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IMPLEMENTATION OF GEOGRAPHICALLY WEIGHTED PANEL REGRESSION WITH GAUSSIAN KERNEL WEIGHTING FUNCTION IN THE OPEN UNEMPLOYMENT RATE MODEL

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ABSTRACT

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This study analyzes the factors influencing the Open Unemployment Rate in Kalimantan using the Geographically Weighted Panel Regression (GWPR) model with Gaussian kernel weighting functions. The GWPR model, a local panel regression approach for spatial data, is compared with the global Fixed Effect Model (FEM). Spatial weighting for parameter estimation employs Fixed Gaussian and Adaptive Gaussian kernels, with the optimum bandwidth determined through Cross Validation (CV), resulting in a minimum CV value of 25.536 for the Adaptive Gaussian Kernel. Local factors identified as influencing the Open Unemployment Rate include the Labor Force Participation Rate (x_1), Expected Years of Schooling (x_2), Average Years of Schooling (x_3), Total Population (x_4), Number of Poor People (x_5), and the Growth Rate of Gross Regional Domestic Product at Constant Prices (x_6). The results underscore the importance of spatial heterogeneity in understanding regional unemployment dynamics, as local variations in these factors significantly affect unemployment rates. Moreover, the GWPR model exhibits a notable improvement in predictive accuracy and goodness of fit compared to the global panel regression model, achieving a coefficient of determination R^2 of 77.96% and a Root Mean Square Error (RMSE) of 0.2726. These findings highlight the GWPR model's potential in regional economic studies and policymaking, offering precise insights into local determinants of unemployment and facilitating the development of targeted and effective interventions.

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1. INTRODUCTION

Open unemployment refers to a condition in which individuals who are part of the labor force actively seek employment but have not yet secured a job. In contrast, individuals who are not employed but do not actively search for work are not classified as unemployed [1]. According to the Central Statistics Agency [2], Indonesia's open unemployment rate reached 7.07% in 2020, an increase of 1.84% compared to 2019. However, in August 2021, Indonesia's open unemployment rate decreased by 0.58% compared to 2020. Similar fluctuations are observed in Kalimantan, one of Indonesia's major islands. Based on Central Statistics Agency data [2], Kalimantan experienced a decrease in the open unemployment rate by 0.26% from 2020, with the rate dropping from 26.97% in 2020 to 26.71% in 2021. In 2021, East Kalimantan recorded the highest open unemployment rate at 6.83%, while Central Kalimantan had the lowest at 4.53%.

Social and economic data are often represented in the form of panel data, as these variables exhibit significant fluctuations over time. Panel data, which combines cross-sectional and time series data, can be effectively analyzed using panel regression techniques. This approach provides a comprehensive understanding of a unit's behavior over time, offering valuable insights into trends and changes [3]. However, panel data with spatial heterogeneity where geographical factors influence the data cannot be accurately modeled using standard panel regression. To address this, the Geographically Weighted Panel Regression (GWPR) model is more appropriate for spatial data analysis. The GWPR model is a localized variant of the panel regression model that incorporates geographical considerations. The parameters in the GWPR model can be estimated using the Weighted Least Squares (WLS) approach [4], which is an extension of the Ordinary Least Squares (OLS) method that accounts for spatial weighting at each observation point. This spatial weighting reflects the influence of neighboring data points, providing a more nuanced understanding of spatial relationships [5][6].

While standard panel regression may not be suitable for spatially heterogeneous data, the GWPR model offers a more accurate and localized approach. In this study, we first applied panel regression with a Fixed Effect Model (FEM) as a benchmark for comparison with the GWPR model. The primary aim of this study is to implement the GWPR model to analyze the Open Unemployment Rate in Kalimantan and identify the factors that influence it. The model's performance is evaluated based on the coefficient of determination and Root Mean Square Error (RMSE). By utilizing the Gaussian Kernel weighting function within the GWPR framework, this study aims to provide more accurate and localized insights into the factors affecting unemployment in Kalimantan, thus contributing to the development of targeted economic policies.

2. RESEARCH METHODS

2.1 Research Data and Variable

Research variable and observation data is described in Table 1.

Table 1. Description of Research Variable and Data Sources

Variable	Symbol	Variable Description	Unit	Source	Scale
Responds	y	Open Unemployment Rate	Percent	Central Statistics Agency Indonesia [2]	56 Regencies/Cities in Kalimantan Year 2019-2021
Predictor	x_1	The Labor Force Participation Rate	Percent		
	x_2	Expected Years of Schooling	Year		
	x_3	Average Years of Schooling	Year		
Predictor	x_4	Total Population	People		
	x_5	Number of Poor People	People		
	x_6	the Growth Rate of Gross Regional Domestic Product at Constant Prices	Percent		

2.2 Research Stages

The modeling approach used in this study is the GWPR with a Gaussian Kernel weighting function, which will be applied to model the Open Unemployment Rate in Kalimantan for the years 2019 to 2021. The following steps outline the implementation of the GWPR model with the Gaussian Kernel weighting function:

1. Descriptive Statistical Analysis

   Perform descriptive analysis to summarize the key characteristics of the data.

2. Multicollinearity Detection

   Assess the presence of multicollinearity between predictor variables to ensure the reliability of the regression model.

3. Data Transformation

   Transform the actual data into demeaned data to facilitate the estimation process.

4. Panel Regression with FEM

   Conduct a panel regression using the FEM as a baseline for comparison with the GWPR model.

5. GWPR Modeling

   a. Calculate the Euclidean distances between observation locations based on geographic coordinates.

   b. Estimate the parameters of the GWPR model.

   c. Perform goodness-of-fit testing for the GWPR model.

   d. Conduct partial significance tests for the GWPR model parameters.

6. Model Evaluation

   Calculate the coefficient of determination (R^2) and the RMSE to evaluate the model's performance.

The Geographically Weighted Panel Regression (GWPR) with Gaussian Kernel Weighting Function is an advanced statistical model that combines spatial and temporal dimensions in analyzing panel data. Panel data refers to observations on multiple entities (e.g., regions, countries) across several time periods. This model extends the Geographically Weighted Regression (GWR), which accounts for spatial heterogeneity by estimating local relationships between response and predictor variables at each location. The local nature of GWR allows the model to capture variations in relationships that differ across geographical locations. In the context of panel data, GWPR also integrates temporal effects, allowing for the examination of both spatial and temporal dynamics simultaneously.

The Gaussian Kernel is a type of weighting function used to determine the influence of neighboring observations on each local regression estimate. It assigns higher weights to closer data points and lower weights to those further away, following a bell curve distribution. This allows the model to emphasize nearby observations more heavily in the regression analysis. By using the Gaussian kernel in conjunction with panel data, the GWPR model estimates location- and time-specific parameters, offering a more flexible and accurate approach to understanding complex datasets where both spatial and temporal variations are significant. This method is particularly useful in fields like economics, epidemiology, and environmental science, where spatially and temporally varying relationships are critical for accurate analysis.

3. RESULTS AND DISCUSSION

3.1 Data Description

The description of the research variables consists of the average, minimum value, and maximum value. The calculation results are presented in **Table 2**.

Table 2. Description of Research Data

Variable	Year	Mean	Maximum	Minimum
Open Unemployment Rate (y)	2019	4.26	9.06	1.71
	2020	4.96	12.36	2.24
	2021	4.95	12.38	2.30
Labor Force Participation Rate (x_1)	2019	68.82	77.38	61.75
	2020	68.99	77.73	60.05
	2021	68.82	78.40	60.86
Old School Expectations (x_2)	2019	12.68	14.99	11.15
	2020	12.72	15.00	11.16
	2021	12.78	15.09	11.17
Average Length of School (x_3)	2019	8.23	11.51	6.00
	2020	8.32	11.52	6.01
	2021	8.41	11.53	6.02
Population (x_4)	2019	247.50	786.10	26.40
	2020	296.70	828.00	25.60
	2021	300.30	831.50	26.40
Number of Poor People (x_5)	2019	17.40	56.34	1.34
	2020	17.32	58.42	1.46
	2021	18.05	62.36	1.49
Rate of Growth of Gross Regional Product on The Basis of Constant Prices (x_6)	2019	5.18	8.17	-2.15
	2020	-1.45	3.39	-4.21
	2021	3.67	5.61	-1.69

Table 2 provides a description of the research data from 2019 to 2021, including variables such as the open unemployment rate, labor force participation rate, years of schooling expectation, average length of schooling, population, number of poor people, and the rate of growth of Gross Regional Product (GRP) based on constant prices. The data shows an increase in the unemployment rate in 2020 due to the pandemic, followed by a slight decrease in 2021, while the labor force participation rate and education indicators showed an upward trend. The population continued to grow, along with an increase in the number of poor people, reaching its highest in 2021. Economic growth saw a sharp contraction in 2020, followed by recovery and growth in 2021, reflecting the pandemic's impact and subsequent economic recovery.

3.2 Multicollinearity Detection

Multicollinearity detection is based on the Variance Inflation Factor (VIF) value calculated using Equation (1) and presented in Table 3.

$$VIF_k = \frac{1}{1 - R_k^2} \tag{1}$$

where VIF_k is the value of the VIF of the k independent variable and R_k^2 is the k coefficient of determination [7].

Table 3. Independent Variable VIF value

Variable (x_k)	VIF_k
Labor Force Participation Rate (x_1)	1.3817
Old School Expectations (x_2)	3.6125
Average Length of School (x_3)	2.9467
Population (x_4)	2.8345
Number of Poor People (x_5)	2.3815
Rate of Growth of Gross Regional Product on The Basis of Constant Prices (x_6)	1.0218

Based on Table 3, the VIF value in each predictor variable is less than 10 which means there is no multicollinearity between predictor variables, so modeling is continued using 6 predictor variables.

3.3 Fixed Effect Model

Based on the general model of FEM in **Equation (2)** follows

$$y_{it} = \beta_{0_i} + \beta_1 x_{it1} + \beta_2 x_{it2} + \cdots + \beta_k x_{itk} + \varepsilon_{it}; i = 1, 2, \ldots, n\,; t = 1, 2, \ldots, T \qquad (2)$$

Estimation of FEM model parameters in **Equation (2)**, can be done by transforming β_{0_i} Through the Within Estimator method. Within estimators using demean data are formed by subtracting each actual data (predictor variable and response variable) from the average time series of all data.

Then the FEM model within estimator for TPT data with 6 predictor variables is

$$y_{it} = \beta_1 x^*_{it1} + \beta_2 x^*_{it2} + \beta_3 x^*_{it3} + \beta_4 x^*_{it4} + \beta_5 x^*_{it5} + \beta_6 x^*_{it1} + \varepsilon_{it};\ i = 1, 2, \ldots, 56\,; t = 1,2,3 \qquad (3)$$

The results of estimating FEM parameters in **Equation (3)** are presented in **Table 4**

Table 4. Estimated Parameter FEM

Parameter	Estimated Value
$\boldsymbol{\beta_1}$	-0.0527
$\boldsymbol{\beta_2}$	0.7364
$\boldsymbol{\beta_3}$	1.0047
$\boldsymbol{\beta_4}$	0.0051
$\boldsymbol{\beta_5}$	0.0795
$\boldsymbol{\beta_6}$	-0.0329

Based on the estimated values of **Table 4** parameters, the FEM model formed is

$$\hat{y}^*_{it} = -0.0527x^*_{it1} + 0.7364x^*_{it2} + 1.0047x^*_{it3} + 0.0051x^*_{it4} + 0.0795x^*_{it5} - 0.0329x^*_{it6} \qquad (4)$$
$$i = 1, 2, \ldots, 56$$
$$t = 1, 2, 3$$

To determine the feasibility of the model, the significance of the parameter was tested simultaneously with the following hypotheses

$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$
(The Labor Force Participation Rate (x_1), Expected Years of Schooling (x_2), Average Years of Schooling (x_3), Total Population (x_4), Number of Poor People (x_5), and the Growth Rate of Gross Regional Domestic Product at Constant Prices (x_6) have no simultaneous effect on the Open Unemployment Rate in Kalimantan)

H_1: There is at least one $\beta_k \neq 0$; $k = 1,2,3,4,5,6$
(The Labor Force Participation Rate (x_1), Expected Years of Schooling (x_2), Average Years of Schooling (x_3), Total Population (x_4), Number of Poor People (x_5), and the Growth Rate of Gross Regional Domestic Product at Constant Prices (x_6) have simultaneous effect on the Open Unemployment Rate in Kalimantan)
with the test statistics used are

$$F_{FEM} = \frac{KTR}{KTG} \qquad (5)$$

Statistics test F_{FEM} with critical areas H_0 at the significance level α if $F_{FEM} > F_{(\alpha\,;nT-n-p)}$ or refuse H_0 if $p_{value} < \alpha$ **[8]**.

Test statistics values F_{FEM} and p_{value} presented on **Table 5**

Table 5. FEM Simultaneous Test

$\boldsymbol{F_{FEM}}$	$\boldsymbol{F_{(0,05;\,6;\,106)}}$	$\boldsymbol{p_{value}}$	**Decision**
12.666	2.1853	9.847×10^{-11}	H_0 reject

Based on **Table 5**, it can be concluded that The Labor Force Participation Rate, Old School Expectations, Average Length of School, the number of population, the number of poor people, and the growth rate of ADHK GRDP have effect on Open Unemployment Rate in Kalimantan

Then a partial test of the significance of FEM parameters was carried out. The hypothesis of testing the significance of FEM parameters partially is as follows.

$H_0: \beta_k = 0\,; k = 1,2, \ldots 6$

(There is no effect of x_k variables Open Unemployment Rate in 56 Regencies/Cities in Kalimantan)

$H_1: \beta_k \neq 0, k = 1,2,\ldots,6$
(There is an effect of at least one of x_k variables on the percentage of stunting toddlers in 34 provinces in Indonesia variables Open Unemployment Rate in 56 Regencies/Cities in Kalimantan)

The results of partial parameter significance test calculations can be seen in **Table 6**.

Table 6. FEM Partial Test

Parameter	$\lvert T_{FEM} \rvert$	p_{value}	Decision
$\boldsymbol{\beta_1}$	1.9375	0.0553	H_0 accepted
$\boldsymbol{\beta_2}$	1.0848	0.2805	H_0 accepted
$\boldsymbol{\beta_3}$	1.7887	0.0765	H_0 accepted
$\boldsymbol{\beta_4}$	5.3706	0.4675×10^{-6}	H_0 rejected
$\boldsymbol{\beta_5}$	1.1010	0.2734	H_0 accepted
$\boldsymbol{\beta_6}$	2.2232	0.0283	H_0 rejected

Based on **Table 6**, it can be concluded that the variables of Population Number and GDP Growth Rate of ADHK partially affect the Open Unemployment Rate in Kalimantan.

3.4 FEM Homoscedasticity Test

Homoscedasticity test is performed to determine whether the error variance of the entire observation site is constant or not. Homoscedasticity uses the Glejser test with the following hypothesis.

$H_0: \sigma_{1,1}^2 = \sigma_{2,1}^2 = \cdots = \sigma_{n,T}^2 = \sigma^2$
(Error variance is constant)

H_1:At least one $\sigma_{i,t}^2 \neq \sigma^2, i = 1,2,\ldots,n\,; t = 1,2,\ldots,T$
(Error variance is not constant)

The statistics of the Glejser Test are given to the **Equation (6)**.

$$F_{Glejser} = \frac{\left(\hat{\boldsymbol{\varphi}}^{\mathbf{T}}\mathbf{X}^{*\mathbf{T}}\boldsymbol{\varepsilon}^* - n(\bar{\varepsilon}^*)^2\right)/p}{\left(\boldsymbol{\varepsilon}^{*\mathbf{T}}\boldsymbol{\varepsilon}^* - \hat{\boldsymbol{\varphi}}^{\mathbf{T}}\mathbf{X}^{*\mathbf{T}}\boldsymbol{\varepsilon}^*\right)/(nT - n - p)} \tag{6}$$

The statistics of the $F_{Glejser}$ test follow the distribution of $F_{(p\,;\,nT-n-p)}$ where n is the number of observation locations, T the number of observation times and p the number of independent variables. The critical area of the Glejser Test where H_0 is denied at the level of significance α if $F_{Glejser} > F_{(\alpha\,;\,p\,;\,nT-n-p)}$ or if $p_{value} < \alpha$ **[9]**.

The calculation results of FEM homoscedasticity test based on R software output can be seen in **Table 7**

Table 7. FEM Glejser Test

$F_{Glejser}$	$F_{(0,05;6;106)}$	p_{value}	Decision
$\mathbf{7.2214}$	2.1853	1.7699×10^{-6}	H_0 reject

Based on **Table 7**, it is concluded that the error variance is not constant across observation sites, thus the homoscedasticity assumption of the FEM model is not satisfied. Thus, the appropriate modeling to model the Open Unemployment Rate in Kalimantan is the GWPR model.

3.5 Spatial Weighting Function

There are several methods that can be used to calculate spatial weighting, including using kernel functions that are divided into fixed kernel functions and adaptive kernel functions **[10][11]**. The fixed kernel function generates a constant bandwidth value for each observation location. While the kernel adaptive function produces different bandwidth values for each observation location. The weighting functions of each of them can be written as follows

1. Fixed Kernel Gaussian

$$W_{ij}(u_i, v_i) = \exp\left[-\frac{1}{2}\left(\frac{d_{ij}}{h}\right)^2\right] \quad (7)$$

2. Adaptive Kernel Gaussian

$$W_{ij}(u_i, v_i) = \exp\left[-\frac{1}{2}\left(\frac{d_{ij}}{h_i}\right)^2\right] \quad (8)$$

One way that can be done to select the optimum bandwidth is to use the Cross Validation (CV) method given to the **Equation (8)**.

$$CV = \sum_{i=1}^{n}[y_i - \hat{y}_{\neq i}(h)]^2 \quad (9)$$

with $\hat{y}_{\neq i}(h)$ is the estimated value of y_i where the observation of the i-th location is omitted from the estimation process **[15]**.

Based **Equation (9)**, CV for kernel fixed gaussian and kernel adaptive gaussian can be seen in **Table 8**.

Table 8. Cross Validation (CV) Values

Weighting Function	CV
Fixed Gaussian	37.369
Adaptive Gaussian	25.536

Based on the CV values in **Table 8**, it can be concluded that the best model is with the kernel adaptive gaussian function with a CV value is 25.536.

3.6 Geographically Weighted Panel Regression (GWPR) Model

GWPR is a modification of the regression model which is a combination of Geographically Weighted Regression and panel data. The GWPR model is a local regression model of FEM, with repeating data at each observation location, different times, and spatial data **[12]**. The coordinates at each observation location are known with the coordinates of the i-th observation location being (u_i, v_i) where u_i state the location of latitude and v_i state the location of longitude. Based on FEM with within estimator, GWPR models at *i* and *t-time* observation locations **[13]**, are given in the **Equation (10)**.

$$\begin{aligned} y_{it}^* = \;& \beta_1(u_i, v_i)x_{it1}^* + \beta_2(u_i, v_i)x_{it2}^* + \beta_3(u_i, v_i)x_{it3}^* + \beta_4(u_i, v_i)x_{it4}^* \\ & +\beta_5(u_i, v_i)x_{it5}^* + \beta_6(u_i, v_i)x_{it6}^* + \varepsilon_{it}^* \end{aligned} \quad (10)$$

3.7 GWPR Model Fit Test

The hypotheses of GWPR model fit test are as follows.

$H_0: \beta_k(u_i, v_i) = \beta_k\ ;\ \ i = 1,2, \dots, 6\ ;\ \ k = 1,2, \dots, 56$

(There is no difference between the panel regression model and the GWPR model)

H_1:At least one $\beta_k(u_i, v_i) \neq \beta_k\ ;\ \ i = 1,2, \dots, 6\ ;\ \ k = 1,2, \dots, 56$

(There is difference between the panel regression model and the GWPR model)

The test statistics used are F_{GWPR} given in **Equation (11)** follows.

$$F_{GWPR} = \frac{JKG(H_0)/db_1}{JKG(H_1)/db_2} \quad (11)$$

Statistics test F_{GWPR} following the distribution $F_{db_1;db_2}$ with critical areas rejecting H_0 at the level of significance α if $F_{GWPR} > F_{\alpha;db_1;db_2}$. H_0 is rejected if $P_{value} < \alpha$ [14].

The values of the test statistics F_{GWPR} can be seen in Table 9 below

Table 9 **Model Fit Test**

F_{GWPR}	$F_{(0,05;97;161)}$	P_{value}	Decision
6.5825	1.3414	0.0000	H_0 rejected

Based on Table 9, it can be concluded that there are significant differences between panel regression models and GWPR models.

3.8 Partial Significance Test of GWPR Parameters

The hypothesis of testing the significance of the parameters GWPR model fit test is as follows

$H_0: \beta_k(u_i, v_i) = 0\ ;\ \ i = 1,2, \dots ,56\ ;\ \ k = 1,2, \dots ,6$

(Variable x_k has no effect on the variable Open unemployment rate in Kalimantan)

$H_1: \beta_k(u_i, v_i) \neq 0\ ;\ \ i = 1,2, \dots ,56\ ;\ \ k = 1,2, \dots ,6$

(Variable x_k has an effect on the variable Open unemployment rate in Kalimantan)

The results of testing the significance on T_{GWPR} model partially for one of the observation locations in the regency of Paser can be seen in Table 10 below.

Table 10 **Partial Significance Test of the GWPR Model**

Location	Parameters	T_{GWPR}	p_{value}
Paser	β_1	-3.8479	0.0002
	β_2	1.7363	0.0857
	β_3	3.4515	0.0008
	β_4	9.8968	-4.63×10^{-16}
	β_5	2.0555	0.0425
	β_6	-4.2210	5.49×10^{-5}

Based on Table 10, the parameters $\beta_1, \beta_3, \beta_4, \beta_5$, and β_5 has a value of $p_{value} < \alpha = 0{,}05$, so it was decided to reject H_0. Thus, it can be concluded that the factors that affect the Open Unemployment Rate in Paser Regency are the labor force participation rate, the average years of schooling, the number of residents, the number of poor people, and the Growth Rate of Gross Regional Domestic Product at Constant Prices.

Grouping of GWPR models for all observation sites based on influential variables is presented in Figure 1.

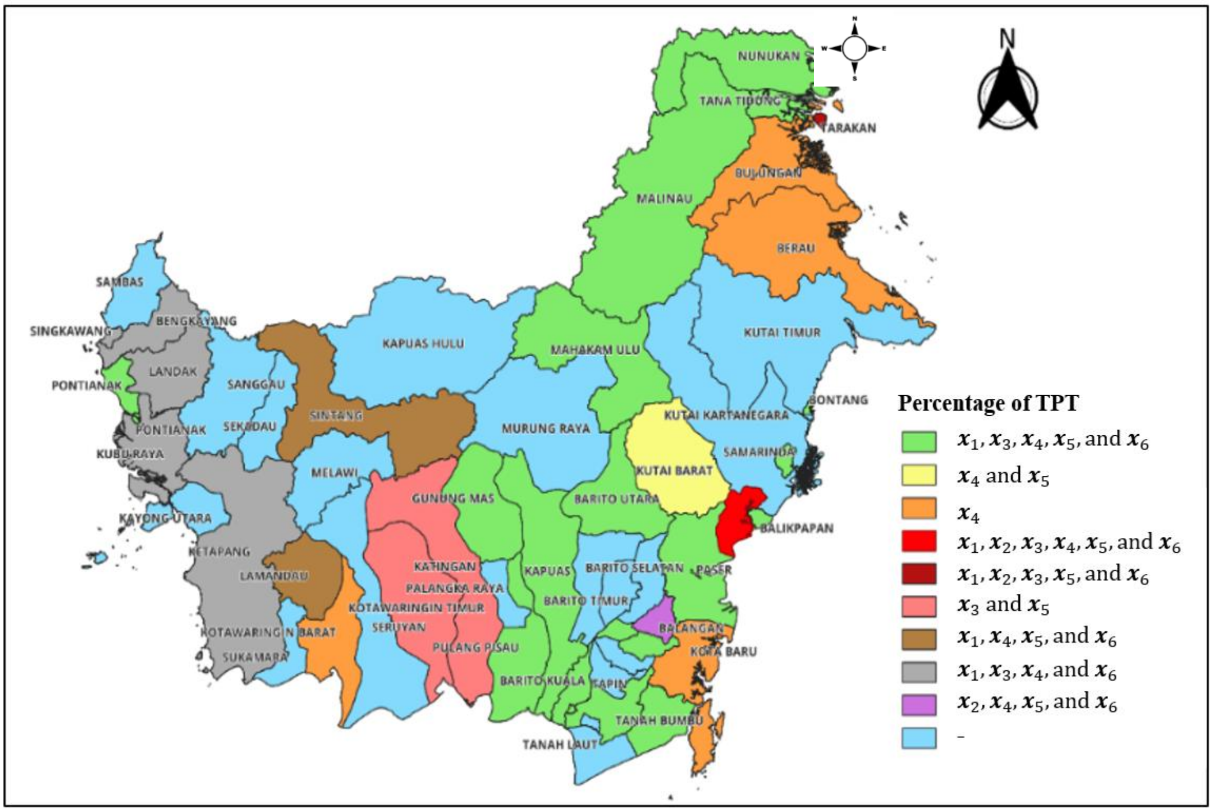

Figure 1. Grouping GWPR Model Based on Influential Variables

The map based on **Figure 1**, The Kalimantan region, where districts and cities are categorized into 10 groups based on factors influencing the Open Unemployment Rate. Each color on the map represents a group characterized by specific combinations of these factors. Explanation of the Green Group. The districts and cities in the green group include:

1. East Kalimantan: Paser, Balikpapan, Samarinda, Bontang.
2. North Kalimantan: Malinau, Tana Tidung, Nunukan.
3. Central Kalimantan: North Barito, Pulang Pisau, Gunung Mas.
4. West Kalimantan: Mempawah, Kapuas Hulu, Pontianak.
5. South Kalimantan: Banjar, Barito Kuala, Tapin, Hulu Sungai Tengah, Hulu Sungai Utara, Tanah Bumbu, Banjarmasin.

This group is characterized by a combination of factors influencing TPT, identified as x_1, x_3, x_4, x_5 and x_6. These shared factors suggest similarities in the economic and social conditions affecting unemployment rates across these areas.

The other color groups on the map represent regions influenced by different combinations of factors, such as x_2, x_4, x_5, and others, as detailed in the legend. This classification highlights the diverse characteristics of each region, reflecting variations in job availability, education levels, and demographic dynamics.

3.9 GWPR Model Goodness of Fit and Accuracy Measures

The measure of goodness of the model in this study is the value of the coefficient of determination and Root Mean Square Error (RMSE) **[16][17]**. The values of the coefficient of determination and RMSE are presented in **Table 11** below.

Table 11. Model Goodness-of-Fit and Accuracy Measures

Model	R^2	RMSE
FEM	41.76%	0.8735
GWPR	77.96%	0.2726

Based on **Table 11**, the FEM model determination coefficient value is 41.76% and the GWPR model determination coefficient value is 77.96%. The RMSE value of the FEM model is 0.8735 and the RMSE value of the GWPR model is 0.2726. Based on the value of the coefficient of determination, the GWPR model is better at modeling the open unemployment rate in Kalimantan because the value of the coefficient of determination of the GWPR model is greater than the value of the FEM coefficient of determination. Then, based on the RMSE value, the GWPR model is better at modeling the open unemployment rate in Kalimantan because the RMSE value of the GWPR model is greater than the RMSE value of the FEM model.

4. CONCLUSIONS

This study used the GWPR model to analyze factors influencing the open unemployment rate. The analysis covered 56 observations of the open unemployment rate across three time periods: $t = 1, t = 2$ and $t = 3$. A more detailed interpretation was conducted for the open unemployment rate model in Paser District. The findings revealed that the labor force participation rate, average years of schooling, total population, poverty rate, and the Growth Rate of Gross Regional Domestic Product at Constant Prices significantly impact the open unemployment rate. This study emphasizes the value of spatial approaches like the GWPR model in providing deeper insights into the relationships between socio-economic variables and unemployment at the regional level. The results are intended to inform more targeted policy-making aimed at reducing the open unemployment rate.

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