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Poverty Modeling in East Java Province Using the Spatial Seemingly Unrelated Regression (SUR) Method

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Abstract - Poverty is a complex problem because it relates to various aspects of human life. In Indonesia, there is one province that has a very high percentage of poverty, namely East Java Province. Although from year to year the poverty rate has decreased, when viewed from the national level it is still very far from the government's expectations of reducing the poverty rate. Cases of poverty can be modeled by Econometrics. Econometric models are often applied to problems involving one or more related equations. One method that can be used to solve several interrelated equations because there is a correlation error regression between one another, namely Seemingly Unrelated Regression which is usually abbreviated as SUR, in this case Spatial Seemingly Unrelated Regression (SUR-Spatial) is development that takes to account the spatial influence between locations. From the results of tests conducted in the SUR-Spatial Lagrange Multiplier model, the poverty data generated by the East Java Province is the SUR-Spatial Autoregressive Model (SUR-SAR). So, with the SUR-SAR model it had been seen that the variable that has a significant effect on the percentage of poor people is the growth rate of Gross Regional Domestic Product based on the constant price of the minimum wage for each district, as well as the average length of school years. Meanwhile, the Poverty Depth Index has an effect because of the growth rate of Gross Regional Domestic Product of constant prices and the average length of schooling. The Poverty Severity Index is influenced by the growth rate of Gross Regional Domestic Product at constant prices and average years of schooling.

Keywords - Poverty, Spatial, SUR, and SUR-SAR

1. INTRODUCTION

According to chambers (1996) poverty is a complex problem because it relates to various aspects of human life. East Java is a province with the second largest economic growth nationally after DKI Jakarta Province. East Java Province's economic growth can be seen from the GRDP at constant prices. In 2010 East Java's economy was able to grow 6.68 percent, in 2021 to 2022 East Java's economic growth will increase from 7.22 percent to 7.27 percent. The existence of the phenomenon of increased economic growth accompanied by increasing the percentage of the population classified as poor in this study.

This research was conducted in East Java Province in 2022. The problem of poverty in East Java Province includes three things, namely the sum of the Percentage of Poor Population,

the Poverty Depth Index, and the value of the Poverty Severity Index which can be modeled in several equations. One of the studies that can be solve the problem of poverty is econometrics. Econometric studies are often used to solve several equations and between the equations there is a relationship. If the equations are interrelated because the regression errors are correlated, the more appropriate approach is Seemingly Unrelated Regression (SUR). Seemingly Unrelated Regression (SUR) was first introduced by Zellner (1962) in the case of investment requests. Some examples of the development of SUR include in the spatial domain (Mur and Lopez,

SUR was first brought into the spatial realm by Anselin (1988). In Indonesia, research on Spatial Seemingly Unrelated Regression (SSUR) was conducted by Pristiandana (2012) and Arum (2014). Much research on poverty has been carried out, including by Setiawati (2012) regarding poverty in East Java using the Spatial panel econometric approach, Anuraga (2014) regarding poverty using the Spatial Structural Equation Modeling-Partial Least Square method, Arisanti (2011) discussing poverty in the Province of East Java with a spatial regression model or single equation. In contrast to previous research, this study discussed the problem of poverty in East Java Province in 2012 involving several similarities and indicated that there was a regional linkage.

2. RESEARCH METHOD

2.1. Data source

In this research the data used is secondary data taken from the Central Bureau of Statistics (BPS) of East Java Province in 2022.

Figure 1. Map of the Province of East Java

2.2. Research Method

The methods and stages used to answer the formulation of the problem in this study are:

1. Conduct a description of each response variable as an initial description of poverty in East Java Province.
2. Identify patterns of relationship
3. Correlate the errors between models of the percentage of poor people.
4. Defines Costumize's spatial weighting
5. Testing the spatial aspect for Spatial SUR with the Lagrange Multiplier test.
6. Doing modeling with a spatial SUR approach.
7. Interpret the spatial SUR model.

The stages of the analysis method can be seen in the following flowchart in Figure 2

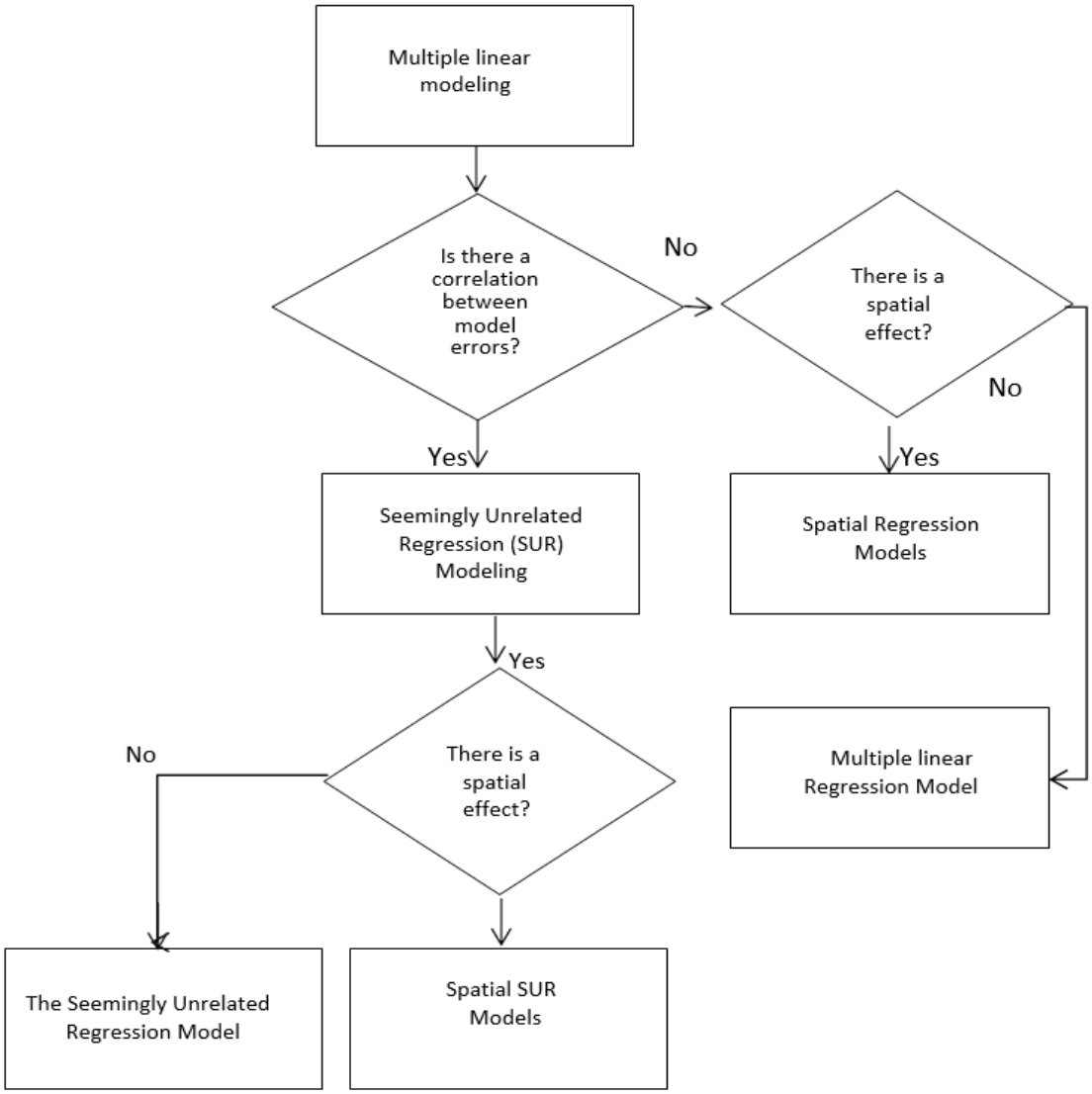

Figure 2 Flowchart of Analysis Method

2.3. Spatial Regression Models

Spatial regression is a development of a regression method that accommodates spatial dependencies. Spatial dependency on spatial regression is represented in a spatial weighting matrix whose elements indicate the presence of regional intersections or regional proximity. The model developed by Anselin (1988) uses cross section spatial data. The model is shown as in equation (1).

$$y = \rho W_1 y + X\beta + u, \quad u = \lambda W_2 u + \varepsilon, \quad \varepsilon \sim N(0, \sigma^2 I) \tag{1}$$

2.4. Seemingly Unrelated Regression Models

Seemingly Unrelated regression(SUR) is a development of a linear regression model consisting of several regression equations, where each equation has a different response variable. According to Kmenta (1971) that in general the SUR model for m equations can be written as follows.

$$\begin{aligned} y_{1j} &= \beta_{10} + \beta_{11}X_{1j,1} + \beta_{12}X_{1j,2} + \cdots + \beta_{1i,p_1}X_{1j,p_1} + \varepsilon_{1j}, \\ y_{2j} &= \beta_{20} + \beta_{11}X_{2j,1} + \beta_{22}X_{2j,2} + \cdots + \beta_{2j,p_2}X_{2j,p_2} + \varepsilon_{2j}, \\ &\vdots \\ y_{mj} &= \beta_{m0} + \beta_{m1}X_{mj,1} + \beta_{m2}X_{mj,2} + \cdots + \beta_{mj}X_{mj,p_m} + \varepsilon_{mj}, \end{aligned} \quad (2)$$

$j = 1,2, \dots, n.$

2.5. Spatial Seemingly Unrealated Regression (SSUR) Models

The spatial SUR model was first introduced by Anselin (1988). The general SUR spatial model is a model with an autoregressive structure that is found in the main equation, error or both. If there is a spatial SUR model whose autoregressive structure is found only in the main equation, it is called SUR-Spatial Autoregressive Model (SUR-SAR). The following is the SUR-Spatial model contained in the main equation (SUR-SAR).

$$\begin{aligned} y_{ij} &= \rho_{ij}Wy_{ij} + X_{ij}\beta + u_{ij} \\ A_{ij}y_{ij} &= X_{ij}\beta + u_{ij} \end{aligned} \quad (3)$$

The general model of SUR-SAR with a single equation will be written as follows.

$$Aij = Iij - \rho ij\boldsymbol{W}i = 1,2, \dots mj = 1,2, \dots n. \quad (4)$$

$$\boldsymbol{A}\boldsymbol{y} = \boldsymbol{X}\boldsymbol{\beta} + \boldsymbol{u} \quad (5)$$

$$\boldsymbol{u} \sim N(\boldsymbol{0}, \boldsymbol{\Omega}) \quad (6)$$

2.6. Research variable

The response variable and predictor variable used in this study shown in Table 1.

Table 1. Research Variables

Variable	Information	Data type	Unit
Y1 Y2 Y3	Percentage of Poor Population poverty depth indicator poverty severity indicator	Ratio Ratio Ratio	Percent Percent Percent
X1 X2 X3 X4 X5	GRDP growth rate at constant prices District minimum wage per month Average length of school Household per capita expenditure Gini index	Ratio Ratio Ratio Ratio Ratio	Percent Hundreds of thousands Year Million/month

2.7. Model Specifications

A measure of poverty is divided into three sizes, namely: Percentage of poor people, depth of poverty, and severity of poverty. So that the formulation of the variables used in this study mostly refers to the poverty modeling framework in Nanga's research (2006), the SUR-SAR model is as follows.

$$y_{1j} = \beta_0 + \rho_1 \left(\sum w_{jk}y_{1k}\right) + \beta_1X_{1j} + \beta_2X_{2j} + \beta_3X_{3j} + \beta_4X_{4j} + \beta_5X_{5j} + \varepsilon_{1j} \quad (7)$$

...

$$y_{3j} = \beta_0 + \rho_3 \left(\sum w_{jk}y_{3k}\right) + \beta_1X_{1j} + \beta_2X_{2j} + \beta_3X_{3j} + \beta_4X_{4j} + \beta_5X_{5j} + \varepsilon_{3j} \quad (8)$$

3. RESULTS AND DISCUSSION

One indicator of the success of development is the reduction in the percentage of poor people. The percentage of poor people in East Java Province during the 2020-2022 period has

always decreased from 15.26 percent in 2020 to 13.40 percent in 2022. Even though there has been a decrease in the percentage of poor people, the percentage of poor people in East Java province is still above the percentage of population The national poor is 1.41 percent to 1.93 percent in the 2020-2022 period. Completely presented in Figure 3.

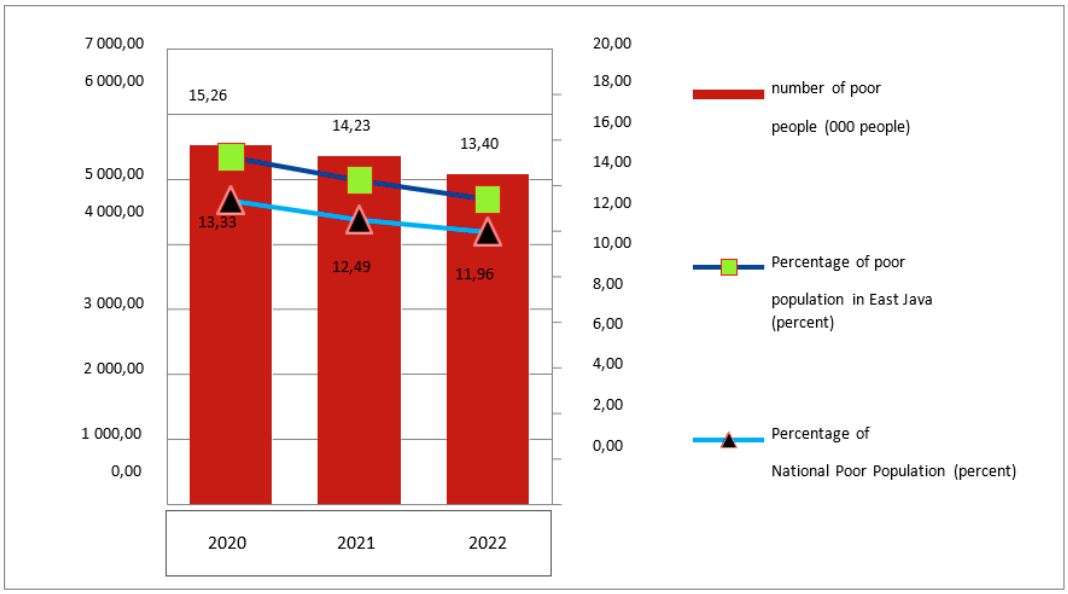

Figure 3. Number of Poor Population in East Java, Percentage of Poor

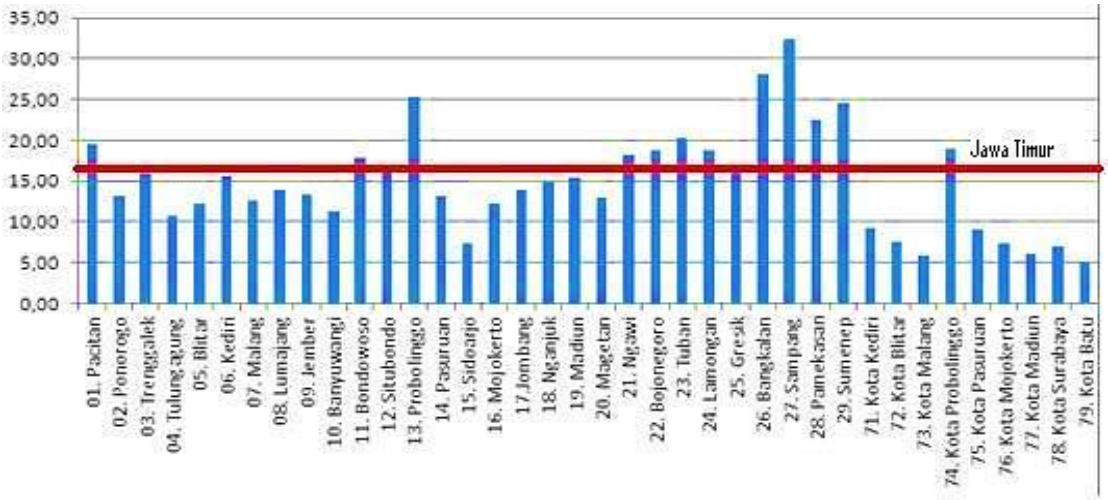

Figure 4. Percentage of East Java Poor Population in 2022

Based on Figure 4, it had been seen the distribution of the percentage of poor people in East Java Province in 2022 is the highest in Sampang Regency with a percentage of poor people of 27.87 percent, while the second and third districts are Bangkalan and Probolinggo Regencies.

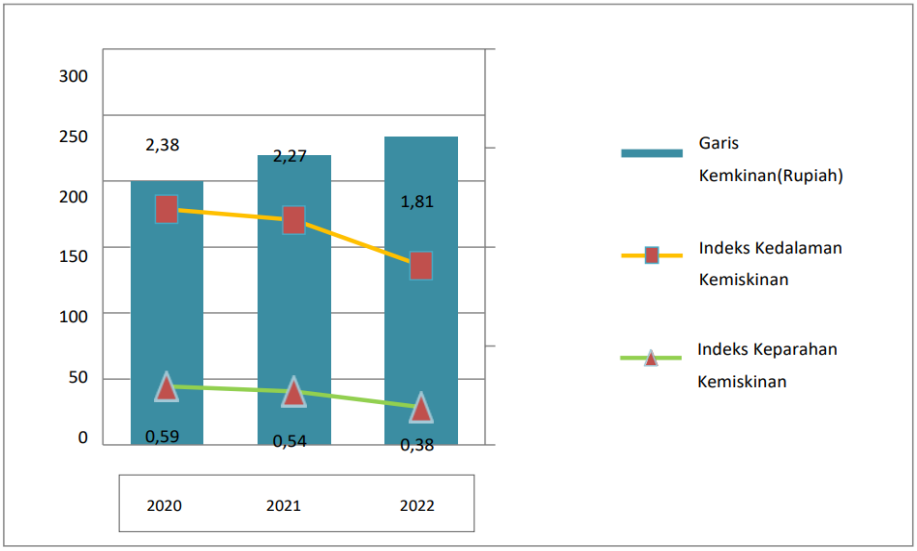

Figure 5. East Java Poverty Line, Depth Index, and Poverty Severity Index 2020-2022

In addition to describing the percentage of poor people, it is also necessary to describe the severity and depth of poverty in East Java Province. In Figure 5 it can be seen that the Poverty Severity Index (Y2) and Poverty Depth Index (Y3) experienced a decreasing trend inthe period 2020 to 2022. The lowest decrease in the Poverty Depth Index occurred in the 2020- 2021 range of 4.62 percent. Meanwhile, the highest decline in the Poverty Depth Index occurred in the 2021-2022 range of 20.26 percent. Meanwhile, the same downward trend occurred in the Poverty Severity Index, with the lowest decline occurring in the 2020-2021 range of 8.47 percent, and the highest decline occurring in the 2021-2022 range of 29.63 percent. After describing the indicators related to poverty in East Java Province, the next step is to identify the pattern of linkages between the response variables and the linkages of the predictor variables. can be seen in Figure 6, namely the relationship between the response variable and the variable that is suspected of influencing it.

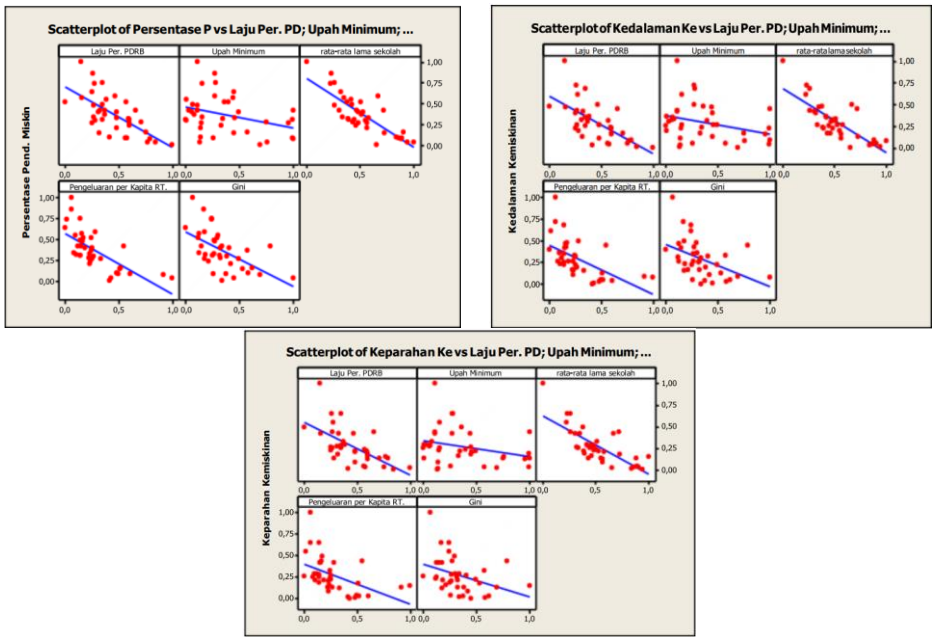

Figure 6. Pattern of Relationship Between Response Variables and Predictor Variables

Based on Figure 6, it can be seen that theconnected model of Percentage of Poor Population with each predictor variable shows a negative pattern. This means that between these variables have an inverse relationship. For example, the higher the GRDP growth rate at constant prices, the lower the poverty percentage. After knowing the relationship pattern in Figure 3, the correlation value of each response variable with the predictor variable that is thought to have an effect is shown in Table 2 and there is a relationship between the predictor variables. In the highest relationship for the first response variable is the relationship between the Percentage of Poor Population (Y1) and theaverage length of schooling (X3), which is equal to -0.819with a P-value of 0.000. There is Y1 a negative correlation between the five predictor variables. The results of parameter estimation for multiple linear regression can be seen in Table 3.

Table 2. Correlation Between Response Variables and Predictor Variables and Between Predictor

		$Y1$	$Y2$	$Y3$	$X1$	$X2$	$X3$	$X4$	$X5$
$Y1$	Mark	1	0.965	0.909	-0.668	-0.345	-0.819	-0.697	-0.574
	P-values		0.000	0.000	0.000	0.034	0.000	0.000	0.000
$Y2$	Mark	0.965	1	0.984	-0.650	-0.308	-0.786	-0.589	-0.464
	P-values	0.000		0.000	0.000	0.060	0.000	0.000	0.003
$Y3$	Mark	0.909	0.984	1	-0.628	-0.282	-0.748	-0.498	-0.372
	P-values	0.000	0.000		0.000	0.086	0.000	0.001	0.021
$X1$	Mark	-0.668	-0.649	-0.627	1	0.579	0.672	0.619	0.434
	P-values	0.000	0.000	0.000		0.000	0.000	0.000	0.006
$X2$	Mark	-0.345	-0.308	-0.282	0.580	1	0.397	0.547	0.293
	P-values	0.034	0.060	0.086	0.000		0.013	0.000	0.074
$X3$	Mark	-0.819	-0.786	-0.748	0.673	0.397	1	0.871	0.709
	P-values	0.000	0.000	0.000	0.000	0.013		0.000	0.000
$X4$	Mark	-0.697	-0.589	-0.498	0.620	0.547	0.871	1	0.801
	P-values	0.000	0.000	0.001	0.000	0.000	0.000		0.000
$X5$	Mark	-0.574	-0.464	-0.372	0.434	0.293	0.709	0.801	1
	P-values	0.000	0.003	0.021	0.007	0.074	0.000	0.000	

Table 3. Estimation of Multiple Linear Regression Parameters

Variable	[Y1] Poverty Percentage			[Y2] Poverty Depth			[Y3] Poverty Severity		
	Koef	SE	P-values	Koef	SE	P-values	Koef	SE	P-values
$X1$	-0.251	0.149	0.101	-0.243	0.151	0.118	-0.231	0.149	0.130
$X2$	0.047	0.138	0.735	-0.009	0.140	0.950	-0.060	0.138	0.666
$X3$	-0.723	0.225	0.003	-1,000	0.230	0.000	-1.198	0.226	0.000
$X4$	0.100	0.273	0.716	0.434	0.279	0.128	0.684	0.274	0.018
$X5$	-0.046	0.169	0.787	0.005	0.173	0.977	0.046	0.169	0.788
R-Squared	0.700 0.347			0.689 0.360			0.700 0.347		

In Table 3 it is known that with a confidence level of 85%, variables have a very significant influence on the percentage of poor people in East Java Province are the GRDP growth rate at constant prices (Y1) and the average length of schooling (X3), as well as there are two significant variables, namely the rate GRDP growth with constant prices (X1) and average length of schooling (X3) on the Poverty Depth Index. Meanwhile, the Poverty Severity Index isinfluenced by the average length of schooling (X3) and the GRDP growth rate at constant prices(X1). The value of the criteria for the goodness of the model with R-Squared and MSE in Table 4.2 gives good results. R-Squared for the model Y1,Y2, and Y3 is 70%; 68.9% and 70%. The multiple error linear regression model is used to initialize the formation of the variance-covariance matrix. Then check whether there is a correlation between the models in Table 4. The correlation between the Percentage of Poor Population (Y1) and the Poverty Depth Index (Y2) and Poverty Severity Index (Y3) are 0.937 and 0.856, respectively. Meanwhile,

thecorrelation between the Poverty Depth Index (Y2) and the Poverty Severity Index (Y3) is 0.976. Significance shows that the correlation is significant with$Y2Y3Y2Y3\alpha$ = 0,05.

Table 4. Correlation Between Model Errors

Error	$Y1$		$Y2$		$Y3$	
	Mark	P-values	Mark	P-values	Mark	P-values
$Y1$	1		0.937	0.000	0.856	0.000
$Y2$	0.937	0.000	1		0.976	0.000
$Y3$	0.856	0.000	0.976	0.000	1	

Spatial aspect testing uses the Lagrange Multiplier test. Table 5 presents the LM SAR and LM SEM values for each1.5730 x 103; 0.5791. The significant LM test is found in the SUR-SAR model, namely at a P-value of 0.000 using α = 0.05. Therefore, the SUR-Spatial model that can be formed is SUR-SAR, which is the SUR model with the addition of spatial effects to the model. Estimation of the SUR - Spatial model for poverty data is carried out using the MLE method.The results of the parameter estimation of the SUR - Spatial model for the 2012 Poverty data in East Java Province can be seen in Table 6.

Table 5. Lagrange Multiplier Testing for Spatial SUR

Testing	Mark	p-values
LM test spatial lag	1,5730 × 103	0.0000
LM test spatial errors	0.5791	0.9012

Table 6. Parameter Estimation of the SUR-SAR Model

Variable	[Y1] Percentage of Poor Population		[Y2] Poverty Depth		[Y3] Poverty Severity	
	Coefficient	P-values	Coefficient	P-values	Coefficient	P-values
Cash	40.04		6,44		1.61	
$X1$	-1.645	0.0001	-0.320	0.0810	-0.090	0.0018
$X3$	-2.023	0.0000	-0.311	0.0205	-0.076	0.0001
MSE	0.4587		0.4790		0.5043	
R-Squared	0.5661		0.5469		0.5229	
Rho	0.4870		0.3860		0.2839	

Based on the modeling results in Table 6, it can be seen that the percentage of poor people (Y1) is affected by the GRDP growth rate at constant prices (X1) and the average length of schooling (X3) with a negative sign. Likewise, the Poverty Depth Index (Y2) and Poverty SeverityIndex (Y3) are also affected by the GDP growth rate at constant prices (X1), and the average length. In accordance with the results of parameter calculations in the SUR-SAR model for poverty data in Table 6, obtained from the Percentage of Poverty Depth Index, Poverty Population and Poverty Severity Index. Equation (9) shows that every increase in the GRDP growth rate at constant prices (X1) of 1 percent will reduce the poverty rate by 1.645 percent provided that other variables are constant. Likewise, an increase in the average length of schooling (X3) of 1 year will reduce the poverty rate by 2.023 percent. The Poverty Depth Index model based on Table 7 is as follows. Based on equation (10) it shows that every increase in the GRDP growth rate at constant prices (X1) of 1 percent will decrease the Poverty Depth Index by 0.320percentand the average length of schooling (X3) of 1 year will reduce the Poverty Depth Index by 0.311percent. Based on equation (11) it can be seen that each increase in the GRDP growth rate at constant prices (X1) of 1 percent will decrease the index by 0.090 percent and for the average length of schooling (X3) 1 year will decrease to an index of 0.076 percent.

$$\hat{y}_j = 40{,}04 + 0{,}4870\left(\sum_{k=1}^{38} W_{jk}y_{1k}\right) - 1{,}645X_1 - 2{,}023X_3 \quad (9)$$

$$\hat{y}_j = 6{,}44 + 0{,}3860 \left(\sum_{k=1}^{38} W_{jk} y_{2k}\right) - 0{,}320X_1 - 0{,}311X_3 \quad (10)$$

$$\hat{y}_j = 1{,}61 + 0{,}2839 \left(\sum_{k=1}^{38} W_{jk} y_{3k}\right) - 0{,}090X_1 - 0{,}076X_3 \quad (11)$$

The resulting model is a Spatial SUR model, where there is a relationship between one district or city and other districts or cities. For example, in this model, the percentage obtained for the Poor Population and Poverty Depth and Severity Index in Pacitan Regency are as:

$$\hat{y}_{1(Pacitan)} = 40{,}04 + 0{,}1623(y_{1(Ponorogo)} + y_{1(Trenggalek)} + y_{1(Magetan)}) + -1{,}645X_1 - 2{,}023X_3$$

$$\hat{y}_{2(Pacitan)} = 6{,}44 + 0{,}1289(y_{2(Ponorogo)} + y_{2(Trenggalek)} + y_{2(Magetan)}) + -0{,}320X_1 - 0{,}311X_3$$

$$\hat{y}_{3(Pacitan)} = 1{,}61 + 0{,}0946(y_{3(Ponorogo)} + y_{3(Trenggalek)} + y_{3(Magetan)}) - 0{,}090X_1 - 0{,}076X_3$$

The equation is the Percentage of Poor Population model for Pacitan District. In this model it is known that the percentage of poor people in Pacitan district is related to the percentage of poor people in Ponorogo, Trenggalek and Magetan districts of 0.1623, which means that every increase in the poor population around the Pacitan area (Ponorogo, Trenggalek and Magetan districts) is 1 percent, it will increase the poor population in Pacitan district by 0.1623 percent. The same goes for the equations, and $\hat{y}1(Pacitan)\hat{y}2(Pacitan)\hat{y}3(Pacitan)$. This section presents the results of the research as well as a comprehensive discussion. Results can be presented in the form of pictures, graphs, tables and others that make it easier for readers to understand [2], [5]. The discussion can be done in several sub-chapters.

4. CONCLUSION

All urban regencies in East Java province have a low percentage of poor population (HCI), depth index (PGI) and poverty severity (PSI), except for Probolinggo City. Meanwhile, districts in the Madura Islands are areas with high HCI, PGI, and PSI. The spatial model used in cases of poverty (HCI, PGI, and PSI) in East Java Province is the Seemingly Unrelated Regression-Spatial Autoregressive Model (SUR-SAR), due to the interrelationships between regions in East Java Regencies/Cities. The results of the SUR- SAR modeling show that the percentage of poor population is affected by the GRDP growth rate at constant prices and average length of school. Likewise, the assessment for the Depth Index and the assessment for Poverty Severity are influenced by the GRDP growth rate. In this study, the model used is the SUR-SAR model with cross-sectional data. Advice that can be given to future researchers is to use the Spatial SUR model with panel data, which, in addition to using cross-section data, also uses time series data.

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