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**COVID-19 pandemic and spatial growth spillovers in Indonesia:**

**A spatial econometric approach**

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**Abstract**

*The unprecedented global COVID-19 pandemic has led to economic slowdown in many countries, including Indonesia. By using economic growth data at the province level, this paper investigates the spatial structure and spatial spillover effects of Indonesian regional economic growth during two different periods; pre-pandemic and in the pandemic period. In doing so, we first define a spatial connectivity structure across provinces before formally implement the appropriate spatial econometric model. Our results reveal two appealing findings. First, there is significant spatial spillovers of provincial economic growth in the pre-pandemic period as opposed to non-significant spatial effect in the pandemic period. This is consistent with the spatial autocorrelation test of economic growth in both periods. Second, there is indication that the catching-up process (convergence) has occurred only in the pre-pandemic period.*

Keywords COVID-19 · pandemic · regional · Indonesia

JEL Classifications C21 · O47 · R10 · R11

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**Introduction**

Initially detected in Wuhan, China in December 2019, the outbreak of novel coronavirus COVID-19 has attracted worldwide attention. According to World Health Organization (WHO), the first detected case outside of China was reported in Thailand on 13 January 2020 (WHO, 2020a). Thereafter, the number of infected people around the world started to show an explosive trend. Referring to the Situation Report of WHO, by the end of January 2020, the disease had infected 9,826 people globally, where 106 people were situated in 19 countries outside China (WHO, 2020b). By the end of June 2020, the same report had announced more than 10 million confirmed cases and more than 500,000 deaths (WHO, 2020c).

To limit the massive spread of the virus, more than 100 countries worldwide had implemented lockdown by the end of March 2020, either a full or partial lockdown (BBC, 2020). As lockdown policy massively instituted around the world, people’s activities had been greatly reduced, including economic and business. Several ideas explain how the pandemic may affect economic activities. A report from Asian Development Bank (ADB, 2020) mentions that COVID-19 outbreak will negatively affect economic activity via multiple channels: a sharp decline in domestic consumption, and possibly investment if views on future business activity is affected; shrinking in tourism and business travel; cross-sector and cross-country spillovers from slowing demand through trade and production linkages; supply-side disruptions to production and trade; and effects on health such as increased disease and mortality as well as shifts in health care spending.

Economists acknowledge these multiple channels of how COVID-19 pandemic reduce economic activities as so-called ‘supply’ and ‘demand’ shocks (Baldwin and Weder di Mauro, 2020). Hausmann (2020) argues the economic impact of COVID-19 is mainly in the forms of negative supply shock stemming from reduction in production capacity. When workers are infected, firms have to limit the contact between workers and if needed, stop the production temporarily. Inoue and Todo (2020) estimate that shutting down firms in Tokyo would result in an 86% reduction in output throughout Japan within one month. If the situation lasts for more than what expected, the supply shock would most likely lead to a demand shock (del Rio-Chanona et al., 2020; Guerrieri et al., 2020). On the other hand, the implementation of mitigation measures such as social distancing by governments and public health authorities in many countries has also led consumers to reduce their consumption, in particular on various services involving frequent physical contact such as restaurants, airlines, and tourism. As the workers in these sectors face significant income reduction due to lower sales, their spending on other goods and services would also decrease, leading to a shrinking in demand for goods and services across many economic sectors (Gourinchas, 2020). Furthermore, the pandemic has also increased uncertainty on future economic prospects. This eventually causes greater negative demand shock stemming from diminished consumption on durable goods and investment.

Since the pandemic is happening across the globe these‘supply’ and ‘demand’ shocks shall put the globalyat risksince the negative economic impact of the pandemic is spreading Taking into account these potential devastating impacts of COVID-19 on economy, in its World Economic Outlook (WEO) Update, June 2020, the International Monetary Fund (IMF, 2020) mentions that global growth in 2020 is projected at –4.9%, 1.9 percentage points below its April forecast, indicating that the pandemic has had a more negative impact on activity in the first half of 2020 than anticipated.

In Indonesia, the first COVID-19 infection was identified and announced in early March 2020. As of 1 July 2020, the number of confirmed infected people in the country had reached close to 57,770, with 2,934 deaths (WHO 2020d). Worse still, it is predicted that total confirmed deaths in Indonesia by 1 November 2020 would reach more than 12,800 (covid19-projections.com 2020). Like elsewhere in the world, the economic impact of COVID-19 in Indonesia is significant. The government’s latest 2020 Gross Domestic Product (GDP) forecast is a range between 1.1% contraction to 0.2% growth, down from 2019’s 5% expansion, due to the fallout of the coronavirus pandemic (https://jp.reuters.com/article/indonesia-politics-economy-gdp-idUSJ9N2C2033). A double hit scenario proposed by the OECD (OECD 2020) projects that the Indonesian economic growth rate could contract to –3.8%.

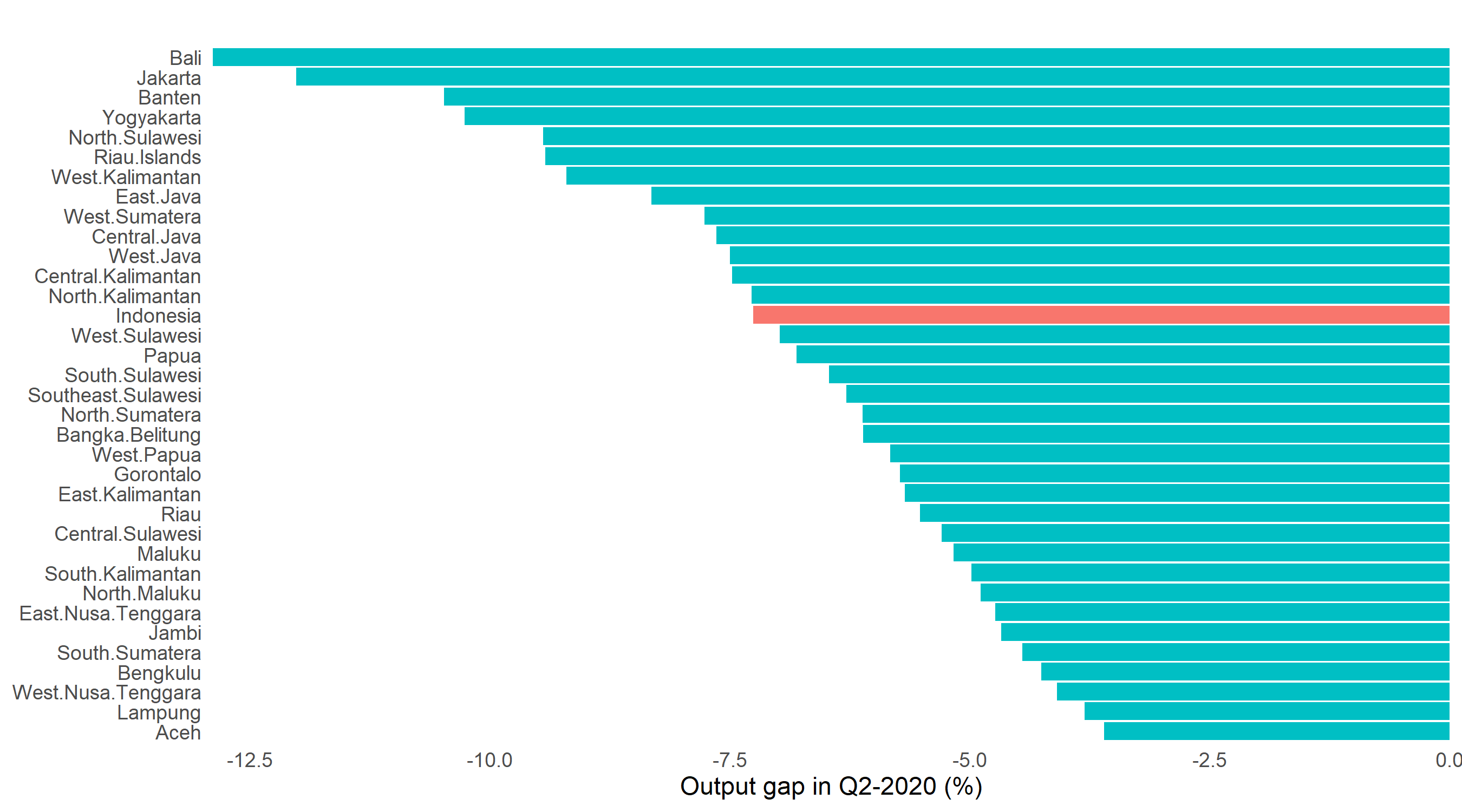


Figure 1. Output gap by province, 2020:Q2

The slowing economic activities in Indonesia has been reflected in the 2020 first semester economic performance. Figure 1 shows the impact of COVID-19 outbreak on national and regional GDP in Indonesia during 2020:Q2 measured in output gap.[[1]](#footnote-1) At the national level, the pandemic had trimmed economic capacity by around 7.5% (see the red colored bar in Figure 1). In other words, under the implementation of large-scale social restrictions policy (Pembatasan Sosial Berskala Besar - PSBB) in many regions, the nation’s economy operated around 92.5% of its capacity. At the provincial level, although vary in magnitude, all provinces exhibited negative output gap, reflecting the depletion in economic capacity. Tourism and services driven regions like Bali, Jakarta and Banten are provinces with the highest negative output gap (see the first three top bars in Figure 1).

Analyzing regional growth dynamics across Indonesian provinces by incorporating the impacts of COVID-19 pandemic is relevant due to the unique feature embedded in the country’s regional growth experience. On one hand, as shown in Figure 1, the impacts of COVID-19 on provincial economic performance are different in magnitude owing to heterogeneity in socio-economic structures across provinces. On the other hand, according to the evidence that has been documented by some researchers, spatial spillover effect plays important role in affecting regional economic outcomes (McCulloch and Sjahrir, 2008; Suphannachart and Resosudarmo, 2009; Day and Lewis, 2013).

Departing from the background discussed above, this paper attempts to analyze how the pandemic affects spatial spillover effects of economic growth across Indonesian provinces. In the absence of adequate number of similar studies available so far, the facts and results revealed in this paper would help to bring new insights in understanding how the spread of COVID-19 affects regional economic growth in Indonesia when the geographical proximity between provinces is accounted for.

**LITERATURE REVIEW**

Indonesia consists of hundreds of ethnic groups with many different cultures and religious beliefs spreading throughout the world’s largest archipelago. Its multidimensional diversity across regions makes Indonesia as one of countries that is attractive for applying spatial analysis. In economic field, analysis using spatial analysis is of particular relevant for Indonesia given its heterogeneity in regional economic structure and regional data availability (Islam and Khan, 1986). This section exposes previous literature that emphasize the role of spatial spillover effect and regional heterogeneity in Indonesia’s regional growth dynamics.

A collection of studies has been implemented to estimate the spillover effects of economic performance across regions in Indonesia. By exploiting a large district-level dataset covering education, population, cultural, economic, and infrastructure variables, McCulloch and Sjahrir (2008) attempt to explain the spatial factor that affect growth when controlling for other variables. Their findings suggest that spatial spillover matters in regional growth dynamics, that is, districts surrounded by the fast-growing neighbors tend to grow faster. Another study is conducted by Suphannachart and Resosudarmo (2009) to analyze the spatial spillover in poverty incidence in Sumatra. Their estimation results present two appealing outcomes; *first,* the poverty incidence in Sumatra is spatially dependent, and *second*, the spatial spillover from neighboring regions is prevalent, that is, the poverty in a district is influenced by the poverty incidence in the neighboring districts. The study of Day and Lewis (2013) also shows the evidence of spatial spillover effects across Indonesian districts. Instead of focusing merely on growth spillover, they analyze spatial spillovers of several different factors that contribute to economic development. Their findings suggest that, in addition to income, the influence of neighbors also includes demographics, human capital and infrastructure component of economic development.

Several authors have also analyzed the impacts of economic shocks on regional economy in Indonesia by highlighting the role of regional heterogeneity. Ridhwan and Bary (2018) develop structural macroeconomic models for 32 provinces to estimate the regional impacts of four types of shocks, both from domestic and external sources: credit volumes, administered price inflation, world output and exchange rate. Their findings show systematic differential responses to the common shocks on both provincial output and inflation. They further point out that provinces in Java island appear to be more resilient relative to the off-Java regions, thanks to its more developed and diversified economy. With respect to policy shock, Ridhwan et al (2014) and Wijoseno (2016) apply Vector Autoregression (VAR) framework and show evidence in asymmetric effect of uniform change in monetary policy rate on provincial output. Their further investigation reveals that province’s economic structure such as bank loans and deposits, share of manufacturing in regional output, firm size, trade openness, and housing prices appear to be the determinants of differential reginal effects of monetary policy, consistent with the theoretical foundation of monetary policy transmission.

**THE PANDEMIC AND REGIONAL ECONOMIC GROWTH IN Q2-2020**

Before formally analyzing the impacts of COVID-19 cases on regional economic growth, it is necessary to document some recent development on the number of COVID-19 cases and economic indicators across Indonesian provinces. In Figure 2 we present the charts of COVID-19 cases and the selected economic variables across provinces in 2020:Q2. This is useful to understand how the pandemic affects economic activities contemporaneously. Panel (a) plots the change in number of COVID-19 cumulative cases (per 100,000 population) from March to June 2020. The highest increase of number of cases is recorded in Jakarta, the capital of Indonesia (100.3), followed by South Kalimantan (72.9), and North Maluku (56.85), while Aceh province records the lowest increase in number of cases per 100,000 population (we computed the change in number of COVID-19 cumulative cases based on the daily data available at https:// kawalCOVID19.id.).

As seen in panel (b), most of provinces (32 out of 34) recorded negative growth in 2020:Q2 (yoy, %), where provinces in Java-Bali region are the worst performers. The economic growth of Bali, Jakarta, Banten provinces are -10.98%, -8.22%, and -7.4% (year-on-year) respectively. On the other hand, two easternmost provinces, West Papua and Papua, were able to maintain positive economic growth of 0.53% and 4.52% respectively. We also utilize the COVID-19 Community Mobility Index from Google to capture the effects of pandemic on people mobility. From panel (c), one may observe that Bali, Maluku and Jakarta are the provinces where mobility reduced the most relative to the baseline.[[2]](#footnote-2) We also document the number of people who lose their jobs as the impacts of COVID-19 pandemic, plotted in panel (d). Similar to the impacts on economic growth, provinces in the Java region report the highest number of people who had lost their jobs due to pandemic. West Java province suffers the most with around 340,000 people reporting lost their jobs from March to June 2020. Next, Jakarta, Central Java and East Java are the other provinces that record high numbers of jobs losses during the same period (we received the data from the Ministry of Manpower).

|  |
| --- |
| (a) Change in number of cases |
| (b) GDP growth in Q2-2020 |
| (c) Change in people’s mobility |

|  |
| --- |
| (d) Number of people who lose jobs |
| (e) Correlation between selected variables. Significant correlation at 5% is marked with star. |

Figure 2. COVID-19 cases and the development of some main economic variables



Lastly, panel (e) show the correlation among the indicators plotted in Figure 2.[[3]](#footnote-3) Several interesting points can be highlighted. First, people’s mobility is significantly having negative correlation with the change in number of COVID-19 cases and the share of TAS (Transportation, Accommodation and Services) in GDP. This means that mobility decreases at the larger rate in provinces with higher COVID-19 cases and TAS share in GDP. Second, GDP growth is more connected to number of jobs loss and TAS share in GDP. Third, in addition to people’s mobility, the change in number of COVID-19 case is also significantly correlated with the share of TAS in GDP. Overall, the plot is useful to explain how the current state in one variable is affecting the others. In particular, the current condition of economic structure has significant correlation with three out of four other variables; it is negatively correlated both with GDP growth and people’s mobility while has positive correlation with the change in number of cases. Since the number of infected people is higher in provinces with higher TAS share in GDP (the positive correlation), local governments implemented large-scale social restrictions (PSBB) policy to minimize contacts among people, such as schools’ closure, work-from-home, restrictions on religious congregations and even closing of houses of worship. As the results, people’s mobility decreased, and the reduction in people’s mobility decelerates economic activities (this explains the negative correlation).[[4]](#footnote-5)

**Data and Methodology**

We use quarterly provincial real GDP data published by Indonesian Central Statistics Bureau to capture real economic variable. The final form of GDP data used is the annual GDP growth rate (yoy, %). We utilize this dataset to estimate the spatial dependence of economic impacts of COVID-19 across provinces. The summary statistics of our regression variables is presented in Table 1.

Table 1. Summary statistics of GDP and GDP growth rate (with and without pandemic periods)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Variables | Mean | Std. Dev | Min | 25% | Median | 75% | Max |
| GDP 2015:Q1 | 64.3 | 90.9 | 4.92 | 15.06 | 27.5 | 60.67 | 351 |
| GDP 2019:Q4 | 83.1 | 119 | 6.87 | 20.61 | 34.6 | 81.78 | 471 |
| GDP 2019:Q1 | 78.5 | 113 | 6.47 | 17.33 | 31.4 | 81.78 | 446 |
| GDP 2020:Q2 | 76.44 | 108 | 6.58 | 17.86 | 32.3 | 79.26 | 415 |
| GDP growth 2015:Q1-2019:Q4 | 5.27 | 3.53 | -23.98 | 4.66 | 5.35 | 6.02 | 34.08 |
| (without pandemic period) |
| GDP growth 2019:Q1-2020:Q2 | 3.10 | 2.35 | -9.30 | 2.91 | 3.20 | 4.15 | 5.61 |
| (with pandemic period) |

*Note:* The GDP is measured in billions Rupiah (2010 constant price). The unit of GDP growth is %, yoy.

To carry out the spatial analysis, we first define a spatial connectivity structure across the provinces of Indonesia. In the literature, there are multiple criteria to define that structure. The most popular are spatial contiguity, spatial distance, and k-nearest neighbors. In this paper, we implement a generalized version of spatial connectivity based on distance, namely inverse distance weight matrix (Anselin and Rey, 2014). To facilitate visual interpretation, Figure 3 shows the overlap between the estimated connectivity structure and the provincial map of Indonesia.

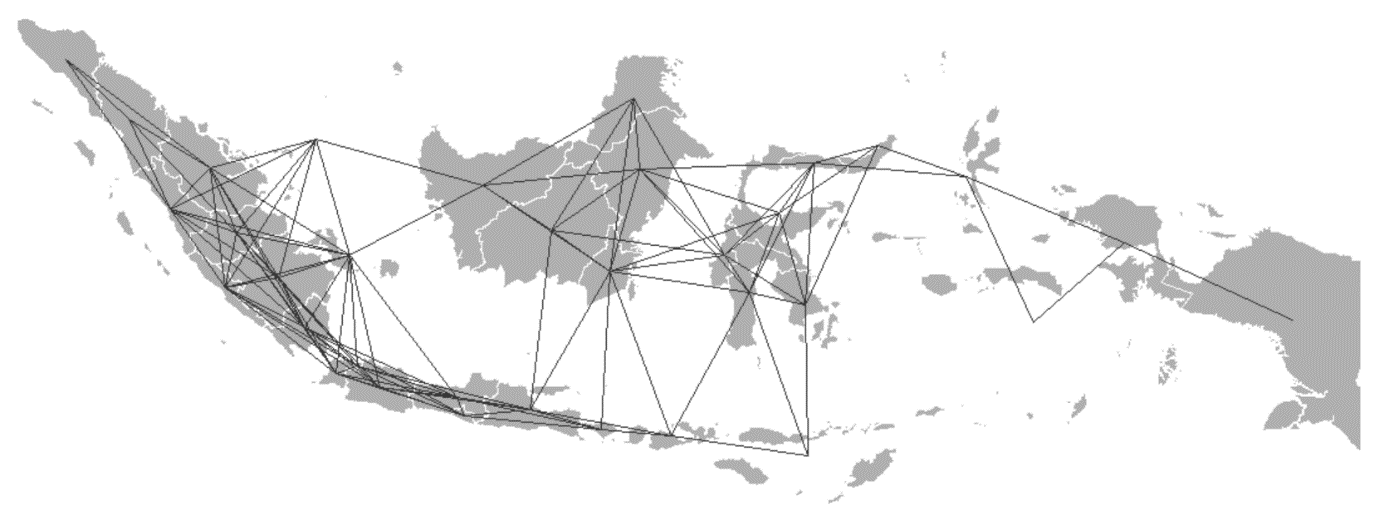


Figure 3. Spatial connectivity structure of the provinces of Indonesia

The spatial exploration is started with an analysis of global spatial dependence. Its main objective is to test for the existence of a spatial autocorrelation in the spatial distribution (Anselin,2007). If the null hypothesis of spatial randomness is rejected, then the spatial autocorrelation of the data provides phenomenon under study. There are some growing statistical tests to examine the existence of spatial dependence in a dataset. Among them, the Moran’s I test is the most prominent.

Global Moran’s I statistics can be defined as:

|  |  |
| --- | --- |
|  | (1) |

where *wij* represents the spatial structure of the data, and it is built from a spatial weight matrix (in this paper we use inverse distance), *xi* is the score of the variable *x* at location *i*, *xj* is the score of the same variable at location *j*, and *μ* is the cross-sectional mean of the data. Anselin (1995) argues that statistical inference for Moran’s I may be applied either utilizing a simulation of a reference distribution based on random permutation or utilizing a normality assumption. In this paper, following Anselin et al. (2007), statistical inference is based on a conditional permutation approach.



As the main analysis of this paper, we examine the regional growth impacts of COVID-19 pandemic by applying spatial regression framework. Basically, spatial analysis is about accounting for spillover effects derived from spatial dependence between regions. Spatial autoregressive models broaden the ordinary linear regression through permitting dependent variables in one area to be affected by dependent variables in neighboring areas, covariates from neighboring areas, and errors from neighboring areas. Anselin (1988) has firstly introduced two common models to recognize spatial dependence through spatial autoregressive models, which are Spatial Lag Model (SLM) and Spatial Error Model (SEM). Then, Fingleton and Lopez-Bazo (2006) also confirm that spatial dependence among growth processes of sub-national level may be caused by two types of features. The first feature is correlated with random shocks, symbolized by spatial error models, coming from neighboring regions and another one is correlated with the growth rates of neighboring regions, symbolized by spatial lag models. Similarly, LeSage and Fischer (2008) also concern attention to the issue of spatial dependence in growth regressions. The issue may come due to pecuniary externalities from neighboring regions (captured by spatial lag) or spatial autocorrelation among regression residuals (captured by spatial errors). If this issue is uncovered, it will lead to inconsistent and bias estimation because correlation between spatially lagged dependent variable ends up in model generating parameter estimates smaller or larger than the true model.



Taking the standard growth regression of Solow without augmenting with human capital and physical capital (Mankiw. et.al, 1992) as the starting point, we follow the seminal works of Rey and Montouri (1999) by involving the role of spatial dependence across regions. The purpose of the inclusion of spatial dependence is to give intuitive comprehension that interactions among geographical neighbors can affect the outcome of the entire regional system.

As mentioned earlier, two most prominent specifications used in the spatial regression literature are SLM and SEM. In our analysis, we implement the cross-sectional spatial regression model. In the SLM specification, spatial dependence exhibits the actual interaction among spatial units that take place through the dependent variable. In this context, our SLM specification is as follows,

|  |  |
| --- | --- |
|  | (2) |

where **W** is the spatial weights matrix that represents the spatial structure of the data, is the spatial lag of the dependent variable, is spatial lag coefficient, is the average growth rate of the GDPduring T period (quarters), is value of the GDP in the initial year, which are 2015:Q1 for the model without pandemic and 2019:Q1 for the model including pandemic period and is error term.

In the SEM specification, on the other hand, spatial dependence could exist in the disturbance or error term structure in the estimation, especially when the spatial dependence is not directly experienced by income or growth. In this context, our SEM specification is written as follows,

|  |  |
| --- | --- |
|  | (3) |

where I is a vector of ones, **W** is the spatial weights matrix, and *λ* is a spatial error coefficient.

Both spatial models are estimated through maximum likelihood estimation. To choose the best model, the measures that commonly used are through R-square, Log-Likelihood, Akaike information criterion (AIC) and Bayesian Information Criterion (BIC). In this paper, the model selection is based on Akaike information criterion (AIC) as well as the Bayesian Information Criterion (BIC). Based on those indicators, the model with the smallest value of AIC and BIC is the fittest.

**Results and discussion**

This section presents the main findings of spatial autoregressive models. In particular, we evaluate how the spillover effects of economic growth – how the growth in a province is affected by the growth in surrounding regions - behave before and after the pandemic period. Ideally, in our equation we would consider all necessary growth determinants mentioned in the standard Solow growth model featuring the Cobb-Douglas production function (Islam, 1995). However, due to data availability and time constraint, we use initial economic condition (log of GDP in 2015:Q1 for modeling the period without pandemic and log of GDP in 2019:Q1 for modeling the period with pandemic) as the proxy of growth determinants, where the economy is assumed to be in its natural condition. Thus, our model captures the spatial effects of economic growth by controlling the natural level of main growth determinants. To understand the impacts of the pandemic, the model is estimated for two different time span; from 2015:Q1 to 2019:Q4 and from 2019:Q1 to 2020:Q2. The first period represents the period without pandemic and the latter is referred to the period with pandemic effect.

Table 2. Spatial autocorrelation (Moran’s I statistics) in province GDP growth

|  |  |  |
| --- | --- | --- |
| Variable | Without pandemic period | With pandemic period |
| GDP growth 2015-2019 | GDP growth 2019-2020 |
| Moran’s I | 0.181\*\* | 0.098\*\* |
| *p-value* | 0.017 | 0.019 |

*Note*: \*\*\* *p* < 0.01, \*\* *p* < 0.05, \* *p* < 0.1

One important assumption in spatial autoregressive model is the existence of spatial dependence in our observed variables. Thus, before estimating the spatial autoregressive model, we conducted global spatial dependence analysis by computing Moran’s I statistics. Table 2 presents the Moran’s I statistics in both periods; the period without pandemic effect and with pandemic effect. The result shows that the Moran’s I statistics of provincial GDP growth at both periods (with and without pandemic periods) are statistically significant. This result provides enough evidence of spatial dependence in our data and thus we may include the role of neighborhood or spatial effects in the regression models.

Table 3. Non-spatial and spatial regression of with and without inclusion of pandemic period

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Without pandemic period | | | With pandemic period | | |
| Variables | Dependent variable: GDP growth of 2015:Q1 – 2019:Q4 | | | Dependent variable: GDP growth of 2019:Q1 – 2020:Q2 | | |
| OLS | SLM | SEM | OLS | SLM | SEM |
| Log of GDP in 2015Q1 | -0.022\*\* | -0.034\*\*\* | -0.024\* |  |  |  |
|  | (0.009) | (0.012) | (0.013) |  |  |  |
| Log of GDP in 2019Q1 |  |  |  | -0.029 | -0.036 | -0.034 |
|  |  |  |  | (0.019) | (0.029) | (0.024) |
| Spatial Lag Coefficient () |  | 0.515\*\*\* |  |  | -0.859 |  |
|  |  | (0.195) |  |  | (0.899) |  |
| Spatial Error Coefficient () |  |  | 0.822\*\*\* |  |  | -1.047 |
|  |  |  | (0.213) |  |  | (0.935) |
| Constant | 0.654\*\*\* | 0.731\*\*\* | 0.627\*\*\* | 0.494 | 0.610 | 0.595 |
|  | (0.170) | (0.193) | (0.215) | (0.174) | (0.504) | (0.419) |
| Model selection/information criteria | | | | | | |
| AIC | -70.381 | -33.320 | -33.036 | -11.758 | -8.731 | -9.045 |
| BIC | -67.328 | -27.215 | -26.931 | -8.705 | -2.625 | -2.940 |
| *Note*: Robust standard error in parentheses. | |  |  |  |  |  |
| \*\*\* *p* < 0.01, \*\* *p* < 0.05, \* *p* < 0.1 |  |  |  |  |  |  |

Table 3 presents the results of non-spatial and spatial regressions of the GDP growth in both periods. All spatial regressions are estimated using maximum likelihood estimator for cross-sectional data. The results show that all coefficient in OLS, SLM and SEM model are significant in pre-pandemic period, while none of coefficient is significant in the pandemic period. In terms of spatial autocorrelation coefficient, which are spatial lag and spatial error coefficient, they confirm the existence of spatially correlated dependent variable and error among provinces (see Table 2 of Moran’s I statistics).

Our results in Table 3 imply two important findings. First, by looking at the coefficients of both SLM and SEM models, the spatial effects of economic growth behave differently between before and after pandemic. In the pre-pandemic period, regional growth is significantly affected by the economic growth and the random shocks from neighboring provinces, in addition to the initial economic size of a given province.[[5]](#footnote-9) In other words, regional growth dynamics is not only influenced by the initial economic size, but also by the spillovers effect of other proximate provinces. The positive coefficient imply that the growth rate of a particular province tends to be affected by the growth rate of its surrounding provinces, similar with the finding of McCulloch and Sjahrir (2008) that suggest districts surrounded by the fast-growing neighbors tend to grow faster. In the pandemic period, on the other hand, the spatial effects of economic growth are not significant. This insignificant coefficient indicates that initial economic size and spillovers effect does not affect the regional growth dynamics within pandemic period inclusion. In addition, the inexistence of spillover effect within pandemic-period inclusion may reflect the disconnection of economic interaction among provinces during ‘lock-down period’ due to pandemic. It is also supported by the decreasing value of Moran’s I statistics in Table 2, indicating the weaker connectivity or economic interaction across regions.



Second, the coefficient of economic size at the initial period is significant in pre-pandemic period but not significant in pandemic period. This finding indicates that the catching-up process (convergence) has occurred only in pre-pandemic period. It is shown by the negative and significant coefficient of the economic size, implying that the smaller initial economic size regions tend to grow faster. This pattern is no longer exist in the pandemic period, indicated by the non-significant coefficient of the initial GDP in all models. However, the negative coefficients of the slopes still provide evidence of convergence; provinces with larger GDP grow slower that those with smaller GDP. This might be interpreted as most of provinces with high GDP (located in Java-Bali region) experience relatively larger growth decline in the pandemic period.

**Conclusion**

The negative impact of COVID-19 pandemic on Indonesian economy is significant, reflected from the massive decline of economic growth in the second quarter of 2020. Regionally, the GDP shortfalls vary across provinces and the growth dynamics in one province may affect the others, known as spatial spillover effects documented in the previous Indonesian regional growth studies.

Departing from this background, our study evaluates the spatial spillover effects of economic growth across Indonesian provinces in two different periods; pre-pandemic and in the pandemic period. The results from spatial econometric models show that the provincial growth in the pre-pandemic period is affected by the spillover of shocks in the surrounding regions, but the spillover effects are found not significant during the pandemic period. The insignificant spatial spillover during the pandemic period may reflect the disconnection of economic interaction among provinces during ‘the lock-down period’.

Given the setup in our regression models, the results also shed some light on the regional convergence pattern. In the pre-pandemic period, the coefficients of the economic size at the initial period are negative and significant for all models. This implies that the provinces with smaller GDP tend to grow faster than those with larger GDP. However, the pattern is no longer exist in the pandemic period, indicated by the non-significant coefficient of the initial GDP in all models. Therefore, we may conclude that the catching-up process (convergence) that occurred in pre-pandemic period was being disrupted in the pandemic period.

As common in other spatial studies, we acknowledge the limitation of this study could include two following issues. First, the specification of weight matrix using inverse distance matrix. Since there is no a single solid method that identifies a unique weight matrix reflecting the connectivity between locations, it is useful to test the models with alternative weight matrix. Second, given the availability issue and time constraints, the data used in the models is very limited to explain the complex regional growth dynamics. Therefore, future studies should incorporate more variables, including the institutional determinants of growth at a province level to obtain reliable estimates.

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1. Output gap is the gap between potential and actual output. For simplicity, we used Hodrick-Prescott (HP) filter to extract the trend of GDP data as estimate of potential output. The computed output gap is the difference between actual GDP data and its estimated trend. [↑](#footnote-ref-1)
2. The data shows how people to (or time spent in) categorized places change compared to baseline days. The baseline day is the median value from the 5-week period Jan 3 – Feb 6, 2020, representing a normal value for that day of the week. For further details about category of places and everything related to the data, please visit

   https://support.google. com/covid19-mobility/answer/9824897?hl=en&ref\_topic=9822927. [↑](#footnote-ref-2)
3. We include the share of Transportation, Accommodation and Services (TAS) to GDP in addition to previous variables. In the statistics of Indonesian GDP, TAS sector includes ”Transportasi dan Pergudangan”, ”Penyediaan Akomodasi dan Makan Minum”, ”Administrasi Pemerintahan, Pertahanan dan Jaminan Sosial Wajib”, and ”Jasa Lainnya”. [↑](#footnote-ref-3)
4. For exploration of COVID-19 cases and its economic impacts across provinces in Indonesia, please visit [RPubs - Covid-19 pandemic and its economic impacts in Indonesia](https://rpubs.com/haginta/covid19-econ-impacts-indonesia) and [Covid-19 pandemic and its economic impacts: An interactive exploration on Indonesian provincial data (shinyapps.io)](https://haginta.shinyapps.io/Covid19_econ_impacts_reg_Indonesia/) [↑](#footnote-ref-5)
5. In this paper, spatial lag is defined as the economic growth rate of neighboring provinces while spatial error is the error (other than growth variables) of neighboring provinces. [↑](#footnote-ref-9)