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Modeling of Rice Production in Central Java Using Spatial Panel

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The purpose of this paper determine the factors that affect rice production in Central Java for period 2009 to 2014 were analyzed in order to meet the objectives of this study. This study using spatial panel with two processes, spatial lag model and spatial error model. The result show that the best model for modeling the data of rice production in Central Java is the spatial lag random effects panel, where *rho* was significant. Here the results show that we observe a strong positive spatial spillover effect for production among neighboring regions. In addition, harvested area and productivity in rice production play an important role. That is, the rice production in the region is influenced by its rice production in an adjacent area, as well as influenced by the area harvested and productivity of the region.
Keywords: Rice Production, Spatial Panel. Spatial Lag Model, Spatial Error Model

1. Introduction

One of the fundamental requirement for humans is food, food commodities have an important role for Indonesia. This is because the demographic structure continues to increase, Indonesia's population has increased every year. In addition, people's purchasing power continues to increase because of the demographic bonus. The population of Indonesia is growing rapidly, especially in big cities in Java. In 2012, Central Java province has a large population, amounting to 32.643.612 comprising of 16.273.976 males and 16.369.636 women.[1]

Based on Law in Republic of Indonesia No.18 of 2012 on food, planning, implementation, and oversight in the provision, affordability, compliance of food consumption and nutrition, as well as food safety by involving the government (central and local) and coordinated and integrated community.[2] Expectations of the law is to fulfill the consumption needs which constantly evolving over time, food supply efforts made by developing food production systems based on local characteristics and optimize the productive land in order to harvest area continues to grow.

Rice is one of the major food and basic commodities for the population of Central Java, even the government do the intervention directly with the commodity that is to determine the price of grain. The differences in geographical characteristics or phenomenon structures owned by the District and City such as the differences in the amount of production, the level of productivity, and the rice harvested area, can cause variations in each region. Moreover, it does not mean each of these regions are independent or not influenced one another. The geographical proximity and similar characteristics between regions, alleged there is an existence of spillover (relationship) between the regions.

One way to define the relationship between economic variables is by using spatial panel modeling, for observation of a unit is not enough to just do the observation of such units at the same time, but also to observe the characteristics of the unit at some period of time. So that, need to use a combination data between cross section data and time series, the combined of the data is called the data panel. There are several advantages using panel data, i.e. data is heterogeneous, more informative, varied, degrees of freedom is greater, more efficient, can avoid the problem of multicollinearity, excelled in studying the dynamic changes, its more can detect and measure the effects of which cannot be observed in pure cross section data and time series, and minimize bias.[3] Moreover, spatial panel models with time effects and fixed effect are more stable and can control heterogeneity and spatial autocorrelation than conventional panel models.[4, 5, 6]

This research was conducted with the approach of spatial regression models based on panel data, the data of regionally-based were most appropriate when using a spatial approach for a region that has the same characteristics allegedly interconnected and pay attention to the effects of time. The application of spatial panel data on rice production has been done include the analysis of spatial variability of climate change impacts on rice,[7] testing the impact of the average variable, and climate variability on rice production of *Aus*, *Aman*, and *Boro* in Bangladesh for the period 1972-2009[8], as well as testing differences in spatial and temporal variations of rice production in China and Brazil.[9]

2. Data and Spesifications Models

The data used in this research were the data obtained from the Statistics Indonesia (BPS) in Central Java for period 2009 to 2014 were analyzed in order to meet the objectives of this study. The values of rice production, harvested area and productivity for each city in Central Java used as research variable. Table 1 show Defining variables suspected to affect the value of rice production in Central Java province.

Table 1. Defining variables suspected to affect the value of rice production in Central Java province.

No	Variable	Indicator	Analysis unit	Data Source
	Endogen Variable			

No	Variable	Indicator	Analysis unit	Data Source
1	Rice Production (y)	Total production of rice for each district and city in Central Java	Ton	BPS
	ExogenousVariable			
2	Productivity (X1)	Rice productivity value for each district and city in Central Java	Ku/ha	BPS
3	Harvested Area (X2)	Rice harvest value for each district and city in Central Java	Million (Rp)	BPS

According to Elhorst's [10], there are two basic models of spatial panel data that used to show spatial correlation. The first model is a model of spatial lag model, this model has the following specifications:

$$y_{it} = \rho \sum_{j=1}^{N} W_{ij} y_{it} + \alpha + X_{it}\beta + \varepsilon_{it} \quad (1)$$

Where y_{it} is dependent variable on the ith region for the tth time period, ρ is the spatial autoregressive coefficient, $W_{ij}$is the spatial weighting matrix element, X_{it} is the predictor variables on the ith region for the tth time period, β is the slope coefficient, α is the intercept regression model, and ε_{it} is an error component in observation units to-i and time to-t.

The second model specification consists of the addition of spatial dependence in the error component called spatial panel error models. Spatial error model does not involve weighting matrix spatial lag of the response variable. Forms of spatial lag panel regression model on the error written by the following equation:

$$y_{it} = \alpha + X_{it}\beta + u_{it}$$

$$u_{it} = \lambda \sum_{j=1}^{N} W_{ij} u_{jt} + \varepsilon_{it} \quad (2)$$

where the u_{it} states spatial autocorrelation error and λ is the spatial autocorrelation coefficient.

Spatial panel models for the data of rice production proposed are 2 basic model of spatial panel on the top by following the Cobb-Douglas production function, as follows:

1). Model of Spatial Panel Lag

$$\ln \mathrm{y}_{\mathbf{it}} = {}^{\circ}\sum_{j=1}^{35} \mathbf{w}_{\mathbf{ij}} \ln \mathrm{y}_{\mathbf{jt}} + {}_{1} \ln \mathrm{X1}_{\mathbf{it}} + {}_{2} \ln \mathrm{X2}_{\mathbf{it}} + \mathbf{u}_{\mathbf{i}} + \pounds_{it} \quad (3)$$

2). Model of Spatial Panel Error

$$\ln y_{it} = \sim + {}_{1} \ln X_{1t} + {}_{2} \ln X_{2t} + u_{it}$$

$$u_{it} = {}^{\mathrm{a}}\sum_{j=1}^{N} W_{ij} u_{jt} + \pounds_{it} \quad (4)$$

3. Results and Discussion

Figure 1 show a visualization of the mapping of rice production in Central Java province in 2014. In rice production variables appear in groups as Grobogan is higher than neighboring area, as well as areas such as Brebes and Cilacap are likely to vary the value of rice production. Central region of Central Java province appeared in groups with production values that are only a few city which has a low production such as Tegal, Pekalongan, Semarang, Salatiga, Magelang and Surakarta because these areas do not have a land area large.

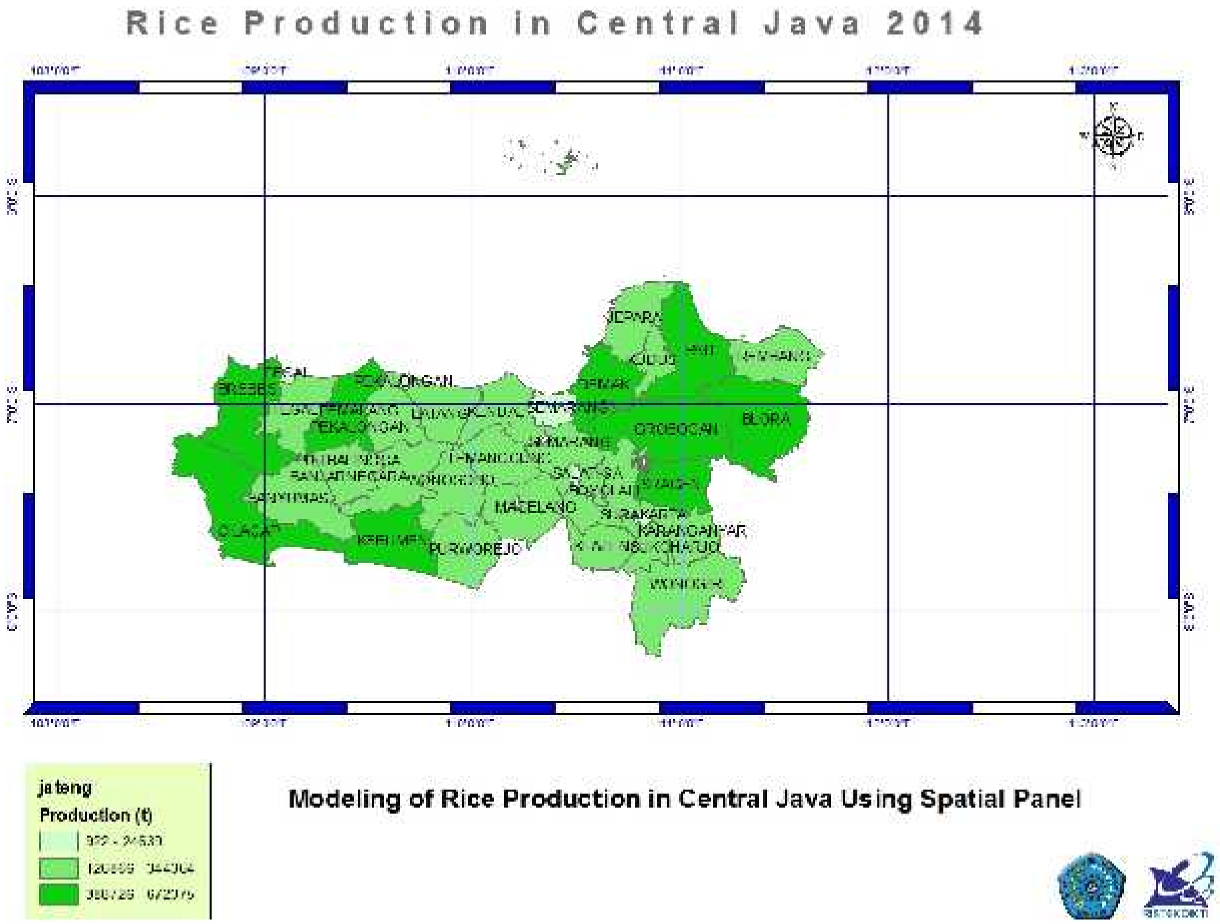

Figure 1. Rice production in Central Java 2014

To determine the best model of spatial panel, we estimated the model of spatial lag panel fixed effect model (SLM-FE), spatial lag panel random effect model (SLM-RE), spatial panel error fixed effect model (SEM-FE), and spatial panel error random effect model (SEM-RE). Table 2 show the results of the Hausman test showsed the *sig* was greater than 5 percent. In addition, strengthened with a *sig* spatial lagged *rho* which less than 5 percent, so that the model chosen was a SLM-RE model.

Table 2. Hausman test and the determination of spatial models

SEM-FE			**SEM-RE**		
Estimate	**Coef**	**Sig**	**Estimate**	**Coeft**	**Sig**
log(X1)	1.000	0.000	Constants	-2.30e+00	0.000
log(X2)	1.000	0.000	log(X1)	9.97e-01	0.000
lambda	0.01	0.924	log(X2)	9.99e-01	0.000
			lambda	1.44e-02	0,1797
SLM-FE			**SLM-RE**		
Estimate	**Coef**	**Sig**	**Estimate**	**Coeft**	**Sig**
log(X1)	1.000	0.000	Constants	-2.30e+00	0.000
log(X2)	1.000	0.000	log(X1)	1.000	0.000
rho	4.07e-05	0.942	log(X2)	9.99e-01	0.000
			rho	-3.27e-05	0,007
Hausman test		0.5059			

Source: Results of processing

Thus, it can be concluded that the result of estimation model of SLM-RE *rho* play an important role in modeling. Application of the random effect gives the interpretation that besides the spatial lag of dependent variable, there is a random effects variable derived from the cross section (region) that affect the production of rice in Central Java. Negative signs coefficient of *rho* indicated that rice production in the adjacent area have a negative effect on the surrounding area.In addition, variable of harvested area and productivity in rice production plays an important role with a significant level of 5 percent. That is, the rice production in the regionis influenced by the rice production in adjacent area, as well as influenced by the area harvested and productivity of the region.

4. Conclusion

Modeling of the data of rice production in Central Java, it can be concluded that, *rho* important role in modeling the spatial lag random effects panel. In addition, variable of harvested area and productivity in rice production plays an important role with a significant level of 5 percent. That is, the production of rice in a region affected by the rice production in adjacent area and influenced by the area harvested and productivity of the region.

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