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THE SPATIAL ECONOMETRICS OF ECONOMIC GROWTH IN SUMATERA UTARA PROVINCE

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Abstract: This study aims to analyze the economic growth of Sumatera Utara using an econometric spatial model. Euclidean distance and Moran's I test were applied to determine the neighborhood and identify the autocorrelation. Based on the Lagrange Multiplier test, the spatial lag model (SAR) was considered. The R Shiny program, which was previously developed by the researcher, was used to estimate the model parameters. The SAR model's diagnostic checking shows that non-autocorrelation, normality, and homogeneity assumptions have been satisfied. Economic growth in the agricultural, forestry, and fishing sectors has a positive and significant effect on increasing economic growth in Sumatera Utara. A good strategy to increase the role of this sector could significantly improve the economy

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of Sumatera Utara. Coconut production has a positive and significant effect on increasing economic growth in Sumatera Utara. The unemployment rate has a negative and significant effect on the decreasing economic growth in Sumatera Utara. Reducing the unemployment rate could be one strategy to improve the economic growth of Sumatera Utara.

Keywords: economic growth; spatial econometrics; Moran's I; SAR.

2010 AMS Subject Classification: 93A30, 62P20, 91B82.

1. INTRODUCTION

Sumatera Utara province is located in the western part of Indonesia and has a land area of 72,981.23 km^2. This province is located close to the equator so that it belongs to a tropical [1]. In 2020, Sumatera Utara's economic growth decreased by 1.07% compared to the previous year, where the largest contraction occurred in the fourth quarter on a year-on-year basis, namely 2.94%. Economic contraction occurred in more than 50% of the districts/cities in Sumatera Utara. One of the strategies that can be done to improve the economy of Sumatera Utara province is to increase the contribution of sectors that have an important role. According to the United Nations Development Program (UNDP) in 2012, 75% of the world's poor live in rural areas and are highly dependent on agriculture and fisheries. In addition to providing food, employment, and income for the survival of the community, agriculture provides inputs and raw materials for other economic sectors [2].

The agriculture, forestry and fisheries sectors provide the largest contribution to the economy of Sumatera Utara. In 2020, two other sectors that make the biggest contribution to the Sumatera Utara's economy are the manufacturing sector and the trade sector. The agricultural sector has an important role in the economy, which can increase economic growth and growth in other sectors such as the industrial sector [3]. The role of the agricultural sector in Sumatera Utara is very important because more than 35% of the working population (15 years and over) make the agricultural sector their main job. The percentage of the population working in the agricultural sector decreased from 35.54% in 2019 to 35.43% in 2020.

Unemployment is one of the problems in Sumatera Utara province. In 2020, the province's unemployment rate ranks fifth highest compared to other provinces in Indonesia. Unemployment is one of the important variables in considering strategic plans to increase economic growth [4]. Keynesian theory holds that unemployment is usually triggered by a total insufficient demand during a certain period in the labor market [4]. Unemployment is a macroeconomic indicator that reflects the inability of an economy to fully utilize labor [5].

Economic growth analysis generally ignores the existence of spatial dependence (spillover effect) [6]. The economic growth of a region is influenced by the performance of its neighbors and then influenced by its own geographical position [6]. There is a spatial dependence that cannot be ignored in analyzing economic growth [6]. Based on the above background, this study aims to conduct a spatial analysis of the influence of the agricultural sector, coconut production, and the unemployment rate on the economic growth of districts/cities in Sumatera Utara province.

2. METHOD

This study used data from the Central Bureau of Statistics (BPS) of Sumatera Utara province and BPS of all districts/cities in Sumatera Utara. The units of analysis in this study are 33 districts/cities in Sumatera Utara. All data used in this study are taken from public domain.

Table 1. Response variable and three predictor variables

Variable	Notation
Economic growth (%)	Y
Economic growth in the agriculture, forestry and fisheries sectors (%)	X_1
Coconut production (thousand tons)	X_2
Open unemployment rate (%)	X_3

Data processing in this study was carried out using the R software and the R shiny web-based application that had been developed by previous researchers. The developed R shiny can be accessed via statistikterapan.shinyapps.io/Spatial_Econometrics/. R shiny is built with the open source R software so that it can be used by users freely. R is free software with open source code so that it can be shared and enhanced by users [7]–[9]. The following are the stages carried out in the analysis of the econometric spatial model [8]:

1. Descriptive analysis and map
2. Classical assumption test
3. Model selection using Lagrange Multiplier (LM) test
4. Parameter estimation using the maximum likelihood estimator (MLE)
5. Diagnostic checking

Descriptive analysis and mapping are used to see the characteristics possessed by districts/cities in Sumatera Utara by using the variables studied. The map used in this study is taken from the open-source software R. Shapiro-Wilk test, Durbin-Watson (DW) test, the VIF multicollinearity test, and the Breusch-pagan test are used to test the assumptions of normality, non-autocorrelation, non-multicollinearity, and homogeneity, respectively, with a 5% alpha. Euclidean distance was used to determine spatial weighted matrix. The Euclidean distance from two locations with coordinates (u_i, v_i) and (u_j, v_j), is defined as follows [8], [10], [11]:

$$d_{ij} = \sqrt{\left(u_i - u_j\right)^2 (v_i - v_j)^2} \tag{1}$$

Inverse distance:

$$w_{ij} = \begin{cases} \frac{1}{d_{ij}^{\propto}} & , if\ i \neq j \\ 0 & , if\ i = j \end{cases} \tag{2}$$

generally, $\alpha = \{1,2\}$

Spatial autocorrelation or spatial dependence can be tested using Moran's I with the following formula [8], [10], [11]:

$$I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum_{i=1}^{n}(y_i - \bar{y})^2} \tag{3}$$

with,

n : number of spatial units

y_i : observation variable at location i

w_{ij} : elements of the spatial weight matrix $\mathbf{W}$

I : Moran’s I global coefficient

Moran's I values range from -1 to 1. Local Moran's I can be used to identify spatial dependencies on each unit with the following formula [8], [10], [11]:

$$I_i = \frac{y_i - \bar{y}}{\sum_{i=1}^{n}(y_i - \bar{y})^2/n} \sum_{j=1}^{n} w_{ij}(y_j - \bar{y}) \tag{4}$$

The null hypothesis for autocorrelation is $I = E(I)$ no spatial dependence. The formula of test statistics can be written as follows [8]:

$$Z(I) = \frac{I - E(I)}{\sqrt{Var(I)}} \sim N(0,1) \tag{5}$$

with,

$$E(I) = -\frac{1}{n-1}$$

$$Var(I) = \frac{n^2.S_1 - n.S_2 + 3.S_0^2}{(n^2-1)S_0^2} - [E(I)]^2$$

$$S_0 = \sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij} \quad ; \; S_1 = \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}(w_{ij} + w_{ji})^2 \quad ; \; S_2 = \sum_{i=1}^{n}\left(\sum_{j=1}^{n} w_{ij} + \sum_{j=1}^{n} w_{ji}\right)^2$$

Reject the null hypothesis at significance level $\propto$ if $Z(I) > Z_{1-\propto}$. There are several spatial econometric models, so we can use Lagrange Multiplier (LM) as the best model selection criteria. LM test for Spatial Autoregressive (SAR) model can be written as follows [8], [12], [13]:

$$\mathbf{y} = \rho\mathbf{W}\mathbf{y} + \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon} \quad ; \; \boldsymbol{\varepsilon} \sim \mathrm{iidN}(0, \sigma^2\mathbf{I}) \tag{6}$$

$$\mathrm{LM_{lag}} = \frac{(\boldsymbol{\varepsilon}^t\mathbf{W}\mathbf{y})^2}{s^2((\mathbf{W}\mathbf{X}\boldsymbol{\beta})^t\mathbf{M}(\mathbf{W}\mathbf{X}\boldsymbol{\beta}) + \mathrm{T}s^2)} \tag{7}$$

with,

$$\mathbf{M} = \mathbf{I} - \mathbf{X}(\mathbf{X}^t\mathbf{X})^{-1}\mathbf{X}^t \quad ; \quad \mathrm{T} = \mathrm{tr}\,((\mathbf{W}^t + \mathbf{W})\,\mathbf{W}) \; ; \quad s^2 = \frac{\hat{\boldsymbol{\varepsilon}}^t\hat{\boldsymbol{\varepsilon}}}{\mathrm{n}}$$

Reject the null hypothesis if $LM_{lag} > \mathrm{X}^2_{(\alpha,1)}$ or $p - value < \propto$, so the SAR model can be used. Parameter estimator of the SAR model is as follows [8]:

$$\hat{\boldsymbol{\beta}}_{\mathrm{SAR}} = (\mathbf{X}^t\mathbf{X})^{-1}\mathbf{X}^t(\mathrm{I} - \rho\mathbf{W})\mathbf{y} \tag{8}$$

3. RESULTS AND DISCUSSION

In 2020, the highest economic growth occurred in the districts of Nias, Nias Utara, and Nias Barat. The lowest economic growth occurred in Medan city, Pematangsiantar, Binjai, and Deli Serdang district. Some areas that have high economic growth are surrounded by high areas as well. The same thing happened in areas with low economic growth.

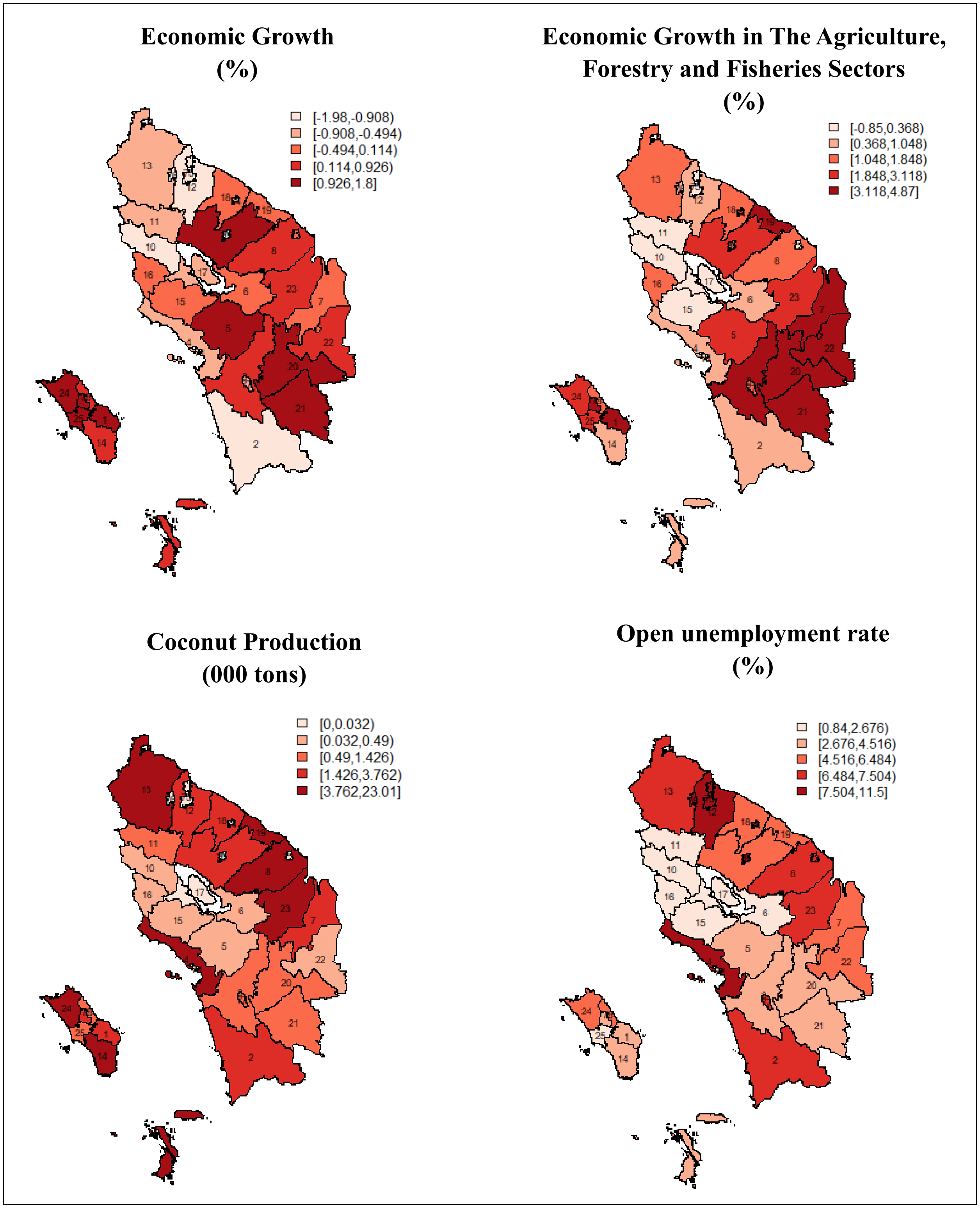

Figure 1. Map of the quantiles of the all variables

Table 2. ID of districts/cities in Sumatera Utara

ID	Districts/cities	ID	Districts/cities
1	Nias	18	Serdang Bedagai
2	Mandailing Natal	19	Batu Bara
3	Tapanuli Selatan	20	Padang Lawas Utara
4	Tapanuli Tengah	21	Padang Lawas
5	Tapanuli Utara	22	Labuhanbatu Selatan
6	Toba	23	Labuhanbatu Utara
7	Labuhanbatu	24	Nias Utara
8	Asahan	25	Nias Barat
9	Simalungun	71	Sibolga
10	Dairi	72	Kota Tanjungbalai
11	Karo	73	Pematangsiantar
12	Deli Serdang	74	Tebing Tinggi
13	Langkat	75	Kota Medan
14	Nias Selatan	76	Kota Binjai
15	Humbang Hasundutan	77	Padangsidimpuan
16	Pakpak Bharat	78	Gunungsitoli
17	Samosir		

Figure 1 shows that Nias, Nias Utara, and Simalungun district have the highest economic growth compared to other districts/cities. This is due to economic growth in the agriculture, forestry and fishery sectors (sector A) in the three districts, high coconut production, and low/moderate unemployment rates. Sector A contributes more than 47% to the economy of the three districts.

Nias Selatan has unique characteristics when compared to other districts/cities. Sector A's economic growth is low at 1.04%, but Nias Selatan's economic growth is high. This can happen because sector A has a contribution of 44.61% to the economy of Nias Selatan district, so that the economic growth of sector A which is classified as low has been able to increase the economic growth of the district. This can also happen because of the very high coconut production, reaching 13.72 thousand tons. High coconut production has a role in the economy of the people of Nias

Selatan district. The low unemployment rate also contributed to the high economic growth of the district. Furthermore, Asahan district also has unique characteristics when compared to other districts. Although this district has a high unemployment rate, the economic growth of Asahan district experienced high economic growth, reaching 0.21%. This can happen because of the very high coconut production, reaching 23.01 thousand tons. The high production of this commodity certainly has an important role in the economy of the Asahan district.

Seven of eight cities in Sumatera Utara province face unemployment problems. The high unemployment rate in these cities resulted in low economic growth in these cities. The same thing happened in four other districts, namely Mandailing Natal, Tapanuli Tengah, Deli Serdang, and Langkat. Overcoming the problem of unemployment in these 11 districts/cities can be a good solution in increasing the economic growth of the region. Inferential analysis using econometric spatial models was carried out to see how these predictor variables have an effect on increasing or decreasing economic growth in Sumatera Utara. Before conducting further analysis, here are the results of the classical assumption test, R-squared, and Moran's I test:

Table 3. Statistic test result of classic assumptions, R-squared, and Moran's I

Statistic test	p-value
Shapiro-Wilk	0.166
Durbin-Watson	0.060
VIF multicollinearity	All variables < 5
Breusch-pagan	0.761
Adjusted R-squared	0.775
Moran's I	0.000 (I = 0.149)

Table 3 shows that classic assumptions in multiple linier regression model have been fulfilled, and 77,5% of economic growth in Sumatera Utara province can be explained by the three predictor variables. The probability of Moran's I is 0.000, so the null hypothesis is rejected, which means that there is a spatial autocorrelation on economic growth in Sumatera Utara province. Moran's index is 0.149 indicating that there is a positive autocorrelation. High economic growth area will be surrounded by high areas as well, and low economic growth area will be surrounded by low areas as well. Based on the results of local Moran's I test which is visualized in Figure 3, it can be seen that there is significant spatial autocorrelation in high and low economic growth areas.

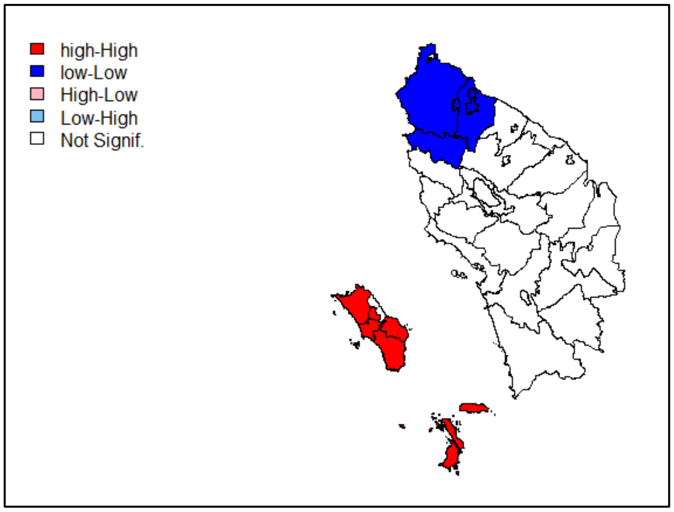

Figure 3. Local Moran's I

Table 4. Lagrange Multiplier (LM) test result

Statistic test	p-value
LM_{err}	0,205
LM_{lag}	0.013

The Lagrange multiplier test of the spatial lag (SAR) model is significant, as shown in Table 4. The maximum likelihood estimator will be used to estimate the parameter model. Table 5 illustrates the result of parameter estimation using Maximum Likelihood Estimator:

Table 5: Model parameter estimation results

	Estimate	**Std. Error**	**z value**	**Pr(>|z|)**
(Intercept)	0.206	0.209	0.987	0.324
X_1 Economic growth in the agriculture, forestry and fisheries sectors	0.412	0.057	7.229	0.000
X_2: Coconut production	0.041	0.016	2.567	0.000
X_3: unemployment rate	-0.186	0.029	-6.375	0.010
Rho	0.475			

LR test value: 4.989, p-value: 0.026

Asymptotic standard error: 0.208
z-value: 2.287, p-value: 0.022

Wald statistic: 5.229, p-value: 0.022

AIC: 55.18

$$\hat{y}_i = 0.475 \sum_{j=1, i \neq j}^{n} w_{ij}\, y_j + 0.206 + 0.412X_{1i} + 0.041X_{2i} - 0.186X_{3i}$$

According to the results in Tables 5, the probability value of the LR test is 0.026, indicating that adding the lag to the model improves it and may result in a decrease in the AIC value. The SAR model is preferable to multiple regression for analyzing the relationship between predictors and economic growth in Sumatera Utara province. The value of Rho is 0.475 and the probability of the Wald test is 0.022, indicating that the relationship between economic growth and all predictor variables is spatially dependent.

Simultaneously, all predictor variables and the spatial lag all contribute significantly to economic growth in Sumatera Utara province. While the test results indicate that the lag is a useful addition, it complicates reading the remainder of the model's parameter estimation in Table 5. Partially, economic growth in the agriculture, forestry and fisheries sectors (X_1), coconut production (X_2), and unemployment rate (X_3) have a significant effect on economic growth in Sumatera Utara province at significance level 0.05 of alpha. These three predictors will be interpreted using the impact measure in Table 6.

Table 6. Direct and indirect impact measure of SAR model

	Direct	**Indirect**	**Total**
X_1 Economic growth in the agriculture, forestry and fisheries sectors (economic growth of sector A)	0.421	0.363	0.784
X_2: Coconut production	0.042	0.036	0.079
X_3: unemployment rate	-0.190	-0.164	-0.355

The impact of covariates that are quantified in Table 6 represents the global average. Direct impact refers to changes that occur locally in an area as a result of changes in a predictor. Indirect impact refers to the spill-over effect, which occurs when predictor variables in the surrounding area change [8]. Additionally, total impact refers to the changes that occur in an area as a result of changes in the area and its surroundings [8]. All predictor variables have a significant effect on economic growth in Sumatera Utara province.

Based on the results shown in table 6, the economic growth in the agriculture, forestry and fisheries sectors variable has a direct effect on increasing economic growth. Each percent increase in economic growth of this sector in an area increases the economic growth in that area by 0.421%. In the Sumatera Utara province, the economic growth of sector A has the greatest direct effect on increasing the economic growth of districts/cities. Accelerating the economic growth of this sector may be one strategy for increasing economic growth in Sumatera Utara province.

Economic growth of sector A has the greatest indirect effect, each percent increase in the economic growth of sector A in the surrounding areas increases the economic growth in an area by 0,363%. The spatial dependence that occurs in an area and its surrounding areas can be an opportunity to improve the economy of the district/city. The magnitude of the sector's contribution to the economy of districts/cities in the province of Sumatera Utara is presented in Figure 4 below:

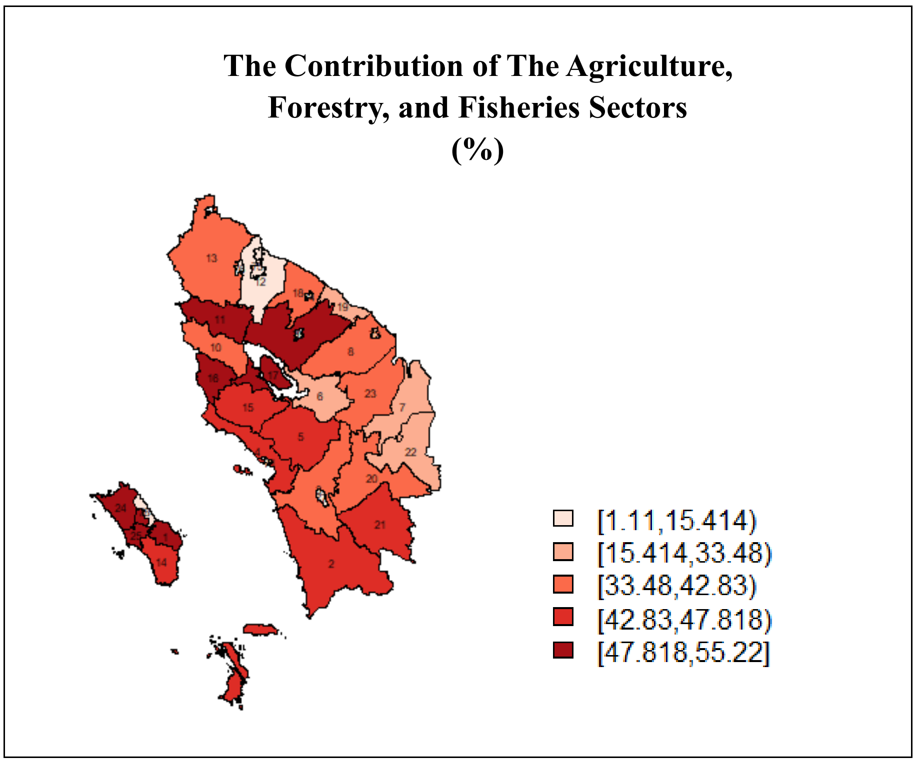

Figure 4. Distribution of Sector Contribution to District/City Economy

The magnitude of the direct and indirect effects of sector A on the economic growth of districts/cities in Sumatera Utara makes this sector one of the strategic sectors in Sumatera Utara's economic recovery. Some districts that have low economic growth due to low economic growth in sector A (although this sector has a large contribution) are Karo, Samosir, Pakpak Bharat, Humbang Hasundutan, Tapanuli Tengah, and Mandailing Natal. Strategic policies in sector A can be carried out in these 6 districts so that the economic recovery of the district/city can be achieved.

Coconut production has a direct effect of 0.042 so an increase of 1000 tons of coconut production can increase 0.042% of the economic growth of the district/city. The predictor's indirect effect is 0.036 so every 1000 tons increase in coconut production in the surrounding areas will increase the economic growth in an area by 0.036%. The effect of this predictor is not large enough compared to the other predictors, but the effect is significant in increasing the economic growth of districts/cities in Sumatera Utara. One of the districts that have low economic growth due to the low coconut production (despite having a large coconut plantation area of 720 Ha) is the Karo district. Strategic policies to increase coconut production can restore the economy of districts/cities in Sumatera Utara.

The open unemployment rate has a direct effect of -0.19 so each percent increase in the unemployment rate can reduce economic growth by 0.19% in the district/city. The indirect effect of the unemployment rate is -0.164 so each percent increase in the unemployment rate in the surrounding areas, will reduce the economic growth in an area by 0.164%. This shows that the inter-regional relationship that allows a person to work outside the area where he lives can help restore the economy of an area. A low unemployment rate in an area can be an attraction for the workforce in other areas. The diagnostic check performed on the SAR model in Table 7 demonstrates that non-autocorrelation, normality, and homogeneity assumptions are satisfied.

Table 7. Diagnostic checking of SAR model

Statistic test	p-value
LM test for residual autocorrelation	0.324
Shapiro-Wilk	0.079
Breusch-Pagan	0.804

4. CONCLUSION

The economic growth of districts/cities in Sumatera Utara province has a spatial autocorrelation. Economic growth in the agricultural, forestry, and fishery sectors (sector A) had a significant effect on increasing the economic growth of districts/cities in Sumatera Utara. Economic recovery can be carried out by implementing strategic policies, especially in sector A in the districts of Karo, Samosir, Pakpak Bharat, Humbang Hasundutan, Tapanuli Tengah, and Mandailing Natal. Sector A provides a high contribution to the economy of these districts, so the low economic growth in this sector has an impact on the low economic growth of the districts.

Increasing coconut production has a significant effect on increasing the economic growth of districts/cities in the province of Sumatera Utara. Unemployment rate has a negative and significant effect on decreasing the economic growth of districts/cities. Unemployment is an important problem in several districts/cities in Sumatera Utara so the right policy in alleviating the unemployment problem can be one solution in increasing the economic growth of districts/cities in Sumatera Utara.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests.

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