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Analysis of Economic Growth in East Nusa Tenggara Province Using Spatial Regression Model

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ABSTRACT

This study investigates the determinants of economic growth in East Nusa Tenggara Province using a spatial regression model approach. The selected variables, based on the Mankiw-Romer-Weil economic growth model, include Gross Regional Domestic Product (Y), labor (X_1), electricity consumption (X_2), local revenue (X_3), capital expenditure (X_4), and average years of schooling (X_5). Analysis of secondary data from 2022 across 22 regencies/cities revealed significant influences of local revenue (X_3), capital expenditure (X_4), and average years of schooling (X_5) on economic growth. Spatial dependence was detected, leading to the adoption of Spatial Autoregressive and Spatial Error Models. The Spatial Error Model emerged as the most suitable, emphasizing the importance of considering local factors like agricultural or tourism sustainability in future research.

Keywords: Spatial Regression, SEM (Spatial Error Model), SAR (Spatial Autoregressive Model), Economic Growth, Gross Regional Domestic Product (PDRB).

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Introduction

In East Nusa Tenggara Province, the economic sector faces significant challenges despite experiencing some growth. The third quarter of 2023 saw a notable slowdown, with economic growth dropping to 2,08%, a stark contrast to the 4,17% growth observed in the previous quarter (BPS, 2023). This economic deceleration has widened the per capita income gap between East Nusa Tenggara and the national average (BPS, 2023). To address these pressing issues and fulfill the local government's vision of enhancing economic well-being, it is imperative to delve deeper into the dynamics of economic growth within the region.

Traditional economic models, while informative, often overlook the intricacies of heterogeneous regions like East Nusa Tenggara. These models fail to account for the spatial dependencies and heterogeneity present (Karim et al., 2017), potentially leading to inaccurate conclusions (Anselin, 2003). Recognizing this, our study adopts a spatial regression approach to analyze economic growth. Spatial regression acknowledges Tobler's First Law *"Everything is related to everything else, but near things are more related than distant things"* (Tobler, 1970) which highlights the significance of proximity in spatial relationships, and addresses spatial autocorrelation and spatial heterogeneity, phenomena prevalent in East Nusa Tenggara's economic landscape (Sinu et al., 2023).

Spatial regression is a method aimed at understanding the relationship between response and predictor variables, considering the spatial or regional interconnections (Dzikirna & Purnami, 2013). The regional aspect is crucial for examination, as different regions inherently possess distinct characteristics. Spatial regression can be categorized into two approaches: point-based and area-based (Salamah et al., 2013). By employing spatial regression techniques, such as Geographically Weighted Regression (GWR), Spatial Autoregressive Models (SAR), or Spatial Error Model (SEM), we aim to elucidate the nuanced interconnections between regions and their impact on economic growth (Lutfiani & Scolastika Mariani, 2017). This methodology allows for a comprehensive understanding of the spatial dynamics influencing economic performance, enabling policymakers to tailor interventions effectively.

Numerous studies have delved into the application of spatial regression in analyzing economic growth dynamics(Rüttenauer, 2022). In assessing economic growth, a pivotal indicator often utilized is the Gross Regional Domestic Product (GRDP), adjusted for constant prices, which exhibits a correlation with the economic performance of neighboring regions(Soraya et al., 2021). Scholars such as Hastin (2022), Triani (2022), Arifin (2019), Puspitasari et al (2019), Wahyuningsih et al (2019), Wibowo et al (2017), have extensively explored economic growth through the lens of factor analysis and regression methodologies. While traditional regression models offer valuable insights, they may inadequately capture the intricacies of heterogeneous regions (Erdkhadifa, 2022). To rectifies this limitation, spatial regression integrates geographical considerations, thereby yielding coefficients that more accurately reflect the spatial dependencies inherent within diverse areas (Novitasari & Khikmah, 2019).

Moreover, the economic growth model employed in this study is the Mankiw-Romer-Weil model, where factors of production as outputs of economic growth are explained by physical capital, labor, technological progress, and human capital (Purba, 2016). However, recognizing the diverse characteristics of East Nusa Tenggara, we acknowledge the necessity of accommodating regional diversity in our model development.

Therefore, this research endeavors to conduct an in-depth economic growth analysis of East Nusa Tenggara, considering both the spatial interdependencies between regions and the diverse factors influencing economic progress. By focusing on the spatial aspects of economic growth, we aim to provide valuable insights that can inform targeted policy interventions aimed at revitalizing the economic landscape and improving the well-being of the population in East Nusa Tenggara.

Research Method

The data utilized in this study comprises secondary data obtained from the Central Statistics Agency (BPS) of East Nusa Tenggara Province. The data extracted pertains to the economic growth in 22 regencies/cities for the year 2022, sourced from the BPS Provincial Publication for East Nusa Tenggara. Subsequently, a digital map is created in Figure 1 to serve as the basis for the formation of the spatial weighting matrix (W). The spatial weighting matrix employed in this study is of the Queen Contiguity type which this theory in spatial econometrics defines spatial relationships between districts based on shared borders or boundaries. This weighting scheme is preferred for its simplicity, ability to capture spatial dependence, and flexibility in defining neighborhood relationships, making it a robust method for analyzing economic interactions between districts.

The selection of research variables used to model economic growth in the East Nusa Tenggara Province is derived from the Mankiw-Romer-Weil economic growth model, as follows:

Table 1. *Definition of Research Variables*

Variables	**Variable Names**	**Explanation**
Y	PDRB	Gross Regional Domestic Product (PDRB) based on constant prices in 22 regencies/cities in East Nusa Tenggara Province (in billion rupiah).
X_1	TPAK	Percentage of the population aged 15 and above who are employed in 22 regencies/cities in East Nusa Tenggara Province.
X_2	PLN	Percentage of households with electricity sourced from the National Electricity Company (PLN) in 22 regencies/cities in East Nusa Tenggara Province.
X_3	PAD	Local government's original income in regencies/cities in East Nusa Tenggara Province (in million rupiah).
X_4	BM	Capital expenditure of local government in 22 regencies/cities in East Nusa Tenggara Province (in million rupiah).
X_5	RLS	Average years of schooling in 22 regencies/cities in East Nusa Tenggara Province.

Meanwhile, the analytical steps to be undertaken are as follows:

- Step 1: identifying spatial dependence.

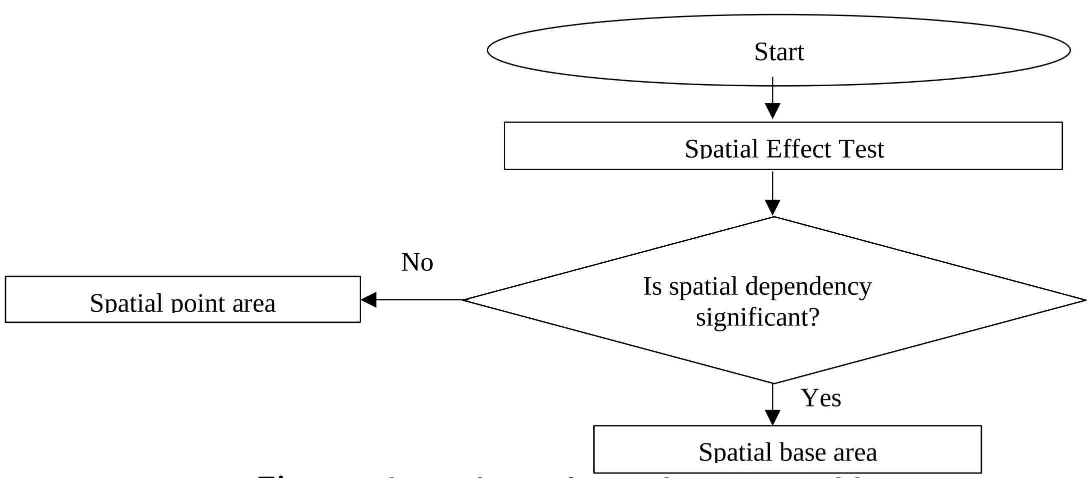

Figure 1. *The initial steps of a spatial regression model*

- Step 2: Comparing the most suitable spatial models

Figure 2 shows a process of evaluating and analyzing different spatial models to determine which one is the most appropriate or effective. This process involves assessing various spatial modeling techniques, such as spatial regression, spatial autoregressive models, spatial econometric models, or other spatial analysis methods, and comparing their performance, accuracy, and suitability based on predefined criteria or objectives.

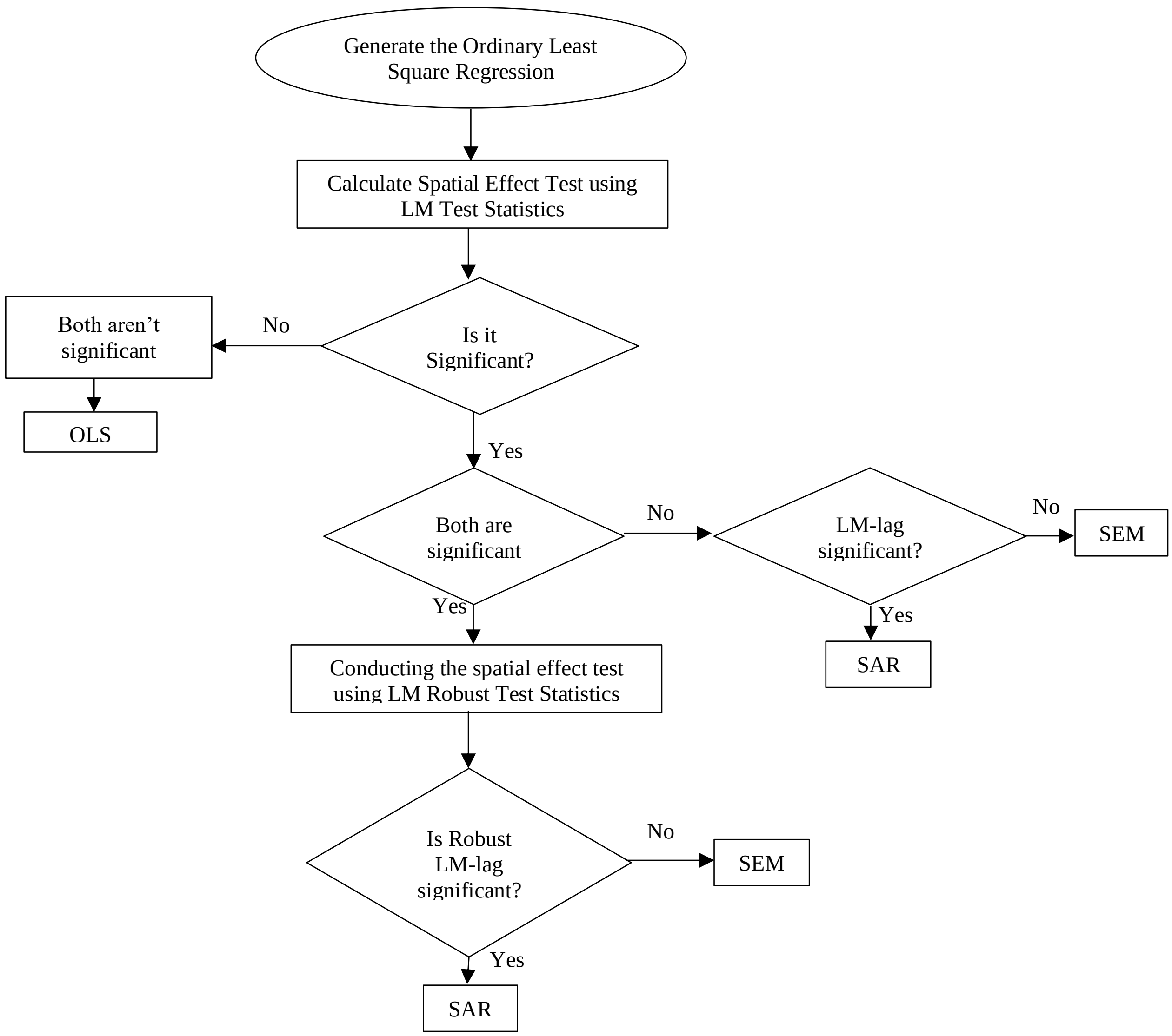

***Figure* 2.** *The second steps of a spatial regression model*

Result and Discussion

a. Description of Economic Growth and Influencing Variables from a Regional Perspective

Based on Figure 3, it illustrates the distribution of Gross Regional Domestic Product (PDRB) across regencies/cities in East Nusa Tenggara (NTT). The color degradation signifies the magnitude of the PDRB values, with darker colors indicating higher PDRB values, and vice versa. The same principle applies to the labor force participation rate (Figure 4), the number of households with electricity sourced from the National Electricity Company (PLN) (Figure 5), local government's original income (Figure 6), capital expenditure (Figure 7), and average years of schooling (Figure 8).

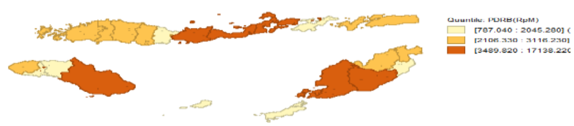

Figure 3. Distribution of Gross Regional Domestic Product (PDRB) in East Nusa Tenggara Province in

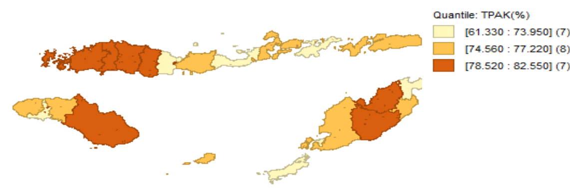

Figure 4. Distribution of Labor Force Participation Rate in East Nusa Tenggara Province in 2022

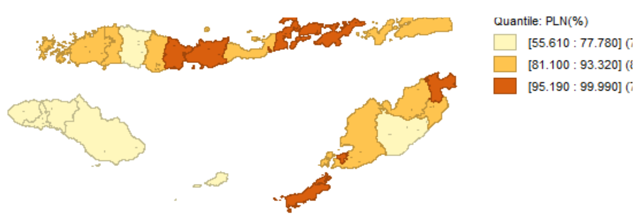

Figure 5. Distribution of PLN Electricity Source in East Nusa Tenggara Province in 2022

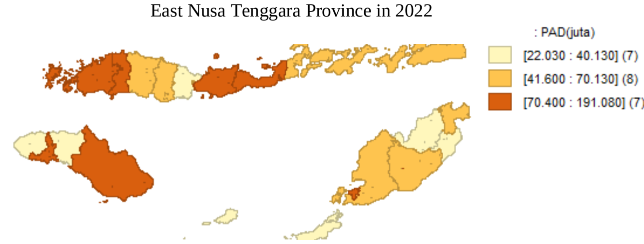

Figure 6. Distribution of Local Government's Original Income (PAD) in East Nusa Tenggara Province in 2022

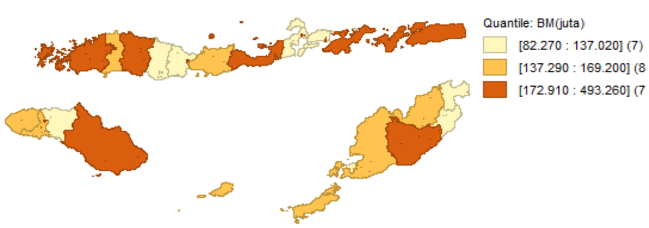

Figure 7. Distribution of Local Government's Capital Expenditure (BM) in East Nusa Tenggara Province in 2022

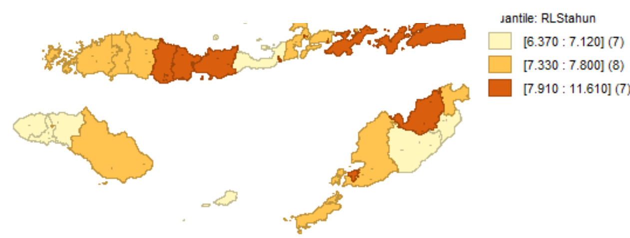

Figure 8. Distribution of Average Years of Schooling (RLS) in East Nusa Tenggara Province in 2022

The figures above indicate that there are three groups of regencies/cities based on the magnitude of the measured variables. Thus, the classification of the distribution of the 22 regencies/cities into low, medium, and high categories can be observed in the following Table 2.

Table 2. *Classification of Regencies/Cities Distribution Based on Low, Medium, High Categories*

Variables	**Classification**		
	Low	**Medium**	**High**
Economic Growth (PDRB)	Nagekeo, Lembata, Sumba Barat, Sumba Timur, Sabu Raijua, Rote Ndao, Malaka	Manggarai Barat, Manggarai, Manggarai Timur, Ngada, Alor, Sumba Barat Daya, Timor Tengah Utara (TTU), Belu	Ende, Sikka, Flores Timur, Sumba Timur, Timor Tengah Selatan (TTS), Kabupaten Kupang, dan Kota Kupang
Labor Force Participation Rate (TPAK)	Nagekeo, Sikka, Lembata, Sumba Barat, Rote Ndao, Belu, Kota Kupang	Ende, Flores Timur, Sumba Barat Daya, Sumba Tengah, Sabu Raijua, Kabupaten Kupang, Malaka	Manggarai Barat, Manggarai, Manggarai Timur, Ngada, Sumba Timur, Timor Tengah Utara (TTU), Timor Tengah Selatan (TTS)
Average households with electricity sourced from Government (PLN)	Manggarai Timur, Sumba Barat, Sumba Barat Daya, Sumba Tengah, Sumba Timur, Sabu Raijua, Timor Tengah Selatan (TTS)	Manggarai Barat, Manggarai, Ngada, Sikka, Alor, Kabupaten Kupang, Timor Tengah Utara (TTU), Malaka	Nagekeo, Ende, Flores Timur, Lembata, Rote Ndao, Belu, Kota Kupang
Local Government's Original Income (PAD)	Nagekeo, Sumba Barat Daya, Sumba Tengah, Sabu Raijua, Rote Ndao, Timor Tengah Utara (TTU), Malaka	Manggarai Timur, Ngada, Flores Timur, Lembata, Alor, Kabupaten Kupang, Timor Tengah Selatan (TTS), Belu	Manggarai Barat, Manggarai, Ende, Sikka, Sumba Barat, Sumba Timur, Kota Kupang
Capital Expenditure (BM)	Ngada, Nagekeo, Flores Timur, Sumba Tengah, Belu, Malaka	Manggarai, Ende, Sumba Barat Daya, Sumba Barat, Sabu Raijua, Rote Ndao, Kota Kupang, Kabupaten Kupang, Timor Tengah Utara (TTU)	Manggarai Barat, Ngada, Sikka, Lembata, Alor, Sumba Timur, Timor Tengah Selatan (TTS)
Average Years of Schooling (RLS)	Sikka, Sumba Barat Daya, Sumba Barat, Sumba Tengah, Sabu Raijua, Timor Tengah Selatan (TTS), Malaka	Manggarai Barat, Manggarai, Manggarai Timur, Flores Timur, Sumba Timur, Rote Ndao, Kabupaten Kupang, Belu	Ngada, Nagekeo, Ende, Lembata, Alor, Timor Tengah Utara (TTU), Kota Kupang

Figure 9 below depicts a scatter plot illustrating the relationship between Gross Regional Domestic Product (PDRB) (Y) and Labor Force Participation Rate (TPAK) (X_1), National Electricity Company (PLN) (X_2), Local Government's Original Income (PAD) (X_3), Capital Expenditure (BM) (X_4), and Average Years of Schooling (RLS) (X_5). From Figure 9, it can be observed that almost all independent variables show a positive relationship trend with the dependent variable. Only variables X_1 and X_4 exhibit a negative relationship trend with the PDRB variable (Y).

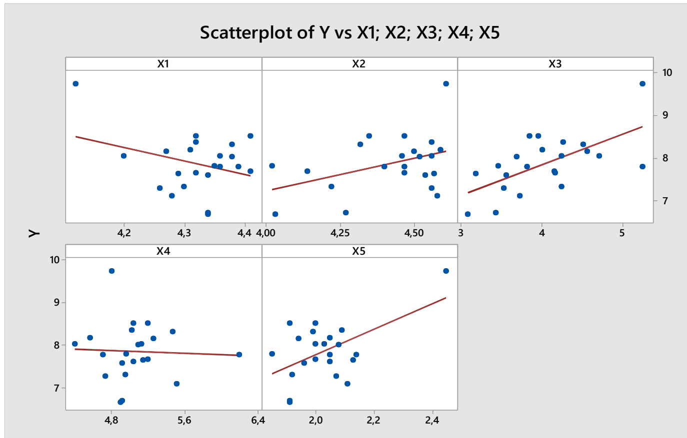

Figure 9. *Scatterplot Relationship Between Dependent and Independent Variables*

The existence of positive and negative relationships is further supported by examining the correlation between each independent variable and the dependent variable in Table 3 below.

Table 3. *Pearson Correlation Output*

Variables	Y
X_1	-0,324
	0,141
X_2	0,410
	0,058
X_3	0,631
	0,002
X_4	-0,047
	0,835
X_5	0,547
	0,008

However, based on the Pearson correlation in Table 3, it can be observed that the significant correlations at α=5% are found only between variables X_3 and X_5. Before proceeding with spatial regression modeling, an initial model of economic growth is established using simultaneous Ordinary Least Squares (OLS) linear regression. Simultaneous OLS modeling is employed to gather information about the collective influence of significant variables on Gross Regional Domestic Product (AKB) in East Nusa Tenggara Province. The output of the OLS regression can be seen in Table 4 below.

Table 4. *Output of Ordinary Least Squares (OLS) Regression Analysis*

Parameter	Estimation	Std. Error	t-statistics	Probability	VIF
Constant	-5923,29	11152,2	-0,531135	0,60262	
TPAK	0,199657	119,118	0,00167612	0,99867	2,14
PLN	-25,626	38,1835	-0,671129	0,51171	1,69
PAD	44,2089	15,0888	2,92991	0,00981	1,73
BM	-17,5621	7,60605	-2,30896	0,03463	1,81
RLS	1483,69	617,204	2,40389	0,02870	2,23
R^2			**0,768201**		
AIC			**397.971**		

Based on Table 4, it can be observed that the significant independent variables at α=5% are only PAD (X_3), BM (X_4), and RLS (X_5). Meanwhile, Table 4 also indicates that all VIF values are <10. This implies that there is no multicollinearity among the independent variables.

b. Spatial Effects Identification

Spatial autocorrelation tests were conducted by examining the Moran's I index values for the observed variables. The results of the Moran's I index calculations using queen contiguity weighting are presented in Figure 10 and Figure 11. Figure 10 depicts the Moran's Scatterplot for Gross Regional Domestic Product (PDRB) based on constant prices using queen contiguity weighting. Meanwhile, Figure 11 provides a clearer visualization of the regencies/cities grouping through the map. From Figure 10 and Figure 11, it is evident that there are regencies/cities located in Quadrant I (high-high).

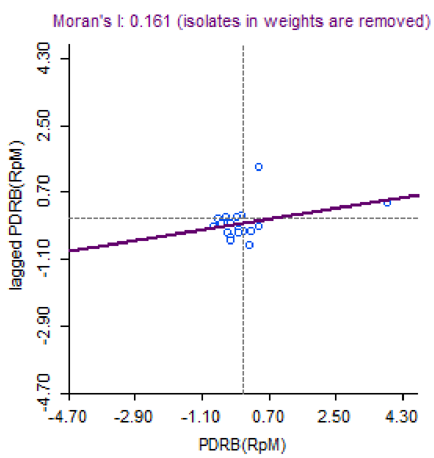

Figure 10. *Moran's Scatterplot of Gross Regional Domestic Product (PDRB) based on constant prices*

Figure 11. *Map of Local Spatial Autocorrelation Grouping with Queen Contiguity Weighting*

This indicates the occurrence of clustering, signifying positive spatial autocorrelation, where one regency/city with a relatively high Gross Regional Domestic Product (PDRB) is surrounded by neighboring regencies/cities with similarly high PDRB. Kabupaten Kupang is positioned in Quadrant I. Meanwhile, regencies/cities in Quadrant IV (high-low) suggest dispersion, indicating negative spatial autocorrelation. In other words, one regency, namely Sumba Timur, exhibits a relatively high PDRB but is surrounded by regencies with lower PDRB. Subsequently, spatial effects identification will be conducted to ascertain the presence of spatial heterogeneity and spatial dependence. Firstly, the diagnosis of spatial heterogeneity effects will be performed to observe variations among locations. Spatial effects testing will be carried out using the Breusch-Pagan test, and the results can be seen in Table 5.

Table 5. *Diagnostic of Heterogeneity*

Test	Df	Value	P-value
Breusch-Pagan test	5	3,8780	0,56711

Based on the results in Table 5, the "prob Breusch-Pagan test" yields a value of 0,56711. Since the P-value > α, the null hypothesis (H0) cannot be rejected. This indicates that there is no influence of spatial heterogeneity in the model. Subsequently, a diagnosis of spatial dependence effects will be conducted. Tests to determine spatial dependence within the error of a model are performed using Moran's I and Lagrange Multiplier (LM) statistics. The diagnostic results of the spatial dependence test can be seen in Table 6 below.

Table 6. *Results of Diagnostic Tests for Spatial Dependence*

No	Spatial Dependency Test	Grade	p-value	Result
1	Moran's I *(error)*	2,4397	0,01470	Reject H_0
2	Lagrange Multiplier *(lag)*	3,1437	0,07622	Failed to reject H_0
	Robust LM (lag)	0,6292	0,42764	Failed to reject H0
3	Lagrange Multiplier *(error)*	2,9041	0,08835	Reject H_0
	Robust LM *(error)*	0,3896	0,53249	Failed to reject H0
4	Lagrange Multiplier (SARMA)	3,5333	0,17090	Failed to reject H_0

The p-value for Moran's I is 0,01470 (reject H0), indicating the presence of spatial dependence in the errors of the OLS regression. In addition to using Moran's I to detect the existence of spatial dependence, the Lagrange Multiplier can identify spatial dependence more specifically, whether in terms of lag, error, or both (lag and error). In the Lagrange Multiplier-Lag test, with α=10%, the obtained p-value is 0,07622 < α=10%, leading to the rejection of H_0. This implies the presence of spatial lag dependence, warranting further investigation into the Spatial Autoregressive Model (SAR). Similarly, in the Lagrange Multiplier-Error test, with α=10%, the p-value is 0.08835 < α=10%, leading to the rejection of H_0. This indicates spatial error dependence, necessitating further exploration into the Spatial Error Model (SEM). Therefore, Table 7 below presents the output of spatial regression using the Spatial Error Model (SEM).

Table 7. *Spatial Regression Output with Spatial Error Model (SEM)*

Parameter	Estimation	Std. Error	Z-value	Probability
Constant	-11701,3	7407,11	-1,57974	0,11417
TPAK	76,5056	76,9627	0,99406	0,32019
PLN	-36,806	32,007	-1,14993	0,25017
PAD	45,3596	11,0235	4,11482	0,00004*
BM	-14,8937	4,3815	-3,39923	0,00068*
RLS	1527,85	434,373	3,51738	0,00044*
Lambda	0,543117	0,160608	3,38163	0,00072
R^2			**0,837610**	
AIC			**393,03**	

Note: *) significant on $\alpha = 5\%$, $Z_{0,025}$ = 1,96, $t_{0,95;5}$=2,570

Next, spatial regression was conducted with the Spatial Autoregressive Model (SAR), and the output can be seen in Table 8 below.

Table 8. *Spatial Regression Output with Spatial Autoregressive Model (SAR)*

Parameter	Estimation	Std. Error	Z-value	Probability
W_PDRB	0,318479	0,146164	2,17891	0,02934
CONSTANT	-7624,29	8580,61	-0,888549	0,37425
TPAK	14,9219	91,9019	0,162368	0,87102
PLN	-32,6646	29,3664	-1,11231	0,26600
PAD	40,9797	11,7372	3,49144	0,00048*
BM	-17,2459	5,84931	-2,948837	0,00319*
RLS	1546,63	474,209	3,2615	0,00111*
R^2		**0,811862**		
AIC		**396,273**		

Note: *) significant on $\alpha = 5\%$, $Z_{0,025} = 1,96$, $t_{0,95;5}$=2,570

From Tables 7 and 8, it can be deduced that the variables significantly influencing at α=5% are PAD (X_3), BM (X_4), and RLS (X_5). The variable PAD (X_3) exhibits a positively signed coefficient. This positive sign indicates that districts proximate to others with high local revenue will tend to experience correspondingly high economic growth (constant-price GDP). Conversely, districts adjacent to those with low local revenue are likely to exhibit low economic growth. The same interpretation can be applied to other variables that are significant with positive coefficients, such as the average length of schooling. Meanwhile, for capital expenditure (BM), the coefficient is negatively signed. This implies that districts neighboring those with high capital expenditure will tend to have low economic growth (constant-price GDP). Conversely, districts in proximity to those with low capital expenditure are likely to experience high economic growth (constant-price GDP).

c. *Selection of the Best Model*

The Selection of the Best Model Using R^2 and AIC (Akaike's Information Criterion) Criteria:

Table 9. *the comparison between R^2 and AIC value of some models*

No	Model	R^2	AIC
1	Classical regression (OLS)	0,768201	397,971
2	*Spatial Error Model* (SEM)	0,837610	393,03
3	*Spatial Autoregressive Model* (SAR)	0,811862	396,273

Based on Table 9, the optimal model is the Spatial Error Model (SEM), as it exhibits the highest coefficient of determination (R^2) at 0,837610 and the lowest Akaike's Information Criterion (AIC) value of 393,03 compared to other models analyzed in this study. Consequently, the SEM model, considering a significance level of 10%, is as follows:

$$\hat{y}_i = -11701,3 + 45,3596X_{3i} - 14,8937X_{4i} + 1527,85X_{5i} + u_i \quad (1)$$

$$u_i = 0,543117 \sum_{j=1, i\neq j}^{n} w_{ij}u_j + \varepsilon_i$$

Where:

$\hat{y}_i$: The i-th Economic Growth of Districts/Cities

X_{1i} : The i-th Labor Force Participation Rate (TPAK) of Districts/Cities

X_{2i} : Households with electricity sourced from government (PLN) in the i-th District/City

X_{3i} : The i-th Local Revenue (PAD) of Districts/Cities

X_{4i} : The i-th Capital Expenditure (BM) of Districts/Cities

X_{5i} : The average length of schooling in the i-th District/City

W_{ij} : The spatial weighting matrix element at the i-th row and j-th column.

u_i : Spatial residual of the i-th District/City.

ε_i : Residual of the i-th District/City.

The findings of this study are substantiated by a body of research including works by Rüttenauer (2022), Erdkhadifa (2022), Soraya et al (2021), Novitasari & Khikmah (2019), Purba (2016). These studies collectively suggest that the economic growth of a given region is intricately linked to its surrounding areas. Therefore, there exists a need for a spatial econometric model capable of capturing the interconnections among these regions. In the present research, we employ a spatial econometrics approach to model economic growth of East Nusa Tenggara Province.

Spatial relationships can guide targeted economic development strategies by identifying clusters of economic activity, informing infrastructure planning, and promoting spatial equity. Understanding connectivity and disparities across regions allows policymakers to prioritize investments and design policies that foster inclusive growth and optimize land use.

Conclusions

The economic growth modeling in the East Nusa Tenggara (NTT) Province using Ordinary Least Squares (OLS) regression method yielded three significant independent variables at α=5%, namely local revenue, capital expenditure, and average length of schooling. Meanwhile, based on diagnostic tests, there is spatial dependence in lag and error, leading to the adoption of Spatial Autoregressive Model (SAR) and Spatial Error Model (SEM) for spatial regression. From these spatial models, it was found that the independent variables significantly influencing economic growth in the 22 districts/cities in NTT Province are local revenue, capital expenditure, and average length of schooling. Queen contiguity was used as the weighting scheme for the spatial models. The criteria for selecting the best model among OLS, SAR, and SEM were based on R^2 and AIC values. According to these criteria, the best spatial regression model is the Spatial Error Model (SEM) due to its highest R2 value of 0,837610 and the lowest AIC value of 393,03.

In this study, it is recommended to consider the unique geographic dynamics in the regional context. Research should identify key variables such as investment, primary economic sectors, infrastructure access, and educational characteristics, measuring potential spatial effects between districts/cities. It is suggested to take into account local factors that may influence economic growth, such as the sustainability of agricultural or tourism sectors, which may differ in each region. A profound understanding of the spatial relationships between districts/cities and the potential domino effects can provide insights into the cause-and-effect dynamics of regional economic growth. Recommendations may include the implementation of fiscal policies and infrastructure development focused on the unique characteristics of each region, as well as data-driven planning to achieve inclusive and sustainable economic growth across all districts/cities in NTT.

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