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Testing the spatial auto-regression (SAR) model on Indonesia's regional economy

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Abstract: Indonesia's regional economy that is proxy by using Gross Regional Domestic Product (GRDP) per capita to form clusters is investigated. Besides, by using the Spatial Auto-regression (SAR) model, the effect of household consumption in a region to the surrounding area's economy is examined. The study on this topic is rather limited, especially in the regional economic development of the country. Furthermore, Indonesia is a heterogeneous country, and its consequence is that development policy should consider the geographic characteristics of the country. The results show that there are regional economy clusters in Java, Kalimantan, Sulawesi, and Sumatra. In contrast, household consumption in a region has a weak influence on the economy in the surrounding area.

Keywords: GRDP, Spatial, SAR, Spillover.

JEL Classification: C53, E27.

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1. INTRODUCTION

In the national economy, it is necessary to analyze the regional economy. One important thing is the disparity of the regional economy, and regional economic growth also affects the national economy. Determining policies to improve the economy should take geographical conditions and the similarity of characteristics between regions into consideration. Regional economic development is an integral part of national economic development, usually measured by the Gross Regional Domestic Product (GRDP) and the presence or absence of a regional spillover effect. In 2018 GDP per capita in all regencies in Indonesia ranged from IDR. 9435 (lowest) to IDR. 692243 (highest) (Statistics Indonesia, 2019). Most of GRDPs are clustered at a value under IDR. 100.000, but the closeness of regencies that have almost the same GRDP have not known geographically yet.

Some factors determine the regional economy, one of them is household spending. Household spending is the amount of final consumption expenditure made by resident households to meet their everyday needs, such as food, clothing, housing (rent), energy, transport, durable goods (notably cars), health costs, leisure, and miscellaneous services. It is typically around 60% of gross domestic product (GDP) and is, therefore, an essential variable for economic analysis of demand (Lequiller & Blades, 2014). Household consumption has quite a significant impact on determining the fluctuation of economic activity from time to time. The higher the quantity and quality of people's consumption, the more the production of goods and services to meet the demands of it. An individual's consumption is directly proportional to his/her income. The people's consumption in Indonesia continues to rise from year to year following the growth of the population, and so do the people's needs for goods and services (Rafiy, Adam, Bachmid, & Saenong, 2018).

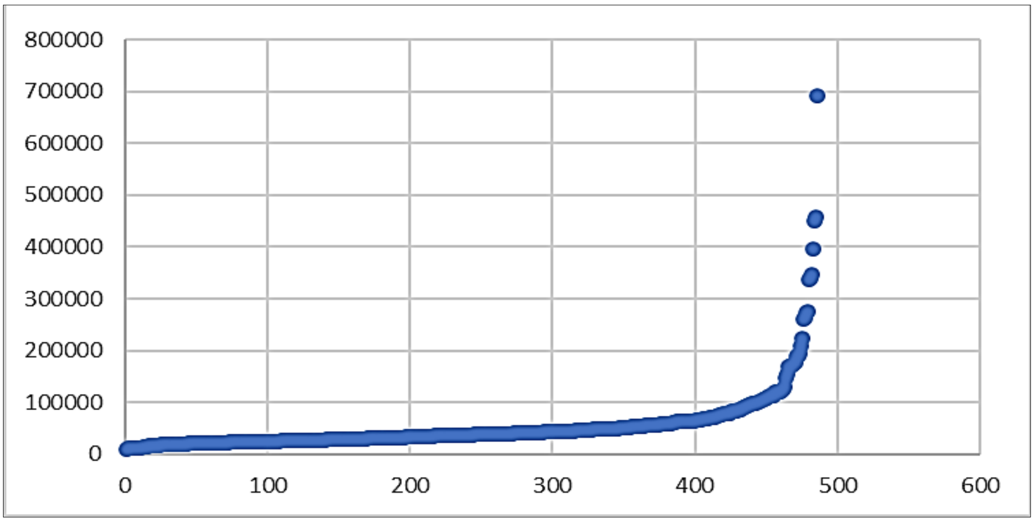

Figure 1. Scatter Plot of Regencies' GRDP in Indonesia 2018 (IDR)
Source: Data proceed, 2020

Various studies on regional economic modelling in Indonesia have been carried out by previous researchers. In his research, Funke & Niebuhr (2005) found spillover research and development between regions that have a positive effect on economic growth in areas that border each other. However, the strength of the spillover weakened as the distance between the regions increased. Then Rafiy et al. (2018) found that there are short-term and long-term effects of household consumption expenditure on economic growth in a region. Nevertheless, not examined how the influence of household consumption on the economy around the economic region. Lembang, Lessil, & Aulele (2017) grouped Indonesia's GRDP at the provincial level using cluster analysis. However, diversity is very high, even at the district level should deepen the cluster analysis to a level lower than the provincial level.

In order to complement the previous research, a spatial analysis was carried out that connected geographical conditions with the economic situation of the region with a narrower level, namely the district level. Spatial analysis is divided into three parts. First, GRDP clustering at the district level is carried out to get a picture of the similarity of district GRDP based on geographical location. Second, the effect of consumption spillover on the economy between districts in Indonesia is examined in its entirety. Third, the effect of consumption spillover on the economy between districts in Indonesia is examined by the island. It is expected that the results of this study can provide a picture of the state of the regional economy from a geographical point of view so that it can be used as a material consideration when making policies relating to regional-based economics. In addition, due to the limitations of the spatial variables observed in this study, it is hoped that further research can develop this spatial model by adding observational variables to obtain a model that better accommodates spatial economic phenomena.

2. LITERATURE REVIEW

Fifty years ago, the geographer and statistician Waldo Tobler formulated the first law of geography: "Everything is related to everything else, but near things are more related than distant things" (Tobler, 1970). This "law" defines the statistical concept of (positive) spatial autocorrelation, according to which two or more objects that are spatially close tend to be more similar to each other –concerning a given attribute Y – than are spatially distant objects. In general, spatial autocorrelation implies spatial clustering, i.e., the existence of sub-areas of the study area where the attribute of interest Y takes higher than average values (hot spots) or lower than average values (cold spots).

Research related to the clustering proliferated during the last decade. Lots of angles can be obtained by digging the topic of and cluster analysis. Furthermore, clusters have become a key focus of discussion and analysis in contemporary debates on urban and regional economic development (Feldman, 1999; Porter, 1990; Setyaningsih, 2012).

The cluster analysis conducted by Lembang, Lessil, & Aulele (2017) on 33 provinces in Indonesia found that the cluster formed into 3 clusters. In detail, cluster 1 of lower GRDP consisting of Sumatera, Kalimantan, Sulawesi, Nusa Tenggara, Bali, Papua, Maluku, and Central Java, D.I. Yogyakarta, and Banten. Cluster 2 of middle GRDP consisting of 1 province of DKI Jakarta and cluster 3 of higher GRDP, which consists of 2 provinces, namely West Java and East Java. However, the study does not elaborate on the clusters at the regency level.

Spatial econometrics relies on the spatial weights matrix to specify the cross-sectional dependence; however, the candidate spatial weights matrices might not be unique (Zhang & Yu, 2018). Typically, the degree of spatial proximity among a given set of N spatial objects is represented by a $N \times N$ matrix called spatial weights matrix and denoted by W. Each element (i, j) of W – which we denote by w_{ij}– expresses the degree of spatial proximity between the pair of objects i and j. Depending on the application, the N main diagonal elements of W are assigned value $w_{ii} = 0$ or value $w_{ii} > 0$. A common variant of W is the row-standardized spatial weights matrix $\mathbf{W}_{std}$, whose elements are defined as follows:

$$\mathbf{W}_{ij}^{std} = \frac{w_{ij}}{\sum_{j=1}^{N} w_{ij}} \tag{1}$$

A local index of spatial autocorrelation expresses, for each region *ri* of a given study area A, the degree of similarity between that region and its neighboring regions with respect to a numeric variable Y (Pfeiffer et al., 2008). Since global indices of spatial autocorrelation summarize the phenomenon of interest in a single value, they are intended not to identify specific spatial clusters, but to detect the presence of a general tendency to cluster within the study area.

In general, the computation of a global index of spatial autocorrelation follows a three-step procedure. First, we compute the degree of similarity ρ_{ij} between every possible pair or regions r_i and r_j with respect to the numeric variable of interest Y. Second, we weight – i.e., multiply – each value ρ_{ij} by the degree of proximity w_{ij} between regions r_i and r_j. Finally, we sum up all the products $w_{ij}\rho_{ij}$ and divide the total by a constant of proportionality. The greater the number of regions with have similar, with respect to Y and spatially close, the greater the value taken by the global index of spatial autocorrelation.

The paper analyses spatial interaction is utilizing a potential measure. The applied measure approximates spatial interaction, assuming that accessibility and the degree of interaction among people decline with increasing geographical distance. The potential measure reflects the intensity of spatial interaction among individuals within a region as well as the possible interaction with agents in neighboring areas. Finally, we will explore the existence of spatial autocorrelation between Indonesia's regional economies (are there economy clusters in regency areas in Indonesia?). Besides, it will be examined whether household consumption in one region affect the economy in the surrounding area (is there a spillover effect between economy regions?).

3. MATERIALS AND METHODS

This paper uses exploratory spatial data analysis (ESDA). ESDA is a set of techniques that have ability to (i) describe and visualize spatial distributions, (ii) discover patterns of spatial association (spatial clustering or hot spots), (iii) identify typical observations (outliers), and (iv) suggest different spatial regimes or other forms of spatial heterogeneity (Anselin, 1996, 1999; Yandell & Anselin, 1990). Central to ESDA is the measure of global and local spatial autocorrelation. The measure of global spatial autocorrelation is usually based on Moran's I statistic, expressed as:

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

Moran's global index I of spatial autocorrelation (Moran, 1948) defines ρij as ρ_{ij} = $(y_i - \bar{y})(y_j - \bar{y})$, where y_i is the value taken by Y in region r_i, y_j is the value taken by Y in region r_j. Under the null hypothesis of no global spatial auto- correlation, the expected value of I is $E(I) = -\frac{1}{N-1}$. $I > E(I)$ indicates positive spatial autocorrelation – nearby regions tend to exhibit similar values of Y. $I < E(I)$ indicates negative spatial autocorrelation – nearby regions tend to exhibit dissimilar values of Y. Positive spatial autocorrelation occurs if the Moran index approaches +1. Negative spatial autocorrelation occurs if in the Moran index approaches -1.

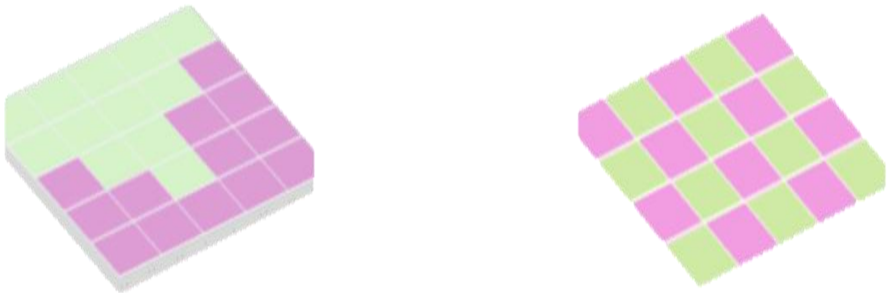

Figure 2. In positive autocorrelation, similar data are clustered together (left), while in a negative autocorrelation, similar data are separated (right).
Source: Data proceed, 2020

This study uses GRDP per capita of regencies and municipalities in Indonesia to illustrate the regional economic condition. To proxy household consumption, household expenditure on food, and non-food of every regency in 2018 is used. All data were retrieved from Statistics Indonesia.

3.1. The specification of model

The linear model for GRDP per capita in regency i ($pdrb_i$) as a function of consumption expenditure is written as:

$$pdrb_i = \beta_0 + \beta_i Consumption_i + \epsilon_i \tag{3}$$

To show that $pdrb_i$ might be influenced by $consumption_j$, additional notation is needed (Badinger & Egger, 2011). For example, $W_{i,j}$ is positive if regency i is neighboring regency to j, and 0 if it is not a neighbor or if $i = j$. Based on this notation, the Spatial Autoregressive (SAR) model is arranged as follows:

$$pdrb_i = \gamma_i \sum_{j=1}^{N} W_{i,j}\, pdrb_j + \beta_i consumption_i + \beta_0 + \epsilon_i \tag{4}$$

Where: $W_{i,j}$ is proximity between regency i and regency to j; $\sum_{j=1}^{N} W_{i,j}\, pdrb_j$ is spatial lag, weighted sum of GRDP per capita of all regencies around regency i; $consumption_i$ household food and non-food consumption expenditure in regency i.

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4. RESULTS AND DISCUSSION

4.1. Estat Moran results for GRDP per capita on National Level

The Null Hypothesis for Moran test for spatial dependence is that error is *i.i.d* (every residual is independent and identically distributed. From estimation on Table. 1 the null hypothesis can be rejected which means that there is cluster(s).

Table 1. Estat Moran results for GRDP per capita on National level

Chi2	Prob > chi	H_0	Cluster(s)
93.46	0.0000	Reject	Exist

Source: Data proceed, 2020

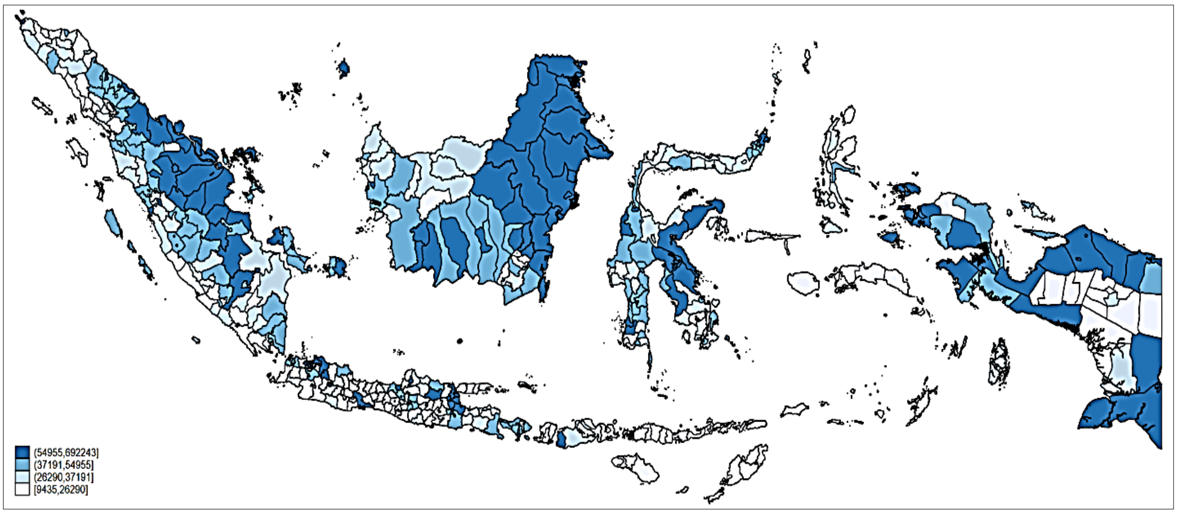

Figure 3. Clusters of GRDP per Capita on National Level
Source: Data proceed, 2020

On the national level, based on the figure 3 it seems that GRDP per capita are spatially interconnected because high GRDP per capita forms clusters. However, if analyzed by the islands, the clusters will not form on all islands. Furthermore, the Moran analysis could proceed into the island level.

4.2. Estat Moran results for GRDP per capita on Island(s) level

The results of Moran index calculation in the Table 2, the result show that high GRDP per capita clusters occurred in Java, Kalimantan, Sulawesi, and Sumatra. Whereas on the islands of Bali, Maluku, NTB, NTT, and Papua, there are no clusters of GRDP per capita. When the Moran test is conducted on districts within the same island or archipelago, the results obtained will vary.

Table 2 shows that districts on large islands such as Java, Sumatra, Kalimantan, Sulawesi and Sumatra tend to form GRDP clusters. This is because interdependence between regencies on the same land is higher than regencies that are separated by water. So that economic activities such as migration, consumption and trade between regencies are more accessible and affect the economic situation in the regency concerned. This situation causes districts with good economies to tend to gather in adjacent areas (Armstrong & Taylor, 2000). Meanwhile, districts on the island of Papua do not form clusters due to low interdependency between districts even though they are directly bordered by land. The impact of low interdependence causes the economy of a district not to have a positive influence on the economy of other districts around it.

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Table 2. Estat Moran results for GRDP per capita on Island(s) level

No.	Island	Chi2	Prob>chi	H_0	Cluster(s)
1	Bali	0.09	0.7686	Accept	Not Exist
2	Java	25.89	0.0000	Reject	Exist
3	Kalimantan	42.15	0.0000	Reject	Exist
4	Maluku	0.01	0.9036	Accept	Not Exist
5	NTB	0.06	0.8017	Accept	Not Exist
6	NTT	0.03	0.8561	Accept	Not Exist
7	Papua	1.56	0.2113	Accept	Not Exist
8	Sulawesi	4.50	0.0339	Reject	Exist
9	Sumatera	29.04	0.0000	Reject	Exist

Source: Data proceed, 2020

4.3. Spatial Auto-regression results on National level

GRDP from all regencies is analyzed simultaneously to estimate the spillover effect generated by the consumption variable.

Table 3. Spatial auto-regression results on National level

Wald chi^2 (2)	Prob>chi^2 (2)	Pseudo R^2	chi^2 (1)	Prob>chi^2 (1)	Direct Impact of Consumption	Indirect Impact of Consumption
89.88	0.0000	0.1549	0.06	0.8111	0.06259	0.0011444

Source: Data proceed, 2020

The Spatial auto-regression estimation results in table 3 show that at the national level, household consumption in a district affects the economy of the district concerned (Prob > Chi^2 (2) = 0.0000). However, this consumption did not have a significant spillover effect (Prob > chi^2 (1) = 0.8111) on the economy of the surrounding districts. However, the magnitude of the variable consumption to GDRP can be seen from the value of direct impact and indirect impact of consumption (LeSage & Pace, 2009). Based on Direct Impact of Consumption, every 1% increase in household consumption in a district will increase 0.06% of the economy in the area regardless of the spillover effect whereas every 1% increase in consumption in one district will increase the economy of other districts that have regional interdependence with the district by 0.001%. Seeing the magnitude of the effect of spill overconsumption that is not too large, it is possible that the more significant spillover effect between districts is generated by factors other than household consumption, for example, research and development (Funke & Niebuhr, 2005).

Figure 4 gives a visualization of the results of the spatial auto-regression based on table 3 above. To simulate the spillover effect in the model, suppose there is a 10% increase in household consumption in Malang district. The increase in consumption affected the economy in Malang Regency (the color turned dark blue). However, economic changes in Malang district cannot change the economy in other districts around Malang (the colour remains light blue). This visualization shows that an increase in consumption in Malang regency can change the economy in the regency, but is unable to change the economy of the surrounding regency.

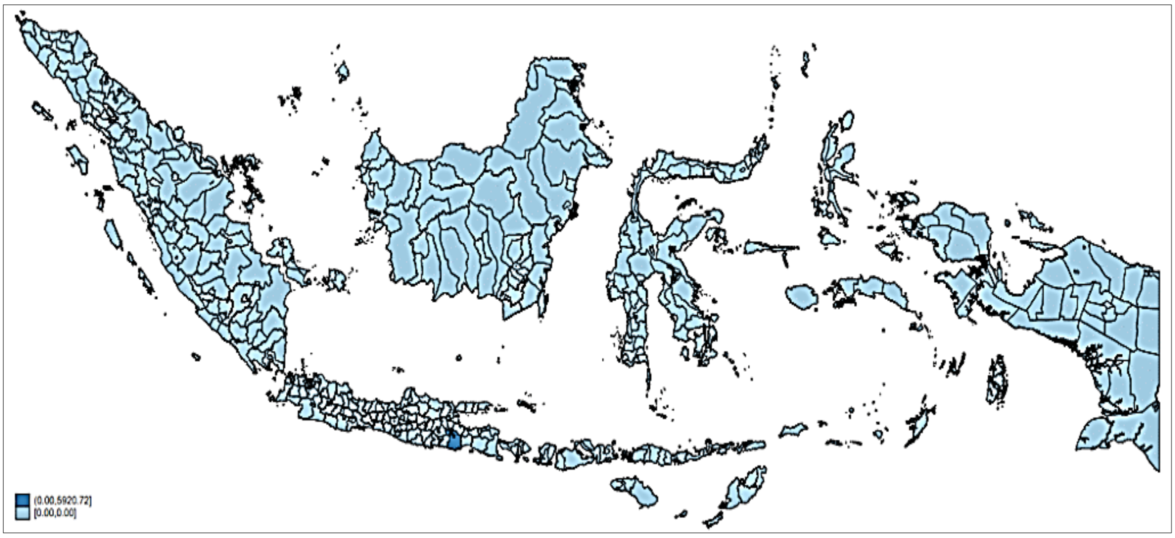

Figure 4. Spillover of Malang regency's GRDP to surrounding regency's GRDP
Source: Data proceed, 2020

4.3. Spatial auto-regression results on Island(s) level

The results of the SAR analysis using GS2SLS on each Island, as shown in table 2 indicate that the consumption in a regency has no significant effect on the GRDP in the surrounding regencies. This does not mean that the household consumption has no effect at all, but that the effect may be limited to the nearest regencies. In other words, the GRDP spillover of one regency against another GRDP is very weak and limited. This result is in line with Funke & Niebuhr. They find that spatial spillover decreases rather quickly with distance. Their paper also confirms the hypothesis about the geographical extent knowledge spillover is bounded (Funke & Niebuhr, 2005). There is supplementary empirical evidence that demand linkages in Germany are strongly localized, and the effects of local demand shocks on wages are geographically rather limited (Brakman, Garretsen, & Schramm, 2000). To show this, a simulation was conducted to show how strong and far the spillover of one regency's GRDP was against another regency's GRDP with the following visualizations.

Table 2. Spatial auto-regression results on Island(s) level

No.	Island	Wald chi^2 (2)	Prob > chi^2 (2)	chi^2 (1)	Prob>chi^2 (1)	Direct Impact of Consumption	Indirect Impact of Consumption
1	Bali	9.39	0.0091	0.51	0.4756	0.0276427	0.0049538
2	Java	44.03	0.0000	0.04	0.8344	0.1107312	0.0041025
3	Kalimantan	27.35	0.0000	3.40	0.0654	0.1030365	0.0487669
4	Maluku	14.56	0.0007	0.89	0.3442	0 .0155946	-0.0009110
5	NTB	3.50	0.1739	0.12	0.7337	0.0624518	0.0150169
6	NTT	66.23	0.0000	0.66	0.4175	0.0446124	-0.0033220
7	Papua	12.94	0.0015	2.37	0.1239	0.1974204	-0.6305600
8	Sulawesi	26.76	0.0000	1.51	0.2193	0.0533216	0.0069930
9	Sumatera	6.03	0.0491	3.94	0.0473	0.0068243	-0.0014790

Source: Data proceed, 2020

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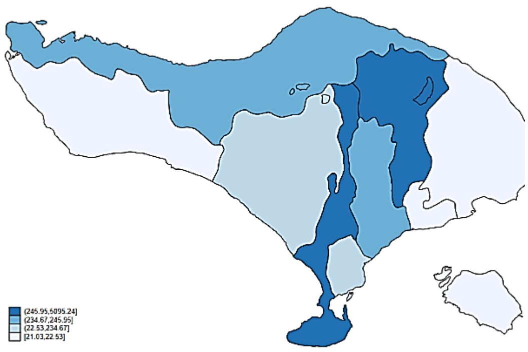

Figure 5. Spillover effect on Bali if Badung Regency's Household Consumption is raised by 10%
Source: Data proceed, 2020

Figure 6. Spillover effect on Java if Malang Regency's Household Consumption is raised by 10%
Source: Data proceed, 2020

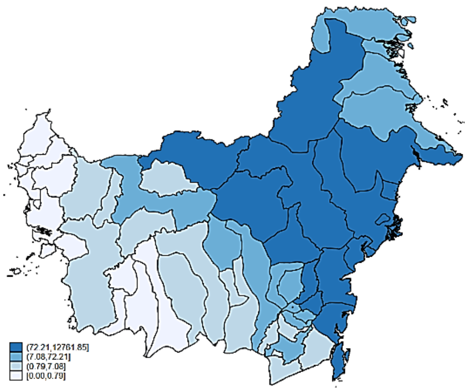

Figure 7. Spillover effect on Kalimantan if Penajam Paser Utara Regency's Household Consumption is raised by 10%
Source: Data proceed, 2020

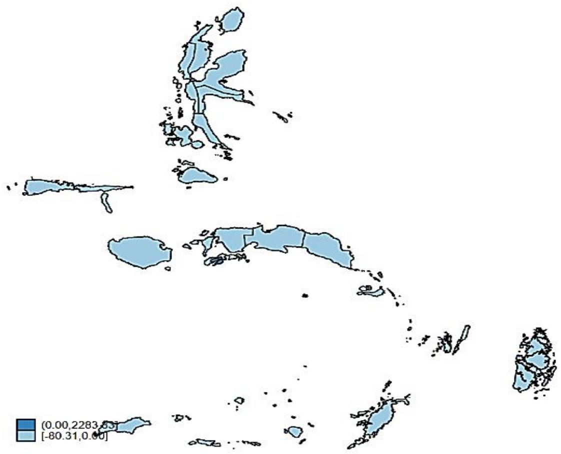

Figure 8. Spillover effect on Maluku if Ambon Municipality's Household Consumption is raised by 10%
Source: Data proceed, 2020

Figure 9. Spillover effect on NTB if Bima Municipality's Household Consumption is raised by 10%
Source: Data proceed, 2020

Figure 10. Spillover effect on NTT if Kupang Municipality's Household Consumption is raised by 10%
Source: Data proceed, 2020

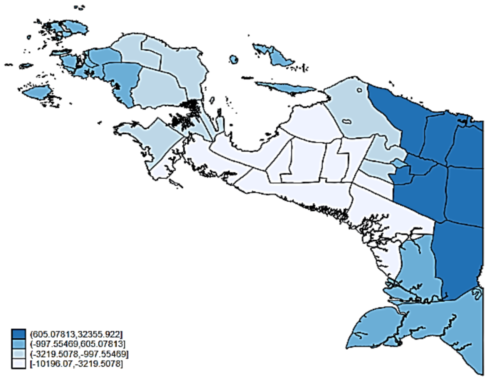

Figure 11. Spillover effect on Papua if Jayapura Municipality's Household Consumption is raised by 10%
Source: Data proceed, 2020

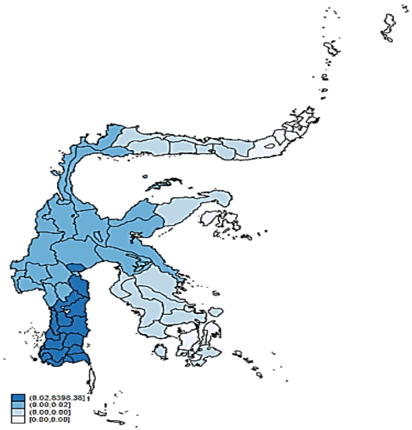

Figure 12. Spillover effect on Sulawesi if Makassar Municipality's Household Consumption is raised by 10%
Source: Data proceed, 2020

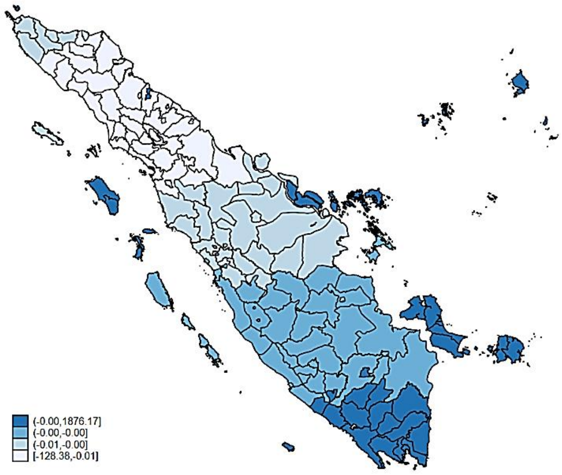

Figure. 13. Spillover effect on Sumatera if Medan Municipality's Household Consumption is raised by 10%
Source: Data proceed, 2020

Figures 5-13 explain about spillover effect in each sample if there are any increasing in household consumption. Based on the figures, Bali, Java, Kalimantan, NTB, and Sulawesi have a positive indirect impact of consumption value. This causes household consumption in one district on the five islands to affect the economy of another district positively, albeit with different magnitudes. Increasing household consumption by 10% in one district on the islands of Java and Kalimantan and Sulawesi can produce a substantial spillover effect on the surrounding area (Figure 6, 7, & 12). This is because the total value of indirect and direct impacts of the three islands is relatively large, so the influence of consumption internally and to other districts is relatively significant. It is different compared to the islands of Bali and NTB, which have a positive spillover effect but with lower magnitude (Figure 5 & 9).

In the Maluku Islands, NTT, and Papua the value of indirect impact is negative so that household consumption in the districts on the three islands hurts the surrounding districts. However, the value of direct impact is far higher than the value of indirect impact so that the negative spillover effect is minimal in magnitude (except Papua). When the simulation is done by increasing the consumption

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of one of the districts on the two islands, the spillover is not visually visible (figures 8 and 10). This result was obtained because in the two islands many districts were separated by waters so that they had relatively low interdependence geographically. On the island of Sumatra, the simulation provided a quite high negative spillover effect (figure 11). By increasing 10% of consumption in one regency in Sumatra, the surrounding economy has declined (white color). Whereas the regency, which is farther away, has a better economic condition (dark blue). This happens because most of Sumatra is landlocked, so interdependencies among regencies are high.

Statistically, interdependencies between regions that cause differences in magnitude and direction of the spillover effect are caused by the weighting of the matrix W in the model. Areas that are directly bordered and not separated by waters will get a higher weight than areas that are not directly bordered or separated by waters. Therefore, in the visualization above, the spillover effect between districts on land-dominated islands is more reliable than between districts in the form of islands.

According to Armstrong & Taylor (2000), economies between regions can be influenced by inter-regional trade caused by specialization of a region. This can be supported by the availability of transportation infrastructure and easy access to distribute raw, intermediate or finished goods. This condition is following the conditions in Java, Kalimantan, Sulawesi and Sumatra. The interdependence between these regions on the island is quite high. On the other hand, on the islands of Papua, the Maluku islands, NTB and NTT the geographical conditions consisting of hills, the amount of water, the lack of transportation infrastructure and the low specialization among regions caused interdependence between districts in the four islands is relatively lower.

5. CONCLUSIONS

This paper attempts to investigate the existence of GRDP clusters that might illustrate the similarity of economic conditions among regions. Moran Index is employed using the Stata software package on the national level and island level to see the different outcomes when the scope of analysis is limited. Besides, by forming a spatial autoregressive model that utilizes spatial lag of surrounding GRDPs, the existence of GRDP spillover that might be generated by household consumption is investigated.

There are some conclusions from this study. First, the clusters of GRDPs formed by particular regencies in some island shows that some similar characteristics exist between those regions in the cluster. In order to boost the economy of regencies that happen to be in the same cluster, the same policies are imposed. This makes sense because similar policies might work in regions with similar features. Second, the regencies belong to the same cluster could improve their engagement on cooperation to promote a better regional economy. Because neighboring regencies that score very different GRDPS could be experiencing competition between them, or there could be policies that disadvantage the surrounding regencies. This matter needs further investigation. Regencies in the same cluster may have less strong restrictions that make products dan factors move faster between regencies; that is why the economic conditions in those regencies are almost similar (Bai, Ma, & Pan, 2012; Poncet, 2005).

Based on the results of SAR estimation, household consumption affects the neighboring regional GRDP despite its limited influence. If the spatial analysis is limited on the Island of Java (figure 8), it can be seen that increasing household consumption by 10% in Malang regency, will strongly influence the value of GRDP in all regencies in East Java Province. However, this influence has slowly declined in the districts in the Central Java province. In the end, the influence was feeble in the regencies in the provinces of West Java and DKI Jakarta, which were located even farther away. This shows that the spillover effect does decrease with increasing distance (Funke & Niebuhr, 2005). To increase the spillover effect, the connectivity between distant regencies must be improved. For instance, by building transportation infrastructure or reducing interregional trade restrictions such as lowering local taxes, it would increase inter-regional trade (Armstrong & Taylor, 2000; Rum, 2011).

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