen in Table 2.

Table 1. Definitions of Operational Variables

Variables	Proxy	Definition
Regional Economic Growth	$(y_{it} - y_{it-1})$	The growth of Gross Domestic Regional Product at constant prices in 2010 divided by total population
Initial per capita income	(y_0)	Absolut total GRDP per capita at constant prices in the first year of study
Physical Capital Investment	(PMTDB)	Gross Fixed Capital Formation or *Pembentukan Modal Tetap Domestik Bruto* (PMTDB) in BPS
Road Infrastructure	(Road)	The ratio of total road length is divided by the total population
Human Capital Investment	(Education)	The ratio of the enrollment population currently at secondary school divided by the number of people aged 16-18 years (Gross Enrollment Ratio or *Angka Partisipasi Kasar*)
Population Growth	(Population)	Population Growth Rate of each region

Variables	Proxy	Definition
Total Factor Productivity	(TFP)	the proportion of the output of all inputs or factors in the production process following Cobb & Douglas (1928); $A = \frac{Y_i}{L_i^{\alpha} K_i^{\beta} \varepsilon_i}$

Source: *Processed by the authors, 2023*

2.2. Addressing Spatial Spillovers: Spatial Weight Matrix

Spatial regression models cannot be separated from the use of a spatial weight matrix. A spatial weights matrix is an $n \times n$ positive symmetric matrix W with element W_{ij} at location i, j for n locations. The values of W_{ij} or the weights for each pair of locations are assigned by some preset rules which define the spatial correlation among locations and, therefore, determine the spatial autocorrelation statistics. By convention, W_{ii} or $W_{jj} = 0$ for the diagonal elements (Dubin, 2012).

According to Lesage & Fischer (2008), the travel time measures of distance reflect economic distance better since it may introduce additional realism to connectivity. The structure of the road networks, the presence of mountains, rivers, oceans, landlocked areas, national car, and lorry speed limits, as well as statutory rest periods for drivers, may lead to large differences between geodesic and drive time distances. The utilization of travel time as a spatial weight matrix has been performed by Vidyattama (2014), Mustajab (2009), and Lesage & Fischer (2008). The Excell Geocoding Tool in Microsoft Excell which is connected to Bing Maps Distance Matrix API was obtained to calculate the travel time between regions. The combination of longitude and latitude was used to detect the location of regions. However, the *inverse distance matrix* was utilized for denoting the regions' correlation in travel time, i.e., $W_{ij} = \frac{1}{d_{ij}}$. Where d_{ij} is the time needed to travel from i to j.

2.3. Exploratory Spatial Data Analysis (ESDA)

Moran's I was mainly used for global autocorrelation analysis, which is defined as:

$$I = \frac{N}{(\Sigma_i \Sigma w_{ij}} \frac{\Sigma_i \Sigma_j W_{ij} (Y_i - \bar{Y})(Y_j - \bar{Y})}{\Sigma_i (Y_i - \bar{Y})^2}$$

Where $\bar{Y}$ is average of observations across regions, W_{ij} is weights of spatial linkages between and , are the data of -th location variable (= 1, 2, …., n), Y_j are the data of i -th location variable (= 1, 2, ….,n). Moran's I is a number that ranges from -1 to 1. If Moran's I is greater than zero ($I > 0$), there is positive spatial autocorrelation, which indicates that the close observation locations have similarity (clustered). If Moran's I is less than zero ($I < 0$), there is negative spatial autocorrelation, which indicates that the observations at an adjacent location tend to be different (dispersed) (Anselin, 1988).

For recognizing the specific location of spatial clusters or grouping and outliers, a local analysis of spatial autocorrelation is needed. According to Anselin (1995), local indicators of spatial association (LISA) is proposed to indicate the existence of any spatial autocorrelation at each unit which determines the spatial relationships among the units. The formula of LISA is as follows.

$$I_i = \frac{(Y_i - \bar{Y}) \Sigma_j W_{ij} (Y_j - \bar{Y})}{\Sigma_i (Y_i - \bar{Y})^2 \, / \, N} : i \neq j$$

The result of $I_i = 0$ indicates that i has no spatial autocorrelation. Otherwise, the result of $I_i \neq 0$ indicates that region has spatial autocorrelation.

For determining the cluster value of region and , Moran Scatter Plot was used. Moran Scatter Plot is an illustration of the relationship between the value of the chosen attribute at each location unit depending on the average value of the same attribute at the neighboring locations. According to local Moran's I Index (I), Moran Scatter Plot is divided into 4 quadrants. Quadrant I is high-high (H-H), which indicates high economic growth with high economic growth of neighbors, or clustering occurred; quadrant II is low-high (L-H), which indicates low economic growth with high economic growth of neighbors or the presence of spatial outlier; quadrant III is low-low (L-L), which indicates low economic growth with low economic growth of neighbors, or clustering occurred; and quadrant IV is high-low (H-L), which indicates high economic growth with low economic growth of neighbors or the presence of spatial outlier.

2.4. Panel Data Spatial Econometric Model (Spatial Durbin Model)

This study uses panel data. According to Elhorst (2014), the growing interest of econometric relationships based on spatial panel is caused by the increased availability of more data sets in which spatial units are followed over time. The selection of panel data model analysis such as fixed effect model, random effect model, or common effect must be considered. In the other words, before obtaining the accurate spatial panel data estimation results, it is necessary to select panel data regression (Elhorst, 2014). Hausman test was used for appropriately selecting the panel model in a spatial econometric. This test can be used to test the random effect model (REM) against the fixed effect model (FEM), which is more efficient than the common effect model (CEM). According to Elhorst (2014), the standard for spatial panels are fixed and random effect. If the result of the Hausman test is 0, random effect model must be used for the panel data model. If the result is not equal to 0, fixed effect model must be used. However, various similar previous studies by Sun et al. (2017), Arbia et al. (2005), Vidyattama (2014), Ervina & Jaya (2018), Wang et al. (2021), and Álvarez & Barbero (2016) used the fixed effect model for spatial panel data model estimation.

This study adopts Spatial Durbin Model (SDM) for the spatial econometric panel data model. According to LeSage & Pace (2009), the Spatial Durbin Model (SDM) is an extension of the Spatial Autoregressive (SAR) Model which adds spatial lag to its independent variables. Numerous past researchers such as Fischer (2011), Aspiansyah & Damayanti (2019), Panzera & Postiglione (2022), Nurjanna et al. (2020), Sun et al. (2017), dan Álvarez & Barbero (2016) found that, should the research on regional economic growth be conducted using MRW Model, the most theoretically appropriate regression type is the Spatial Durbin Model. This model enables the determination of a region's economic growth with the help of the region's independent variables, other region's economic growth, and independent variables of other regions (Aspiansyah & Damayanti, 2019).

The estimation model for region using SDM (Fischer, 2011) is as follows.

$$y_{it} = \beta_0 + \lambda \sum_{j=1}^{n} w_{ij} y_{jt} + \beta_k x_{it} + \gamma_k \sum_{j=1}^{n} w_{ij} x_{jt} + \varepsilon_i \qquad (1)$$

Where,
y_{it} : $n \times 1$ vector of the dependent variable of each region at time
y_{jt} : $n \times 1$ vector of depenent variable of each region at time
x_{it} : independent variable of i region at time t
x_{jt} : $n \times 1$ vector of independent variable of each region at time
λ : the spatial autocorrelation coefficient
w_{ij} : $i \times j$ spatial weight matrix
β_0 : intercept or constant parameter
β_k : $k \times 1$ vector of regression parameters
γ_k : $k \times 1$ weighted vector of regression parameters
ε_i : $n \times 1$ vectors of error terms at time

The model estimation of SDM above is modified to structural model (Elhorst, 2014):

$$Y = \lambda WY + \beta_0 + X\beta + WX\lambda + \varepsilon$$

Where, λ, β, and γ are parameters from the dependent variable with spatial lag weighted,

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independent variable without spatial lag weighted, and independent variable without spatial lag weighted.

Based on equation 1, the proposed model, which is the combination of all variables of MRW Model, the model design of this study is as follows.

$$\boldsymbol{y_{it}} - \boldsymbol{y_{it-1}} = \beta_0 + \lambda \sum_{j=1}^{119} W_{ij}\, y_{jt} - y_{jt-1} + \beta_1 y_{0_{it}} + \beta_2 PMTDB_{it} + \beta_3 \text{Road}_{it} + \beta_4 \text{Population}_{it} + \beta_5 Education_{it} + \beta_6 TFP_{it} + \gamma_1 \sum_{j=1}^{119} W_{ij}\, y_{0_{jt}} + \gamma_2 \sum_{j=1}^{119} W_{ij}\, PMTDB_{jt} + \gamma_3 \sum_{j=1}^{119} W_{ij}\, \text{Road}_{jt} + \gamma_4 \sum_{j=1}^{119} W_{ij}\, \text{Population}_{jt} + \gamma_5 \sum_{j=1}^{119} W_{ij}\, Education_{jt} + \gamma_6 \sum_{j=1}^{119} W_{ij}\, TFP_{jt} + \varepsilon_{it}$$

3. RESULTS AND DISCUSSIONS

3.1. Descriptive Analysis

The distribution of this research's data was explained using descriptive statistics. There are several items that can be statistically identified. The economic growth level of a regency, which is the response or dependent variable of this study, is proxied by per capita GRDP growth. The descriptive statistics was useful in identifying that the average economic growth of regencies and cities in Java during the 2015-2019 period was 4.654%, with the highest economic growth being in Blora Regency in 2016 (23.016%) and the lowest economic growth being in Bangkalan Regency in 2015 (3.529%). Other statistical data of other variables such as mean, median, highest value, and lowest value ais presented in Table 3 below.

Table 2. Summary of Descriptive Statistics

Variable	N	Mean	Median	Minimum	Maximum
Per capita GRDP Growth	119	4.65400	4.78400	-3.52900	23.0160
Initial per capita GRDP	119	3.64e+7	1.90e+7	1.10e+7	3.88e+7
PMTDB	119	2.2e+13	7.9e+12	2.6e+11	2.3e+14
Road Infrastructure	119	0.88580	0.78760	0.00000	2.55160
Population Growth	119	0.82480	0.64200	0.00220	8.85700
Gross Enrollment Ratio	119	83.7700	83.3800	43.0700	142.190
TFP	119	1.91640	1.69420	0.72850	8.46750

Source: Processed by the authors

3.2. Exploratory Spatial Data Analysis (ESDA)

For exploring the spatial dependence on inter-regional economic growth among 119 regencies and cities in Java, statistical data over from 2015 to 2019 were employed. The data was gathered from Statistics Indonesia. In order to investigate the spatial dependence or spatial autocorrelation on inter-regional economic growth in Java in general, Moran's I value was used. According to Table 3 below, the Moran's I value for per capita regional income growth can be indicated for per-year spatial dependence on inter-regional economic growth. To perform analyses on spatial dependence, spatial connectivity or spatial weight matrix across the 119 regencies and cities in Java was constructed. In this paper, travel time adopting inverse distance matrix was used for defining the neighborhood of each region. Then each region obtains 118 links or neighbors, and the total number of nonzero links is 14.042.

Table 3. Global Autocorrelation Test Result (Moran's I) of per capita regional income growth

Year	Moran's I Value	p-value	Expectation
2015	0.0087	0.0234	-0.0085
2016	0.0069	0.0294	-0.0085
2017	0.0104	0.0216	-0.0085
2018	0.0056	0.0669	-0.0085
2019	0.0179	0.0024	-0.0085

Source: Processed by authors

The measurement of the global spatial autocorrelation based on Moran's I value and p-value (Table 3) shows the existence or significance of spatial dependence among the 119 regencies and cities in Java every year from 2015 to 2019. All Moran's I value of all years fall between -1.0 and +1.0 or ≠0 with the p¬-value of < 0.05 (significance level of 5%), with an exception for 2018 whose p¬-value is < 0.1 or the significance level of 10%. Based on those values, there are positive spatial autocorrelations or spatial clustering among the 119 regencies and cities in Java from 2015 to 2019. However, the low Moran's I value indicate the low inter-regional spatial autocorrelation/dependence or economic growth spillover. This low spillover occurred since all of the 119 regencies and cities in Java were involved together as an observation unit. Whereas, according to their economic activity, each regency and city have the clustering characteristic or spatial concentration. The rapid development of regions in Java is driven by economic activities in metropolitan areas and large cities. Regencies and cities with the lower distance from metropolitan areas enjoy more economic spillover effect (Pravitasari et al., 2021). Rahadini (2018) even stated that the two largest manufacturing concentrations within Java are in Greater Jakarta and Greater Surabaya. They create bipolar patterns of economic activities from eastern Java to western Java along north Java corridor. This leads to differences in regional development between northern and southern regions of Java.

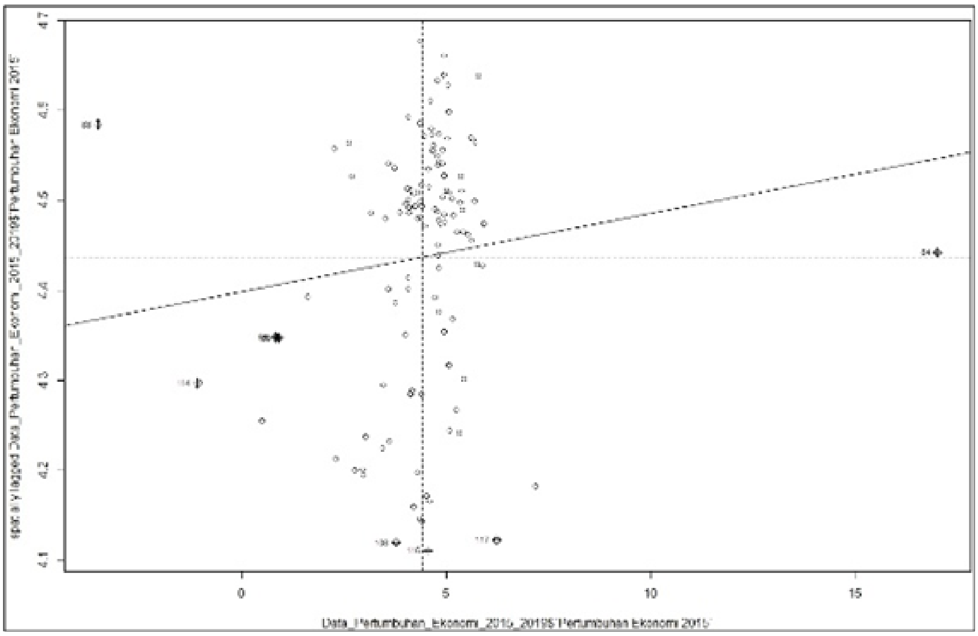

Figure 4. Moran Scatterplot of Economic Growth in 2015 (The First Period of Study)

Source: Processed by the authors

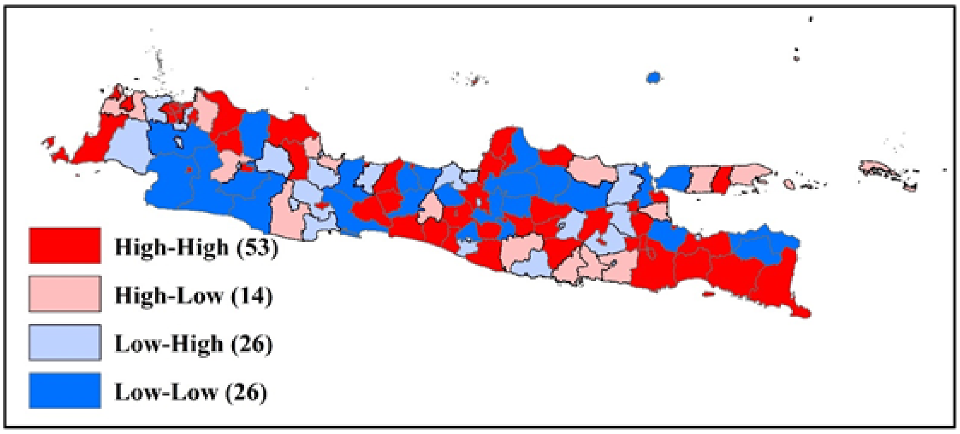

Figure 5. Clustering Map of Moran Scatter Plot in 2015 (The First Period of Study)
Source: Processed by the authors

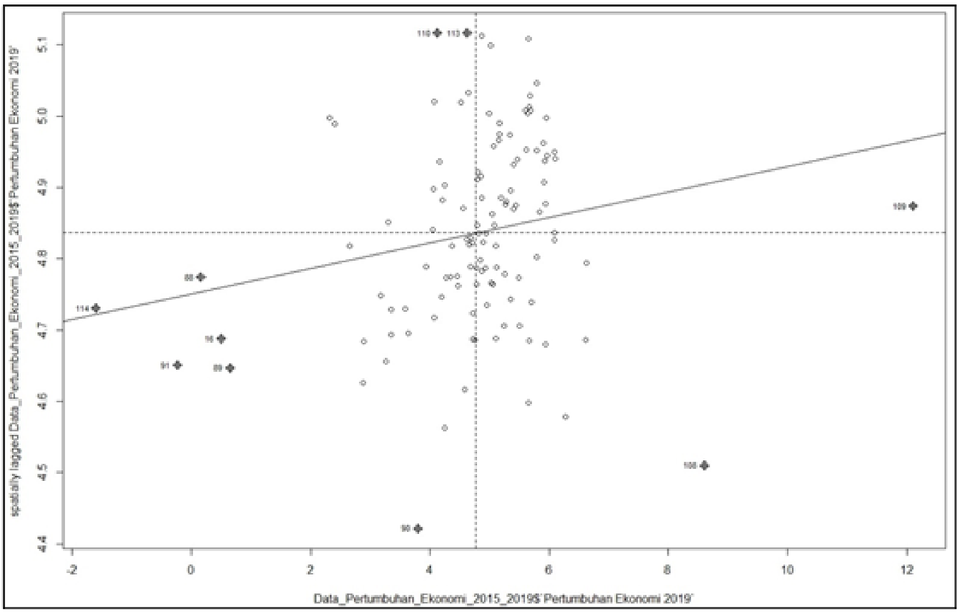

Figure 6. Moran Scatterplot of Economic Growth in 2019 (The Last Period of Study)
Source: Processed by the authors

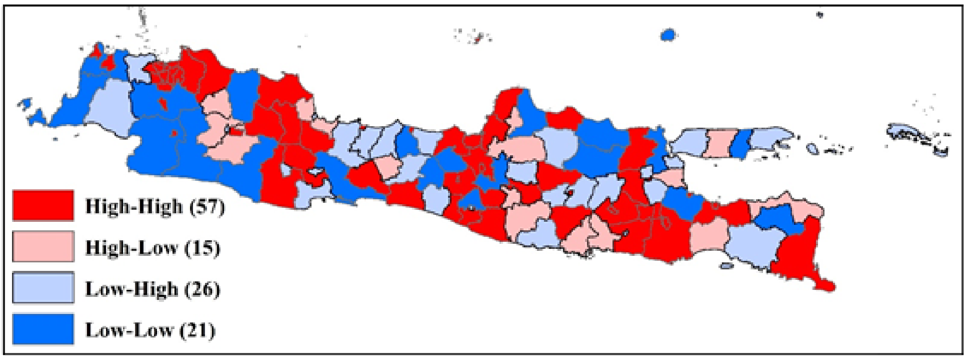

Figure 7. Clustering Map of Moran Scatter Plot in 2019 (The Last Period of Study)
Source: Processed by the authors

3.3. Panel Data of Spatial Econometric Model (Spatial Durbin Model)

According to Elhorst (2014), before proceeding to data analysis for modeling the spatial panel data, it is important to determine the best model using the Hausman Test. The result of the Hausman Test is that the *p*-value = 5.79e-07. As the *p*-value < 0.05, the hypothesis is rejected. Hence, this study uses the Fixed Effect Model (FEM) in combination the with Spatial Durbin Model (SDM). The use of SDM model in this research accommodates dependencies on the inter-regional economic growth by the 2015-2019 panel data . Then, SDM-FE concept model was used to examine the determinant factors affecting the economic growth of a region. According to numerous previous researchers, the economic growth a region is influenced by the determinants of the region itself, by the determinants of other regions (spatial spillover), and by the economic growth of other regions (spatial spillover). The regression results are shown in Table 4 below.

Table 4. The estimation results of Spatial Economic Growth using SDM-FE

Variable Name	Coefficient	Std.Error	t-value	Pr (>|t |)
Initial per capita income	-0.46798	0.171727	-2.7252	0.006427 **
Physical Capital Investment	0.350384	0.090599	3.8674	0.000110 ***
Road Infrastructure	0.2997	0.16375	1.8302	0.067215 *
Population Growth	-0.7177	0.097467	-7.3636	1.791e-13 ***
Human Capital Investment	0.012776	0.004852	2.6329	0.008465 **
TFP	-0.03119	0.111981	-0.2785	0.780622
x.Initial per capita income	4.419659	2.338222	1.8902	0.058734 *
x. Physical Capital Investment	-0.6389	1.328174	-0.481	0.630491
x. Road Infrastructure	2.992056	2.023131	1.4789	0.139161
x. Population Growth	1.960392	1.263541	1.5515	0.12078
x. Human Capital Investment	-0.12644	0.076502	-1.6528	0.098367 *
x. TFP	-1.08896	1.763451	-0.6175	0.536894
(lambda)	-0.96179	0.36091	-2.6649	0.007701 **

Source: Processed by the authors (R studio)
The spatial weight matrix (*W*) is based on the travel time between the regions
***p < 0.01, **p < 0.05, *p < 0.1

Based on the results of the spatial regression estimation on the panel data in Table 4, the influence of all determinants of spatial dependence on inter-regional economic growth in Java can be interpreted. The results were obtained from the application of Fixed Effect of Spatial Durbin Model using splm package in R Studio. The estimation results show that the influences of the determinants from the region itself (*i*) – such as initial per capita income, physical capital investment, road infrastructure, population growth, and education except total factor productivity – are significant. This confirms the MRW theory of Mankiw et al. (1992). However, the direction of the effects is different. As the directions of physical capital investment, road infrastructure, and education are positive, those of per capita income and population growth are negative.

First, the spatial autocorrelation λ (lambda) is negative and significant. It can be seen from the coefficient value of -0.96179 and the *p*-value of 0.007701 (significant at 0.01). The value of shows the existence of spatial dependence in the inter-regional economic growth in Java. This result indicates that all regions in Java cannot be treated as an independent observation unit and that, hence, the growth model among the regencies and cities in Java should explicitly account for this spatial dependence. This result supports the findings of Aritenang (2014), Miranti & Mendez (2022), Aspiansyah & Damayanti (2019), Nurjanna et al. (2020), Ervina & Jaya (2018), and Laksono et al. (2018) that spatial dependence in inter-regional economic growth in Indonesia, both provincial and by districts, exists. However, Takeda (2013) concluded that there is no spatial regional economic dependence in Indonesia. The estimation results show that the coefficient of spatial economic growth (-0.96179) indicates negative spatial spillover effects among regions in Java. It also indicates that increased economic growth of regions around a regency or city in Java might decrease its current economic growth. According to Laksono et al. (2018) and Pasaribu et al. (2014)the empirical analysis on the spillover effect is important since the application of growth centers theories that has been done by developed countries and also by developing countries still raise pro-cons. Examination on spillover effect of growth centers in Kalimantan specifically has been done in order to reveal whether its contribution as a National Energy Stocks as mentioned in MP3EI program does not caused backwash effect for the surrounding areas. Early investigation of existence of spatial lag dependent between growth centers in Kalimantan and its surrounding areas was tested using Lagrange Multiplier Spatial Lag Dependent. It proved that output growth, labor growth, and investment growth which happened in the growth centers in Kalimantan significantly had negative spillover effect (backwash effect, the negative spillover effect is also called as the backwash effect. The labor movement from underdeveloped to more developed areas, unbalanced investment flows, trade and industry activities dominated by more developed regions, and the better accessibility in more developed regions are the causes of the negative spatial spillover effect (Laksono et al., 2018). This result is similar to the findings of Aritenang (2014), who studied selected districts in Indonesia, of Laksono et al. (2018), who studied regencies and cities in East Java, and of Vidyattama (2014), who studied the matter at a provincial level. Vidyattama (2014) argued that the negative spatial spillover was caused by several developed areas like Jakarta, which have absorbed the financial and human capital resources from other regions.

Second, the (β) coefficient of initial per capita income is -0.46798 with the *p*-value 0.006427. The negative sign of the initial per capita income specifically indicates convergencies among the 119 regencies and cities in Java. This finding confirms the regional economic growth concept of MRW model suggested by Mankiw et al. (1992). The identified convergencies point out the process of economic disparity reduction across the Javanese regencies and cities. This finding is similar to the finding of Aspiansyah & Damayanti (2019) that convergencies exist in the economic growth of Indonesian provinces and the finding of Miranti & Mendez (2022), who studied all regencies and cities in Indonesia. The spatial lag coefficient of the initial per capita income (γ) is 4.419659 with the *p*-value of 0.058734. This significant and positive impact implies that the increase of initial per capita income in a certain regency or city tend to increase the economic growth of its neighboring regencies and/or cities. In other words, positive spatial spillover occurs. This finding supports the result of Aspiansyah & Damayanti (2019), Álvarez & Barbero (2016), and Sun et al. (2017). Hence, when a region neighbors another richer region, the former region will benefit from the latter region's economic activity due to intensive commercial relations between the two (Álvarez & Barbero, 2016).

Third, the (β) coefficient of physical capital investment is 0.350384 with the *p*-value of 0.000110. The positive sign of the physical capital investment indicates the positive influence on the regencies and cities' own economic growth. In other words, it was proven that the larger the initial per capita income, the higher the economic growth of the regencies and cities in Java. This result supports the finding of Fischer (2011), which adopted Mankiw et al. (1992) in describing the source of economic growth from physical capital, labor, and human capital. Further, the estimation of the spatial lag of physical capital investment (γ) resulted in the coefficient of -0.6389 and the *p*-value of 0.630491, indicating no spillover effect.

Thus, the increase or the decrease in the physical capital investment of regencies and cities has no tendency of either increasing or decreasing the economic growth of other regencies and cities. Aspiansyah & Damayanti (2019) and Miranti & Mendez (2022) also did not find any spatial dependence effect of physical capital investment on regional economic growth in Indonesia. According to Aspiansyah & Damayanti (2019), the absence of the spillover effect of physical capital investment on the regional economic growth was caused by the limited physical capital of a region.

Fourth, the (β) coefficient of road infrastructure is 0.2997 with the p-value 0.067215. The positive sign of the road infrastructure indicates the positive influence on the regencies and cities' own economic growth. In other words, the better the road infrastructure of a region, the higher its economic growth through accessibility. Vidyattama (2014) also found that road infrastructure is a positive determinant for regional economic in Indonesia. Arbués et al. (2014) examined that road infrastructure is an important determinant for accessibility to enhance 47 provinces in Spain. Meanwhile, the spatial lag estimation for road infrastructure (γ) resulted in the coefficient of 2.992056 and the p-value of 0.139161, indicating no spillover effect. Thus, the increase or decrease in the road infrastructure of regencies and cities has no tendency of either increasing or decreasing the economic growth of other regencies and cities. This result contradicts the findings of Vidyattama (2014) and Arbués et al. (2014). Rahadini (2018) argued that the bipolar development from Jakarta to Surabaya, in which goods and services are transported, has transformed some regions in Central Java into traversed areas. Thus, Central Java was divided into three regions according to certain characteristics.

Fifth, the (β) coefficient of population growth is -0.7177 with the p-value of 1.791e-13. The negative sign for the population growth indicates the negative influence on the regencies and cities' own economic growth. In other words, it was proven that the larger the population growth, the lower the economic growth of the regencies and cities in Java. The significant and negative influence of population growth supports the findings of Ertur & Koch (2007), Aspiansyah & Damayanti (2019), Álvarez & Barbero (2016), and Sun et al. (2017). According to Aspiansyah & Damayanti (2019), high population growth leads to a low proportion of labor force, which decrease per capita income. Meanwhile, the spatial lag estimation of population growth (γ) resulted in the coefficient of 1.960392 and the p-value of 0.12078, indicating no significant spillover effect. The absence of spatial lag of population growth indicates that the increase or decrease in the population growth of regencies and cities has no tendency of either increasing or decreasing the economic growth of other regencies and cities. This result varies from the findings of previous research in general. Álvarez & Barbero (2016) concluded no spillover effect of population growth between provinces in Spain. Supartoyo et al. (2013) argued that the insignificant spatial effect of population growth on economic growth was caused by low quality of population for the current economic activities. Large populations with low quality burdens the economy, not enhancing it. According to the theories, economic growth is determined by population growth rate. However, population growth does not necessarily give a positive contribution to economic growth.

Sixth, the (β) coefficient of education, i.e., the proxy of human capital investment, is 0.012776 with the p-value of 0.008465. The positive sign of the education indicates the positive influence on the regencies and cities' own economic growth. In other words, it was proven that the better the education, the higher the economic growth of the regencies and cities in Java. The significant and positive influence of education supports the findings of Aspiansyah & Damayanti (2019), Fischer (2011), Nurjanna et al. (2020), and Álvarez & Barbero (2016). This result is also in line with the theory of MRW Model. Increasing investment in human capital through education will improve production, which in turn will increase economic output. However, this result contradicts the finding of Miranti & Mendez (2022) that education has no influence on human capital and on regional economy in Indonesia. Meanwhile, the spatial lag estimation of education

(γ) resulted in the coefficient of -0.12644 and the p-value of 0.098367 (significant at 0.1), indicating significant spillover effects. The existence of spatial lag of human capital investment indicates that the increase of human capital investment in regencies and cities tend to decrease the economic growth of other regencies and cities. This result is similar to the findings of Álvarez & Barbero (2016) and Miranti & Mendez (2022) that the increasing economic growth through spatial spillover of human capital investment is caused by the migration of low or skilled labor between regions. The migration of population is caused by various factors, generally economic activity. However, this result contradicts the findings of Aspiansyah & Damayanti (2019) and Fischer (2011).

Seventh, the (β) coefficient and the p-value of total factor productivity (TFP) indicate no influence on the regencies and cities' own economic growth. The results of the spatial lag estimation on the total factor productivity indicate no spatial spillover effect, which means that the increase or decrease in total factor productivity in regencies and cities has not tendency of affecting the economic growth of other regencies and cities. This result differs from the findings of Ertur & Koch (2007) and Fischer (2011), whose research uses the MRW model of Mankiw et al. (1992). The absence of total factor productivity among regencies and cities in Java indicates that there is no maximization in the driving factors of TFP such as level of openness, R&D investment, industrial structure, government expenditure, and human capital (Zeng et al., 2022).

After examining the role of spatial dependence in the inter-regional economic growth of 119 regencies and cities in Java, it can be inferred that negative spillover effects or backwash effect occurred (see Table 4). This is an indication that development activities in Java as a whole have not been synergistic. Therefore, development policies from government need to be carried out. These policies are needed to balance the development across regions and to decrease the backwash effect in the spatial growth process because such effect can cause divergence and worsen the inequality in the economic growth among regions (Barro & Sala-I-Martin, 1992).

In the Indonesian context, strategies to reduce inequality and to distribute growth among regions have been made, but the policy implementation evaluation must follow. In detail, the development strategy for each region has been written in the National Medium-Term Development Plan (RPJMN), the most recent being the 2020-2024 RPJMN. There are two types of development policy approaches for each district and city in Java: the growth approach and the equity approach. The growth approach is the development of growth centers through regional potentials that can increase added value, foreign exchange, employment opportunities, and even distribution of economic growth for the next five years. The equity approach prioritizes the development of hinterlands, which are around growth centers, as well as of backward regions. The two approaches are applied to maintain the growth momentum of developed regions and increase equity in less developed regions. The application of the two approaches is supported by Hardjoko et al. (2021) and Sakti (2005), who mentioned pro-growth (pro-concentration) and pro-equity (pro-dispersion) regional development. The combination of these two policies is the right collaboration to increase convergency and reduce economic disparities between regions. In addition to the implementation of the RPJMN, the opening of toll-road gates in each region must also be evaluated because its impact varies across regions. Ardiyono et al. (2018)found that the revenues of Small and Medium-Sized Enterprises (SMEs) around hotels and restaurants along the non-toll road of Pantura in Subang, Indramayu and Brebes has decreased along with the reduction of traffic. Similarly, Dwiputri et al. (2022) found a negative impact of the opening of the Pandaan-Malang toll road on the income of the people living around the toll-road exits.

4. CONCLUSIONS

Java is the most influential Island in Indonesia. It is based on the fact that great economic potentials and huge socioeconomic problems are side by side in Java. As the home of 56,10% people of Indonesia, Java's contribution to the country's national GRDP is 59%. However, most socioeconomic problems like poverty, unemployment, and inter-regional income disparity hosted in Java. This research aims to analyze the role of spatial dependence on the economic growth of 119 regencies and cities in Java and its role in Java's economic development during the 2015-2019 period. To attain the objectives, Mankiw-Romer-Weil (MRW Model) was used in combination with Spatial Durbin Model (SDM). This theory was used to declare that the concept of economic growth in a region is influenced by the determinants of the region itself, by the determinants of other regions, and by the economic growth of other regions.

Global Moran I and Local Moran as a cross-sectional analysis was to detect the effect of spatial dependence on annual economic growth. Based on the results of the significance test, the effects of spatial dependence on annual economic growth do exist. The Global Moran statistic is positive, indicating spatial clustering. The Local Moran and its Moran Scatterplot depict the clustering of all units of observation according to its spatial linkages with other regions. Quadrant I is high-high (H-H), quadrant II is low-high (L-H), quadrant III is low-low (L-L), and quadrant IV is high-low (H-L).

Spatial Durbin Model with Fixed Effect Model was used for spatial panel data analysis which covers 119 units of observation during the 2015-2019 period. The main result of the analysis indicates that spatial dependence in the economic growth among regencies and cities in Java does exist. The significant and negative effects are the lead for the negative correlation with inter-regional economic growth. They indicate that increased economic growth of regions around a regency or city in Java might decrease its current economic growth. Meanwhile, all of the determining factors originating from the region itself, i.e., initial per capita income, physical capital investment, road infrastructure, population growth, and education, except total factor productivity, have significant effects. However, the direction of the effects is different. As the effects of physical capital investment, road infrastructure, and education are significantly positive, the impacts of initial per capita income and population growth are significantly negative. Regarding the determinants originating from other regions, only do the spatial lags of initial per capita income and education have significant effects on economic growth. As shown in several other studies, this study provides more and newer nuanced process of inter-regional spatial dependence in economic growth. Future studies are suggested to add other spatial weight matrices, such as contiguity, distance, and travel cost, in order to come up with comparable results.

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6. REFERENCES

Álvarez, I., & Barbero, J. (2016). The public sector and convergence with spatial interdependence: empirical evidence from Spain. *Applied Economics*, *48*, 2238–2252. https://doi.org/10.1080/00036846.2015.1117048

Anselin, L. (1988). *Spatial Econometrics: Methods and Models*. *4*. https://doi.org/10.1007/978-94-015-7799-1

Anselin, L. (1995). Local Indicators of Spatial Association—LISA. *Geographical Analysis*, *27*(2), 93–115. https://doi.org/10.1111/j.1538-4632.1995.tb00338.x

Anselin, L., & Getis, A. (2010). Spatial statistical analysis and geographic information systems. *Advances in Spatial Science*, *61*, 35–47. https://doi.org/10.1007/978-3-642-01976-0_3

Arbia, G., Basile, R., & Piras, G. (2005). *Using Spatial Panel Data in Modelling Regional Growth and Convergence* (ISAE Working Papers, Issue 55). ISTAT - Italian National Institute of Statistics - (Rome, ITALY). https://econpapers.repec.org/RePEc:isa:wpaper:55

Arbués, P., Mayor, M., & Baños-Pino, J. (2014). *Productivity and accessibility of road transportation infrastructure in Spain: A spatial econometric approach* (pp. 177–194). https://doi.org/10.4337/9781782540731.00017

Ardiyono, S., Parenrengi, N. P. A., & Faturachman, F. (2018). How does toll road impact accessibilities, trades, and investments in short term? A case study of Cipali toll road in West Java, Indonesia. *Journal of Infrastructure, Policy and Development*, *2*. https://doi.org/10.24294/jipd.v2i2.673

Aritenang, A. F. (2014). The spatial effect of fiscal decentralisation on regional disparities: the case from Indonesia. *Indonesian Journal of Geography*, *46*(1), 1–11. https://doi.org/10.22146/IJG.4985

Asian Development Bank. (2012). *Infrastructure for supporting inclusive growth and poverty reduction in Asia*. 87. http://hdl.handle.net/11540/104

Aspiansyah, A., & Damayanti, A. (2019). Model Pertumbuhan Ekonomi Indonesia: Peranan Ketergantungan Spasial. *Jurnal Ekonomi Dan Pembangunan Indonesia*, *19*(1), 62–83. https://doi.org/10.21002/JEPI.V19I1.810

Statistics Indonesia. (n.d.). Retrieved October 13, 2021, from https://www.bps.go.id/subject/52/produk-domestik-regional-bruto--lapangan-usaha-.html#subjekViewTab2

Statistics Indonesia. (2021a). *Berita Resmi Statistik Hasil Sensus Penduduk 2020*.

Statistics Indonesia. (2021b). *Kemiskinan dan Ketimpangan*. https://www.bps.go.id/subject/23/kemiskinan-dan-ketimpangan.html

Banerjee, A., Duflo, E., & Qian, N. (2020). On the road: Access to transportation infrastructure and economic growth in China. *Journal of Development Economics*, *145*, 102442. https://doi.org/https://doi.org/10.1016/j.jdeveco.2020.102442

Barro, R. J., & Sala-I-Martin, X. (1992). Convergence. *Journal of Political Economy*, 223–251. https://doi.org/10.1086/261816

Capello, R. (2009). Spatial Spillovers and Regional Growth: A Cognitive Approach. *Http://Dx.Doi.Org/10.1080/09654310902778045*, *17*(5), 639–658. https://doi.org/10.1080/09654310902778045

Case, A. C., Rosen, H. S., & Hines, J. R. (1993). Budget spillovers and fiscal policy interdependence: Evidence from the states. *Journal of Public Economics*, *52*(3), 285–307. https://doi.org/https://doi.org/10.1016/0047-2727(93)90036-S

Chen, S., & He, X. (2014). Road to success? The effects of road toll on economic growth in China. *Https://Doi.Org/10.1080/13504851.2014.931913*, *22*(2), 158–162. https://doi.org/10.1080/13504851.2014.931913

Cheshire, P., & Malecki, E. (2003). Growth, Development, and Innovation: A Look Backward and Forward. *Review of Economic Design*, *83*, 249–267. https://doi.org/10.1007/s10110-003-0185-8

Cobb, C. W., & Douglas, P. H. (1928). A Theory of Production. *The American Economic Review*, *18*(1), 139–165. http://www.jstor.org/stable/1811556

Day, J., & Lewis, B. (2013). Beyond univariate measurement of spatial autocorrelation: disaggregated spillover effects for Indonesia. *Annals of GIS*, *19*(3), 169–185.

Dubin, R. (2012). Spatial Weights. *The SAGE Handbook of Spatial Analysis*, 125–157. https://doi.org/10.4135/9780857020130.N8

Dwiputri, I. N., Seprillina, L., & Yusida, E. (2022). The Effect of the Operational Exit Tolls on the Welfare of the Local Community. *Signifikan: Jurnal Ilmu Ekonomi*, *11*(1), 73–82. https://doi.org/10.15408/SJIE.V11I1.22108

Elhorst, J. (2014). *Spatial Econometrics: From Cross-Sectional Data to Spatial Panels*. https://doi.org/10.1007/978-3-642-40340-8

Endah Ervina, M., & Jaya, M. (2018). Analyzing Factors Affecting GRDP in Indonesia Using Spatial Panel Data Model. *Modern Applied Science*, *13*, 148. https://doi.org/10.5539/mas.v13n1p148

Ertur, C., & Koch, W. (2007). Growth, technological interdependence and spatial externalities: theory and evidence. *Journal of Applied Econometrics*, *22*(6), 1033–1062. https://doi.org/https://doi.org/10.1002/jae.963

Firman, T. (2017). The urbanisation of Java, 2000–2010: towards 'the island of mega-urban regions.' *Asian Population Studies*, *13*(1), 50–66. https://doi.org/10.1080/17441730.2016.1247587

Fischer, M. M. (2011). A spatial Mankiw-Romer-Weil model: Theory and evidence. *Annals of Regional Science*, *47*(2), 419–436. https://doi.org/10.1007/S00168-010-0384-6

Hardjoko, A., Santoso, D., & Sakti, R. (2021). The Effect of Industrial Agglomeration on Economic Growth in East Java, Indonesia. *Journal of Asian Finance Economics and Business*, *8*, 249–257. https://doi.org/10.13106/jafeb.2021.vol8.no10.0249

Harris, R. (2011). Models of Regional Growth: ast, prPesent and Future. *Journal of Economic Surveys*, *25*(5), 913–951. https://doi.org/https://doi.org/10.1111/j.1467-6419.2010.00630.x

Haughton, J., & Khandker, S. (2009). *Handbook on Poverty and Inequality*.

Hidayat, A., Prasetya, F., & Pangestuty, F. W. (2021). Role of Internet Accessibility in Reducing the Poverty rates in Java; a Spatial Approach. *Journal of Indonesian Applied Economics*, *9*(1), 21–31. https://doi.org/10.21776/UB.JIAE.2021.009.01.3

Kuncoro, M. (2002). *Analisis spasial dan regional: studi aglomerasi & kluster industri Indonesia*. Unit Penerbit dan Percetakan AMP YKPN.

Laksono, H., Rustiadi, E., & Siregar, H. (2018). Spillover Spasial Negatif Pertumbuhan Ekonomi Antar Kabupaten/Kota Di Provinsi Jawa Timur. *Tata Loka*, *20*(3), 266–277.

Lesage, J. P., & Fischer, M. M. (2008). Spatial Growth Regressions: Model Specification, Estimation and Interpretation. *Spatial Economic Analysis*, *3*(3), 275–304. https://doi.org/10.1080/17421770802353758

LeSage, J., & Pace, R. K. (2009). *Introduction to spatial econometrics*. Chapman and Hall/CRC.

Mankiw Gregory, N., Romer, D., & Weil, D. N. (1992). A contribution to the empirics of economic growth. *Quarterly Journal of Economics*, *107*(2), 407–437. https://doi.org/10.2307/2118477

Mankiw, N. G. (2010). *Macroeconomics, 7th Edition*. Worth Publishers. http://www.worthpublishers.com/mankiw

Miranti, R. C., & Mendez, C. (2022). Social and Economic Convergence across Districts in Indonesia: A Spatial Econometric Approach. *Bulletin of Indonesian Economic Studies*, 1–31. https://doi.org/10.1080/00074918.2022.2071415

Mustajab, M. (2009). *Infrastructure investment in Indonesia : process and impact / Mohammad Mustajab*. Rijksuniversiteit.

Nijkamp, P., & Poot, J. (1998). original: Spatial perspectives on new theories of economic growth. *The Annals of Regional Science*, *32*(1), 7–37. https://econpapers.repec.org/RePEc:spr:anresc:v:32:y:1998:i:1:p:7-37

Nurjanna, Ladjind, Agus, Sumana, Rachmad, & Kresnac. (2020). *The Impact of Total Factor Productivity and Spatial Dependence on Per Capita Income Convergence*.

Panzera, D., & Postiglione, P. (2022). The impact of regional inequality on economic growth: a spatial econometric approach. *Regional Studies*, *56*(5), 687–702. https://doi.org/10.1080/00343404.2021.1910228

Pasaribu, E., Priyarsono, D., Siregar, H., Rustiadi, E., & Belakang, A. (2014). *Dampak Spillover Pusat Pertumbuhan di*

Kalimantan. *Vol 5*, 225–238. https://doi.org/10.22212/jekp.v5i2.90

Pravitasari, A. E., Rustiadi, E., Priatama, R. A., Murtadho, A., Kurnia, A. A., Mulya, S. P., Saizen, I., Widodo, C. E., & Wulandari, S. (2021). Spatiotemporal Distribution Patterns and Local Driving Factors of Regional Development in Java. In *ISPRS International Journal of Geo-Information* (Vol. 10, Issue 12). https://doi.org/10.3390/ijgi10120812

Rahadini, A. (2018). *Regional Disparities in Central Java. An Empirical Study* [Institut für Regionalwissenschaft (IfR)]. https://doi.org/DOI: 10.5445/IR/1000078692

Rummaya, Wardaya, W., & Landiyanto, E. (2005). Club Convergence & Regional Spillovers In East Java. *EconWPA, GE, Growth, Math Methods*.

Rustiadi, E., Panuju, D. R., & Pravitasari, A. E. (2010). *Java Island: Regional Disparity and Sustainabillty Perspectives* (pp. 94–114). https://agris.fao.org/agris-search/search.do?recordID=ID2021109133

Rustiadi, E., Saefulhakim, S., & Panuju, D. R. (2009). *Perencanaan dan pengembangan wilayah*. Crestpent Press dan Yayasan Obor Indonesia. https://books.google.com/books/about/Perencanaan_dan_Pengembangan_Wilayah.html?hl=id&id=vW6rDAAAQBAJ

Sakti, R. K. (2005). *Analisis spasial industri besar menengah Jawa Timur:: Studi kasus koridor Utara Selatan tahun 1990-2001*. Universitas Gadjah Mada.

Santos-Marquez, F., Gunawan, A., & Mendez, C. (2022). Regional income disparities, distributional convergence, and spatial effects: evidence from Indonesian regions 2010–2017. *GeoJournal*, *87*. https://doi.org/10.1007/s10708-021-10377-7

Sapena, M., & Ruiz, L. Á. (2019). Analysis of land use/land cover spatio-temporal metrics and population dynamics for urban growth characterization. *Computers, Environment and Urban Systems*, *73*, 27–39. https://doi.org/https://doi.org/10.1016/j.compenvurbsys.2018.08.001

Simon, J. L. (1990). *Population matters: People, resources, environment, and immigration*. Transaction Publishers.

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, *70*(1), 65–94. https://doi.org/10.2307/1884513

Sun, X., Chen, F., & Hewings, G. J. D. (2017). Spatial Perspective on Regional Growth in China: Evidence from an Extended Neoclassic Growth Model. *Emerging Markets Finance and Trade*, *53*(9), 2063–2081. https://doi.org/10.1080/1540496X.2016.1275554

Supartoyo, Y. H., Tatuh, J., & Sendouw, R. H. E. (2013). The Economic Growth and the Regional Characteristics : The Case of Indonesia. *Bulletin of Monetary Economics and Banking*, *16*(1), 1–16. https://doi.org/10.21098/BEMP.V16I1.435

Takeda, T. K.-H. C. (Pembimbing/Promotor); (2013). *Structural changes and regional income disparity in Indonesia : 1990 -2010*.

Vidyattama, Y. (2014). Issues in Applying Spatial Autocorrelation on Indonesia's Provincial ncome grGowth Analysis. *The Australasian Journal of Regional Studies*, *20*, 375–402.

Wang, J. (2017). *Economic Geography: Spatial Interaction*. https://doi.org/10.1002/9781118786352.wbieg0641

Wang, Y., Liang, Z., & Chen, H. (2021). Research on the Spatial Spillover Effect of Ecological Innovation Ability and Regional Economic Growth. *IOP Conference Series: Earth and Environmental Science*, *769*(2), 22008. https://doi.org/10.1088/1755-1315/769/2/022008

Wibisono, P., & Kuncoro, M. (2015). Efek Limpahan Pertumbuhan Antar-Kabupaten/Kota di Provinsi Jawa Timur Tahun 2001–2013. *Jurnal Ekonomi Dan Pembangunan Indonesia*, *16*(1), 31–46. https://doi.org/10.21002/JEPI.V16I1.584

Williamson, J. G. (1965). Regional Inequality and the Process of National Development: A Description of the Patterns. *Economic Development and Cultural Change*, *13*(4), 1–84. http://www.jstor.org/stable/1152097

Zeng, S., Shu, X., & Ye, W. (2022). Total Factor Productivity and High-Quality Economic Development: A Theoretical and Empirical Analysis of the Yangtze River Economic Belt, China. *International Journal of Environmental Research and Public Health*, *19*(5). https://doi.org/10.3390/ijerph19052783