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ASYMMETRIC IMPACTS OF MONETARY POLICY SHOCK ON OUTPUT GAP: EVIDENCE FROM REGIONS IN INDONESIA

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ABSTRACT

We examine the impact of the monetary policy on regional output gaps across 33 Indonesian provinces. Heterogeneous regional responses of the output gap to monetary policy shock are captured using the Vector Autoregressive model. Moreover, the idiosyncratic variations across provinces accounted for different responses are observed with the spatial econometric model. The spatial analysis suggests that economic structure and financial depth positively and significantly determine the aforesaid asymmetric responses. On the other hand, economic size and trade openness have a negative impact on them.

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I. INTRODUCTION

Many empirical studies have shown the asymmetric impacts of monetary policy on the economy. The monetary policy change has created non-homogenous responses during the period of recession or expansion (Garcia and Schaller, 2002; Peersman and Smets, 2005; Bliss and Kaufman, 2002; Dolado and Maria-Dolores, 2006; Weise, 1999; Lo and Piger, 2005; Hoppner *et al*., 2008.), generated different magnitudes of response for monetary tightening or expansion (Kilinc and Tunc, 2019), and caused heterogeneous sectoral impact (Jansen *et al*., 2013; Sengupta, 2014; Singh and Rao, 2018). However, only a few studies have analysed the heterogeneous response to monetary policy changes across the region in an economy and the regional characteristics that account for the variation of the response to a nationwide monetary policy. Until the early 2000s, these topics were only explored in developed nations such as in the USA (Carlino and DeFina 1998) and Europe (Dornbusch *et al*., 1998; Arnold, 2001). Then, the geographical focus of the study started to shift to developing countries like India (Nachane *et al*., 2001) and Indonesia (Ridhwan *et al*., 2011).

Understanding the different impacts of a monetary policy change at the regional level is crucial in achieving monetary policy goals for all regions under a common monetary area. The monetary policy stance is uniform for all regions in a monetary area and is designed to only respond to the state of economic variables at the aggregate level (national level). Hence, a monetary policy change will arguably have asymmetric impacts across regions, especially in the countries where the idiosyncratic variations among regions are high. The evidence of persistent differences in output growth and inflation divergence across participating regions is indisputable proof of the existence of these asymmetries (Reuter and Sinn, 2001; Weber and Beck, 2005). Against this backdrop, it is also essential to incorporate regional heterogeneity in examining the transmission of monetary policy across regions to guide policymakers to formulate an appropriate strategic policy (Anagnostou and Gajewski, 2020).

In an archipelagic country that is separated by seas, clustered on islands, and very diverse economically, like Indonesia, a monetary policy change may result in different responses in real economic activities across its 34 provinces. The impacts of the monetary policy shock are also propagated by the fact that business cycles across provinces are not synchronous. The heterogeneous responses to monetary policy shock and asymmetric business cycles across provinces concurrently will result in varied macroeconomic fluctuations at the regional level. The specific issue in Indonesia is that six provinces in the Java Island, which contribute to around 60% of the national output, dominate the economy. Thus, national-level macroeconomic variables data mainly represent the condition of provinces in Java Island. Consequently, monetary policy change mostly only responds to the macroeconomics dynamics of the Java Island. To our knowledge, there are only two studies on the asymmetric impact of monetary policy between regions in Indonesia, and the former focused on the regional output responses (Ridhwan *et al*., 2011) while the latter focused on the regional inflation responses (Aginta and Someya, 2021).

When central bank policymakers set the opportune monetary policy stance, they employ various indicators of economic activity, one of them is the output gap.

The output gap is commonly used to measure economic fluctuations (Hubbard *et al*., 2012), and its fluctuation is more related to inflationary pressure (Fisher *et al*., 1997). A central bank focuses on restoring the economy to its potential level and avoids inflation by narrowing the output gap. Meanwhile, asymmetric business cycles often prevail across regions in a common currency area (Artis *et al*., 2011). Furthermore, the heterogeneous responses and unsynchronized business cycle at a regional level will complicate monetary policy operation as a counter-cyclical policy measure to smooth output fluctuation and keep the output gap close to zero for all regions.

There are some aspects which can be improved from the previous analysis. First, the preceding analysis on the effect of monetary policy shocks on real economic activity focused more on the response of real output or real output growth (Tan *et al*., 2010; Ridhwan *et al*., 2011; Sengupta, 2014; Ma, 2018; Goshit *et al*., 2020; Narayan *et al*. 2009) instead of the output gap. Second, most of them concentrate on the national level analysis, which has common institutional, monetary, and fiscal regimes. Lastly, most investigations on the sources of heterogeneous impacts of monetary policy do not consider spatial dependence aspects or employ appropriate spatial analysis.

Our paper aims to fill this research gap in the following two ways. First, we emphasize our analysis on the response of Indonesia's monetary policy to the regional output gap as it is important to observe the impact of monetary policy on the output gap to delineate the efficacy of monetary policy in smoothing the business cycle as its main role. Second, this is the first paper on Indonesia which combines the VAR and spatial econometric models to investigate the asymmetric impact of monetary policy on regional output gaps as well as the factors causing the heterogeneous responses. Although previous studies have highlighted the possibility of spatial dependence on the regional responses of monetary policy (Salvatore *et al*., 2021; Aginta and Someya, 2021), none of them has implemented an opportune spatial approach to observe this issue.

This study is carried out based on the VAR model, which isolates the various exogenous innovations to identify the real effect of a monetary policy shock between the systems estimation in 33 Indonesian provinces. The heterogeneous responses are derived from the impulse responses using the VAR model for each province during the period 2005Q1 to 2019Q4 and captured the direction of responses, its magnitude, and timing of the responses. Although most provinces respond negatively to contractionary monetary policy, some provinces responded positively. The magnitude of the responses varies across all provinces; some provinces respond strongly, while others tend to have weak responses in the short- or long-run. The speed of policy transmission in influencing real economic activity varies across provinces. Some provinces record the biggest response during the first four quarters, while others take longer time to observe bigger responses.

Through spatial econometric analysis, we conclude that economic structure, financial depth, provinces' relative economic sizes, and trade openness are associated with the asymmetric response of the regional output gap to a monetary policy shock in the short-run and the biggest responses. The higher the shares of the manufacturing sector in the region and financial depth will intensify the impact of monetary policy shock on the regional output gap. In contrast, economic size and trade openness have a negative effect on the impulse response of regional output gaps to a monetary policy change. However, those four variables are only statistically significant in the short-run and the biggest responses.

To check the robustness of our estimation results, we carry out additional empirical works by modifying the spatial weight matrix and the estimation methods. First, we use the inverse Euclidean distance as an alternative computation of spatial weight matrix. Furthermore, we also utilise generalized spatial two-stage least squares estimates. The results of the robustness checks are consistent with our findings discussed earlier.

The rest of the article is organized as follows. Section II presents the theory and a literature review that discusses the relationship between monetary policy and output gap and the factors that explain the heterogeneous response to monetary policy shock. Section III provides a discussion on data and methodology used in this study. Section IV discusses the empirical findings and finally, Section V provides some concluding remarks.

II. LITERATURE REVIEW

A. Output Gap and Monetary Policy

Monetary authorities worldwide have different mandates in each economy. However, generally, they are assigned to control inflation or both control inflation and smoothing the business cycle (output gap volatility). Some central banks have only focused on maintaining price stability while the others complemented with the duty to keep the economy in full employment to sustain economic growth and shrug off unemployment. To achieve their primary target(s), central banks adjust their monetary policy instrument responding to the changes in the macroeconomic variables such as output gap and inflation (Taylor, 1993; McConnell and Perez-Quiros, 2000; Jensen, 2000; Dufrenot *et al*., 2004; Boivin and Giannoni, 2006; Casares, 2009).

Conceptually, the output gap is the percentage deviation of real output from its potential output. The potential output reflects the optimum capacity of output production given the current level of technology and factors of production. A positive output gap means the economy over-utilized its production factors and reflects inflationary pressure. A negative output gap means the production factor is underemployed and reflects deflationary pressure. In contrast, a zero-output gap means that the economy runs at its most efficient level or its full capacity (Jahan and Mahmud, 2013). An output gap implies that the economy is working inefficiently, which is undesirable (Salunkhe and Patnaik, 2017). Output gaps can emerge from demand-side or supply-side shock. If a positive demand shock arises, there is an excess demand for output compared to what the economy can supply in the short-run. This can induce a higher price level or inflation.

In a persistent positive output gap, inflation will soar, and a persistent negative shock will push the price level down. An appropriate policy could force the output gap close to zero, which results in non-accelerating or non-decelerating levels of inflation. Accordingly, the output gap serves as an essential signal for monetary policy formulation. To achieve the inflation target, Monetary Authorities could introduce a tight monetary policy to offset the positive demand shock when a persistent positive output gap occurs and expansionary monetary policy to stimulate aggregate demand, which eventually leads to higher output.

B. Factors Explaining the Regional Asymmetric Response to a Monetary Policy Shock

The literature on the impact of monetary policy on the real economic variables suggests evidence of asymmetric responses to monetary adjustments at a regional level. Empirical studies also provide a reference for potential sources of the different effects of monetary policy, including regional variations in the share of the interest-sensitive economic sector to regional output (economic structure), the share of the financial sector to the output (financial deepening), contribution of international trade to the output (trade openness), and the level of development (economic size).

B.I. Manufacturing Sector

The sectoral effects of monetary policy have been widely studied, and empirical studies have proven that the manufacturing sector is one of the most sensitive sectors which reacts to the changes in interest rate (Bernanke and Gertler, 1995; Arnold and Vrugt, 2002; Alam and Waheed, 2006; Otero and David, 2017; Nachane *et al*., 2001; Pizzuto, 2020) due to the relation between interest rates and investment and consumption. The interest rate will affect the investment demand since the interest rate will influence the future expected yield of an investment. A low interest rate will increase the expected yield of the projects, thereby encouraging firms to commit to projects or carry-on capital expenditure. The manufacturing sector is the sector in the economy which is most likely to carry on long-term projects compared to the other sectors. The interest rate change will reduce the cost of borrowing for household loans from the consumption side, which promotes durable manufactured goods purchases, such as electronics or automotive products.

B.II. Financial Depth

There exists an influential body of literature on the relation between financial depth and economic performance. However, the role of financial depth in affecting the impact of the negative shocks on economic performance is still inconclusive. Some studies suggest that financial depth plays a significant role in smoothing the response and transmission mechanism of the adverse shock to the economy. The development and deepening of financial markets minimize the impact of adverse shocks and reduces output volatility by allowing easier access to financial resources when the economy has a liquidity problem, especially during a recession (Bernanke and Gertler, 1989; Raddatz, 2006; Larrain, 2006; Caglayan *et al*., 2017). In addition, Ferreira da Silva (2002) found that countries with a higher level of financial deepening encounter less volatile business cycles.

Meanwhile, other studies have argued that financial deepening magnifies the response to shocks, predominantly negative monetary policy shocks. The banking sector is sensitive to interest rate changes in providing loans, and an economy's dependence on the banking sector (bank-centric) will amplify the response to monetary policy shock (Kashyap and Stein, 1997; Dornbusch *et al*., 1998). Furthermore, the variation in the concentration of the degree of financial deepening combined with manufacturing enterprises concentration is responsible for the heterogeneous response to monetary policy shock (Nachane *et al*., 2001).

B.III. Level of Openness

Theoretically, trade openness reduces the monetary policy's effectiveness. In an open economy, expansionary monetary policy will lead to the undesirable consequences of currency depreciation. Real exchange rate depreciation relatively inflates imported input prices and consumer goods, incites higher wage demand, and induces inefficiently higher inflation (Romer, 1993). Thus, expansionary monetary policy shock will have less power to stimulate the economy and result in higher inflation (Karras, 1999; Karras, 2001). The monetary authorities face a trade-off issue; the expansionary policy will ignite higher inflation. This discourages monetary authorities from introducing the expansionary monetary policy, which results in maintaining low inflation expectations in the highly open economy (Lane, 1997).

B.IV. Level of Development

The asymmetric impacts of monetary policy across countries with different levels of development are reported in previous studies. The heterogeneous impacts on monetary policy depend on the country's reliance on cash. Typically, informal sectors play a significant role in developing economies, in which cash is primarily used for transactions, and for developing countries with high inflation, where financial institutions prefer to hold a substantial share of liquid assets (Reed and Ghossoub, 2012). Moreover, Friedman and Woodford (2010) also found that the effects of monetary policy are distinctly related to the financial sector structure. The monetary policy impact is less efficient and less stable in developing countries compared to developed countries (Mishra *et al*., 2010). A more recent study by Nguyen (2019) argued that the evaluation of the impact of monetary policy in emerging and developing economies is less conclusive and often contradictory.

III. DATA AND METHODOLOGY

A. Data

In this study, we consider 33 Indonesian provinces. We use quarterly data which spans the period 2005Q1 to 2019Q4. Among 34 provinces in Indonesia, we merge North Kalimantan (Kaltara) with its pre-decentralized province, East Kalimantan (Kaltim) since it was formed less than ten years ago.

Four variables (namely, the output gap at the national level, price level, interest rate, and output gap at the regional level) are used to calculate the different responses of real economic activity to a monetary policy shock at the regional level. To estimate the output gap, we employed the standard Hodrick-Prescott

(HP) Filter[1]. The second variable is the interest rates, which represent the monetary policy. Instead of money supply, Bank Indonesia (BI) conducts monetary policy by managing interest rates as its operational target to achieve macroeconomic policy objectives. Several interest rate measurements can be employed, such as 30-day Bank Indonesia Treasury Bills (Bank Indonesia Certificate), SBI rates, 77-Day Repo rates, or interest rates for the money market. As suggested by Agung (1998) and Ridhwan *et al*. (2011), the money market interest rate is more suitable for indicating monetary policy innovation in Indonesia since the money market interest rate is determined by the BI as a benchmark rate for money market actors. The price level is measured by the Consumer Price Index (CPI). The actual output for the estimation is in real terms and is seasonally adjusted.

As elaborated in Section II, the variables employed to examine the sources of heterogeneous impacts of monetary policy on output gap at the provincial level are:

(i) Economic structure, proxied by the share of manufacturing sector to Gross Domestic Regional Product (GDRP);
(ii) Level of development, proxied by the economic size, which is the relative size of the provincial output to national output (Gross Domestic Product, GDP) for each province;
(iii) Financial depth, which is the percentage of the banking credit to GDRP; and
(iv) Level of openness, represented by trade openness, which is calculated by the percentage of the regional exports and imports to GDRP.

Information regarding the dataset is provided in Table 1.

[1] The HP Filter decomposes a time series into a scalar trend (long-term trend) and cyclical component. Let a time series variable y_t, where y_t is a seasonally adjusted gross domestic regional product (GDRP) for t=1,2,…,T, and comprises a trend (τ_t) and cyclical (c_t) components, $y_t = \tau_t + c_t$. Given the value of λ chosen, there is a trend component that will solve:

$$\min_{\tau}\{\sum_{t=1}^{T}(y_t - \tau_t)^2 + \lambda\sum_{t=2}^{T-1}[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2\}$$

where λ is a smoothing constant to penalize the variation in the growth rate of the scalar trend component. The common practice, as Hodrick and Prescott (1997) proposed, is that the value of λ for quarterly data is 1600. Following Hodrick-Prescott (1997), the filter is given by:

$$HP = [\lambda L^2 - 4\lambda L + (1 + 6\lambda) - 4\lambda L^{-1} + \lambda L^{-2}]^{-1}$$

where L is lag operator.

Table 1.
List of Variables

This table provides detail description of all variables used in this study.

Variable	Frequency	Period	Unit	Description	Source
National Output gap ($\hat{y}_t$) *and Regional Level Output Gap* ($\widehat{y_{it}}$)	Quarterly	2005:2019	percentage	Percentage deviation of actual output to potential output	BI (own estimation)
Price Level (CPI)	Quarterly	2005:2019	Index	A weighted average of prices of a basket of consumers goods and services	CEIC
Interest rate (JIBOR)	Quarterly	2005:2019	percentage	Jakarta Interbank Offer Rate (JIBOR) as money market benchmark rate	BI
Economic Structure (ES_i)	Average	2010:2019	percentage	Share of the regional manufacturing sector to Gross Domestic Regional Product (GDRP)	CEIC, BI
Economic Size (EZ_i)	Average	2010:2019	percentage	Relative size provincial output (GDRP) to national output (GDP)	CEIC
Financial Depth (FD_i)	Average	2010:2019	percentage	Share of regional credit to Gross Domestic Regional Product (GDRP)	CEIC, BI
Trade Openness (TO_i)	Average	2010:2019	percentage	Share of regional trade volume to Gross Domestic Regional Product (GDRP)	CEIC, BI

B. Methodology

To evaluate the asymmetric responses of the business cycle to an interest rate shock for each province, we calculated the Impulse Response Function (IRF) using the VAR model. The VAR model is a standard empirical method employed to analyse monetary policy transmission mechanisms due to its ability to deal with endogeneity issues and shock identification. While acknowledging several approaches of shock identification, we follow a wide range of papers identifying monetary policy shock using VAR. Technically, the shock is identified as part of interest rate which is not explained by an assortment of variables in the regression model (Evans and Kuttner, 1998; Rudebusch, 1998).

After obtaining impulse response from the VAR model, we apply a spatial econometrics model to determine the factors that cause the heterogeneous impact of monetary policy on regional output gaps. The spatial econometrics approach enables us to check on dependence among observations (LeSage and Pace, 2010), meaning that a pattern of data in a region may have an impact on its neighboring regions. If we estimate the model with conventional cross-section or panel data analysis, which posits no correlation among regions/observations, the resulting coefficients may be biased (LeSage, 2008).

B.I. Vector AutoRegression (VAR)
The VAR model is established for each province in Indonesia. Let Y_{it} be the vector of endogenous variables for province *i* in period *t*:

$$Y_{it} = (\widehat{y_t}, \pi_t, r_t, \widehat{y_{it}}) \tag{1}$$

where $\widehat{y_t}$ is the output gap at the national level at time t, π_t is the price level at time t which is represented by the CPI, r_t is the policy rate (JIBOR) introduced by the central bank applied nationally at time t, and $\widehat{y_{it}}$ is the output gap for province i at time t. The dynamics model of Y_{it} are represented by the equation as follows:

$$AY_{it} = B(L)Y_{it-1} + e_{it} \tag{2}$$

where A is $n \times n$ polynomial matrix of the coefficient depicting the contemporaneous correlation among variables, $B(L)$ is $n \ x \ n$ polynomial matrix of endogenous variables in the lag operator L, and e_{it} is $n \ x$ 1 vector of the structural error term.

The reduced form of the system can be written as follows:

$$Y_{it} = C(L)Y_{it-1} + u_{it} \tag{3}$$

where $C(L)=A^{-1} B(L)$ is a matrix of contemporaneous correlation with an infinite lag order polynomial, and u_{it} is a vector of reduced-from disturbances, with $var(u_{it})=\Sigma$.

Since our interest is in measuring the provincial output gap's response to the interest rate variable, we did not report the parameters and statistical testing from the VAR estimation. Instead, we present the IRF estimation results, following Sims (1980).

For the VAR model estimation, as a standard procedure, we need to check whether all our variables follow stationary process. The stationarity of all variables is necessary to ensure that the parameters of the estimation are not spurious. However, Sims (1980) and Sims *et al.* (1990) suggested estimating the VAR model in levels. Since the interest is determining the interrelationship among variables and is not focused on the estimations of the parameters, requiring the data to be $I(0)$ will lead to a loss of the genuine relationship between variables and bias impulse response. Therefore, we estimate the VAR models with all variables at their level form..

The following procedure is deciding the opportune lag length. This is crucial since the model estimation on the causal relationship is sensitive to the selected lag length. To select the optimal lag length, we employed standard information criteria: Akaike Information Criteria (AIC), sequentially modified LR test statistic (LR), Final Prediction Error (FPE), schwarz information criterion (SC), and Hannan-Quinn information criterion (HQ). Furthermore, a stability check was carried out to ensure the VAR models satisfied the stability condition. Moreover, residual testing was conducted for the normality, autocorrelation, and heteroskedasticity testing to conform to the classical Ordinary Least Squares (OLS) assumption.

We derived the information from impulse response functions to apprehend the different impacts of interest rate on the output gap at the provincial level. We selected the fourth quarter, and the twentieth quarter from the accumulated impulse response and the biggest value from the point of estimates of impulse response. The value of the fourth quarter represents the short-term impact, and the biggest value corresponds to the highest magnitude of the impact. The twentieth quarter value reflects the long-term effect of an interest rate shock on the provincial-level output gap.

B.II. Spatial Analysis

After calculating the impulse response function for 33 provinces, further analysis will test the factors that account for the different effects of the interest rate shock on the provincial-level business cycle, including the spatial aspects. To assess the spatial impact of the asymmetric impacts of output gap to a monetary policy shock, we constructed a spatial regression model with the fourth quarter, the biggest value, and the twentieth quarter acting as the dependent variables. Since the value of the impulse response function is obtained from the estimation of the whole sample period, the value of the independent variables is the average value of each cross-sectional observation, following Carlino and DeFina (1998).

We identified the factors that explain the different responses to monetary policy shocks. The variations in the economic structure, financial depth, economic size, and trade openness among provinces are employed as the independent variables. The economic structure is used to verify the manufacturing sector's responsiveness and to confirm the interest rate transmission channel to a monetary policy change. The financial depth variable was employed to show the effect of financial development on the response to a monetary policy shock as well as to confirm the credit and interest rate transmission channel. Meanwhile, economic size was used to refer to the level of development affecting the response to a monetary policy shock. Moreover, trade openness was employed to ensure the exchange rate monetary policy transmission channel and examine whether the global market's engagement influences the response to a monetary policy shock.

Furthermore, the essential feature of spatial models is spatial weighting matrix specification. The matrix presents the distribution of spatial relationships. The spatial weighting matrix (*W*) is a matrix with *n x n* dimension, where *n* is the number of regions being observed. The common ways to specify spatial weighting are distinct into two approaches, contiguity-based weights, and distance-based weights. Acknowledging the challenge in constructing the matrix based on the contiguity for the case of Indonesia (where some regions/provinces are isolated by sea) and following previous studies, we employ the inverse distance-based weights matrix (see, for instance, Miranti and Mendez, 2020).

When there is no spatial dependence, the Standard Linear Model (SLM) can be estimated by using OLS regression (Golgher and Voss, 2016), which is specified as follows:

$$y = \beta_i x_i + \varepsilon \tag{4}$$

where y is the vectors of dependent variables, x_i is the vectors of independent variables, β_i denotes parameters of the vectors of independent variables, and ε is the error term. To identify the existence of spatial autocorrelation, we conduct Global Moran's I test (Anselin, 2001) on the OLS residuals.

According to Anselin (2001), spatial dependence can enter the model via two different channels. First, a spatially lagged dependent variable (*Wy*) incorporates in the model as an additional regressor. Such a model is called the Spatial AutoRegressive (SAR) model. Second, the model with spatial dependence in the component of error term or known as the Spatial Error Model (SEM). The SAR and SEM will be estimated by the Maximum Likelihood (ML) framework following Fischer and Wang (2011).

The regression model of SAR will be specified as follows:

$$y = \rho W y + \beta_i x_i + \varepsilon \tag{5}$$

or in reduced form:

$$(I - \rho W)\, y = \beta_i x_i + \varepsilon \tag{6}$$

where ρ is a spatial autoregressive parameter.

The Spatial Error Model (SEM) will be specified as follows:

$$y = \beta_i x_i + \varepsilon;\ \varepsilon = \lambda W \varepsilon + \mu \tag{7}$$

where λ the spatial dependence parameter.

If the Moran's I confirmed the presence of spatial autocorrelation, the spatial model is more appropriate. Then, the Lagrange Multiplier (LM) test is used to choose a SAR or SEM as the preeminent model from the OLS regression, following Anselin (2001).

IV. ESTIMATION RESULTS

This section consists of four subsections. We present results related to optimal lag length for VAR estimation in the first subsection, subsequently impulse response to an interest rate shock is discussed in the second subsection. The third subsection explains the result of spatial analysis, and the last subsection discusses robustness check.

A. Optimal Lag Length Checking

The optimal lag length selection from the AIC, LR, FPE, SC, HQ, and a stability condition check suggests that the lag length for each VAR estimation for each province varies and ranges between one to three lags. The results are presented in Table 2.

Table 2.
Optimal Lag Order

This table shows the selected lag order of the VAR Model by using five lag order selection criteria (AIC, LR, FPE, SC, HQ) and conducting the stability check.

No.	Province	Lag Order Selected	Lag Order Selection Criteria
1	Nanggroe Aceh Darussalam (NAD)	1	AIC, LR, FPE, SC, HQ
2	Sumatera Utara (SUT)	1	AIC, LR, FPE
3	Kepulauan Riau (KPR)	1	AIC, LR, FPE, SC, HQ
4	Riau (RIA)	1	AIC, LR, FPE, SC, HQ
5	Sumatera Barat (SBR)	1	AIC, LR, FPE
6	Jambi (JMB)	1	AIC, LR, FPE, HQ
7	Sumatera Selatan (SSL)	1	AIC, LR, FPE, SC, HQ
8	Bangka Belitung (BBL)	1	LR, FPE, SC, HQ
9	Bengkulu (BKL)	1	LR, FPE, SC, HQ
10	Lampung (LPG)	1	AIC, LR, FPE
11	DKI Jakarta (DKI)	1	AIC, LR, FPE, SC, HQ
12	Banten (BTN)	1	AIC, LR, FPE, SC, HQ
13	Jawa Barat (JBR)	1	AIC, LR, FPE, SC, HQ
14	Jawa Tengah (JTN)	1	AIC, LR, FPE
15	D.I. Yogyakarta (DIY)	1	AIC, LR, FPE
16	Jawa Timur (JTM)	1	AIC, LR, FPE
17	Bali (BLI)	3	AIC, LR, FPE, SC, HQ
18	Nusa Tenggara Barat (NTB)	2	LR, FPE, SC, HQ
19	Nusa Tenggara Timur (NTT)	1	AIC, LR, FPE
20	Kalimantan Selatan (KSL)	1	LR, FPE, SC, HQ
21	Kalimantan Timur dan Utara (KTMU)	1	AIC, LR, FPE
22	Kalimantan Tengah (KTG)	1	AIC, LR, FPE, SC, HQ
23	Kalimantan Barat (KBR)	1	AIC, LR, FPE, SC, HQ
24	Sulawesi Utara (SUT)	1	AIC, LR, FPE, SC, HQ
25	Sulawesi Selatan (SSL)	1	AIC, LR, FPE, SC, HQ
26	Sulawesi Tenggara (STG)	1	AIC, LR, FPE, SC, HQ
27	Sulawesi Tengah (STH)	1	AIC, LR, FPE
28	Gorontalo (GOR)	1	AIC, LR, FPE
29	Maluku (MAL)	1	AIC, LR, FPE, SC, HQ
30	Maluku Utara (MUT)	2	AIC, LR, FPE, SC, HQ
31	Papua (PAP)	2	AIC, LR, FPE
32	Papua Barat (PBR)	1	AIC, LR, FPE, HQ
33	Sulawesi Barat (SBR)	1	LR, SC, HQ

B. Impulse Response to an Interest Rate Shock

Figures 1 present the accumulated impulse response for 33 provinces resulting from one percentage point unexpected rise in monetary policy rate change over 20 quarters after the shock. Table 3 provides the summary of the difference of province's response to the interest rate shock in terms of direction, magnitude, and timing.

Figure 1.
Impulse Response of Output Gap to a 1 Percentage Point Interest Rate Increase (Accumulated)

This figure describes the accumulated impulse response of the regional output gap to a 1 percentage point interest rate increase for 33 provinces in Indonesia for 20 quarters. We also show the confidence band of the impulse response displayed by the red lines.

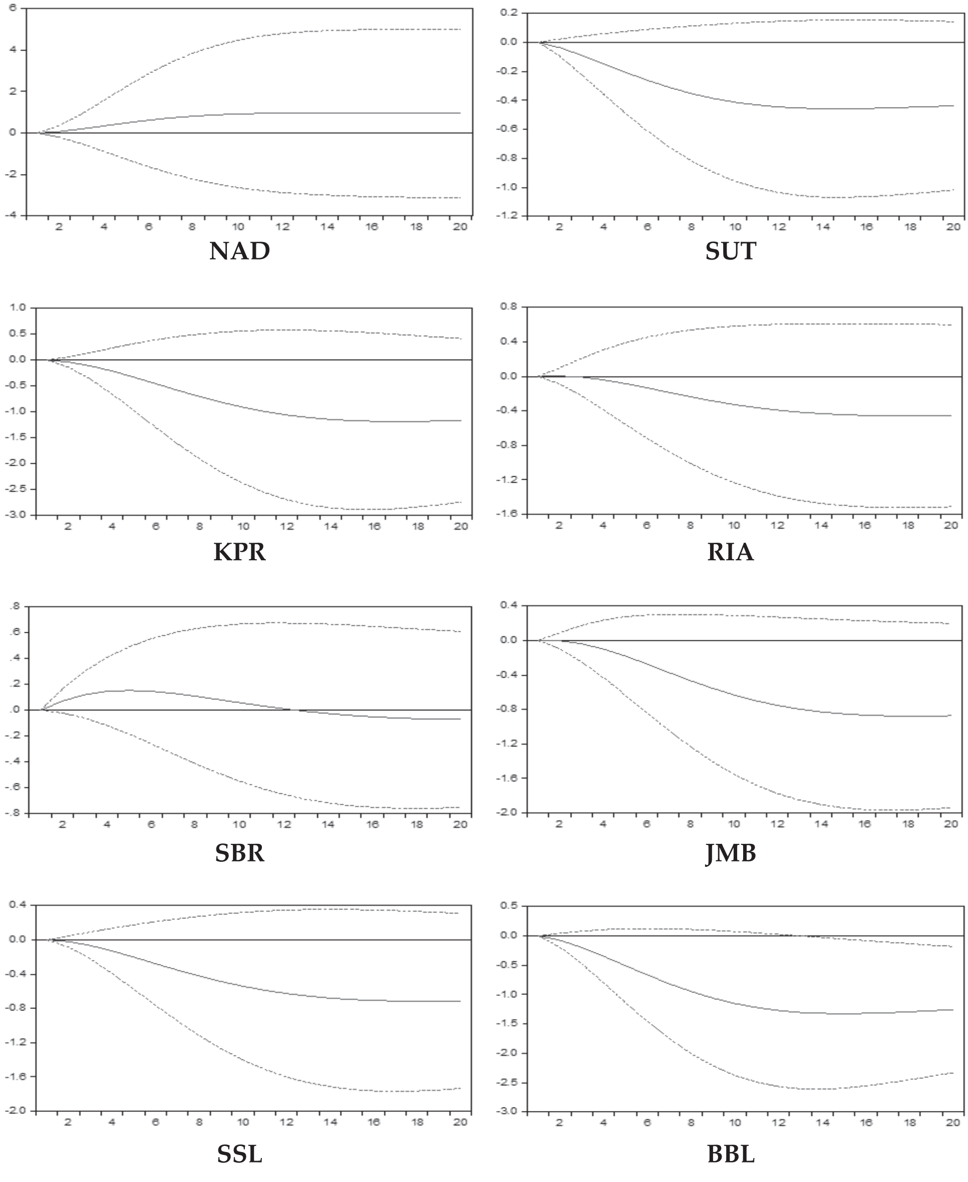


Figure 1.
Impulse Response of Output Gap to a 1 Percentage Point Interest Rate Increase (Accumulated) (Continued)

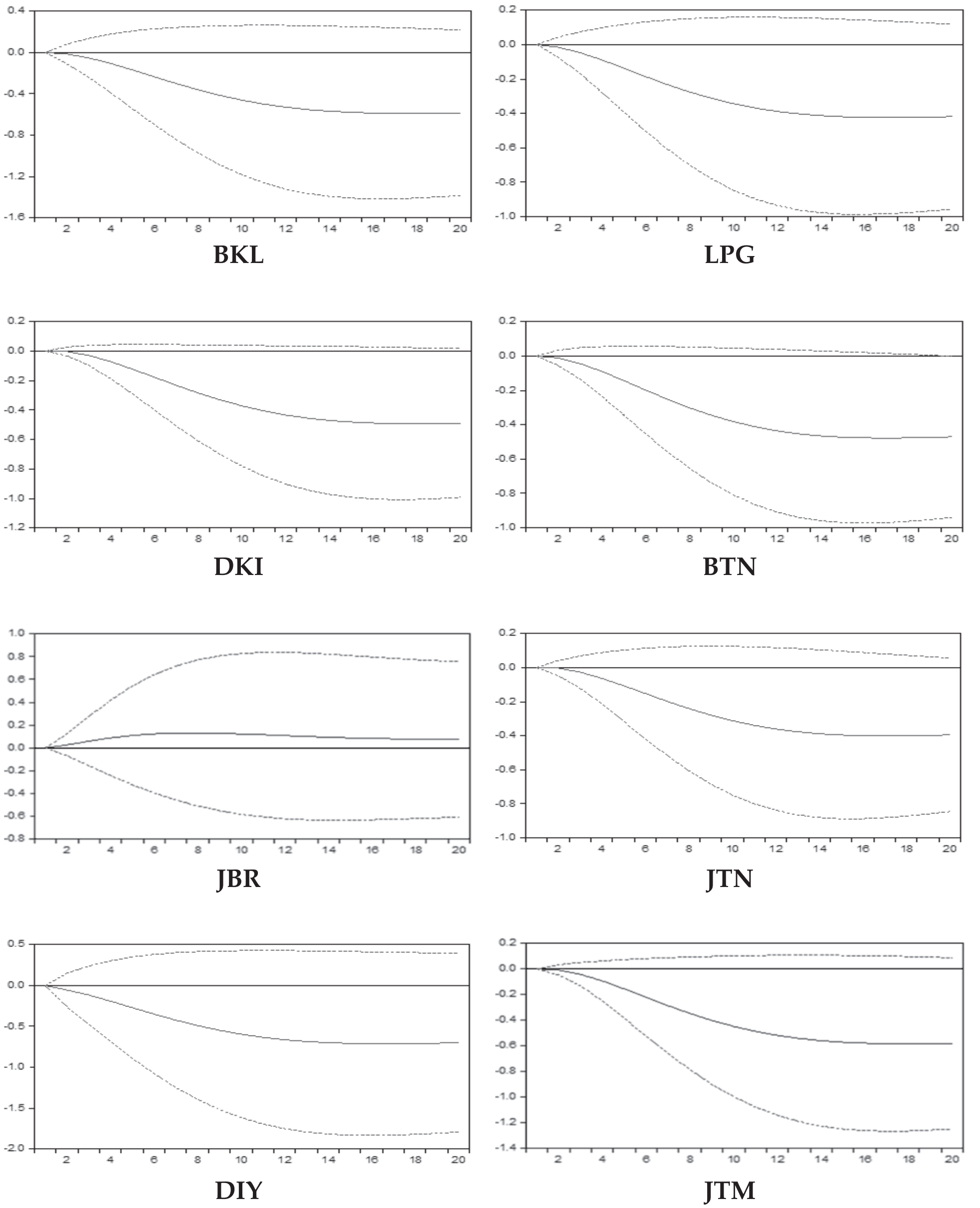


Figure 1.
Impulse Response of Output Gap to a 1 Percentage Point Interest Rate Increase (Accumulated) (Continued)

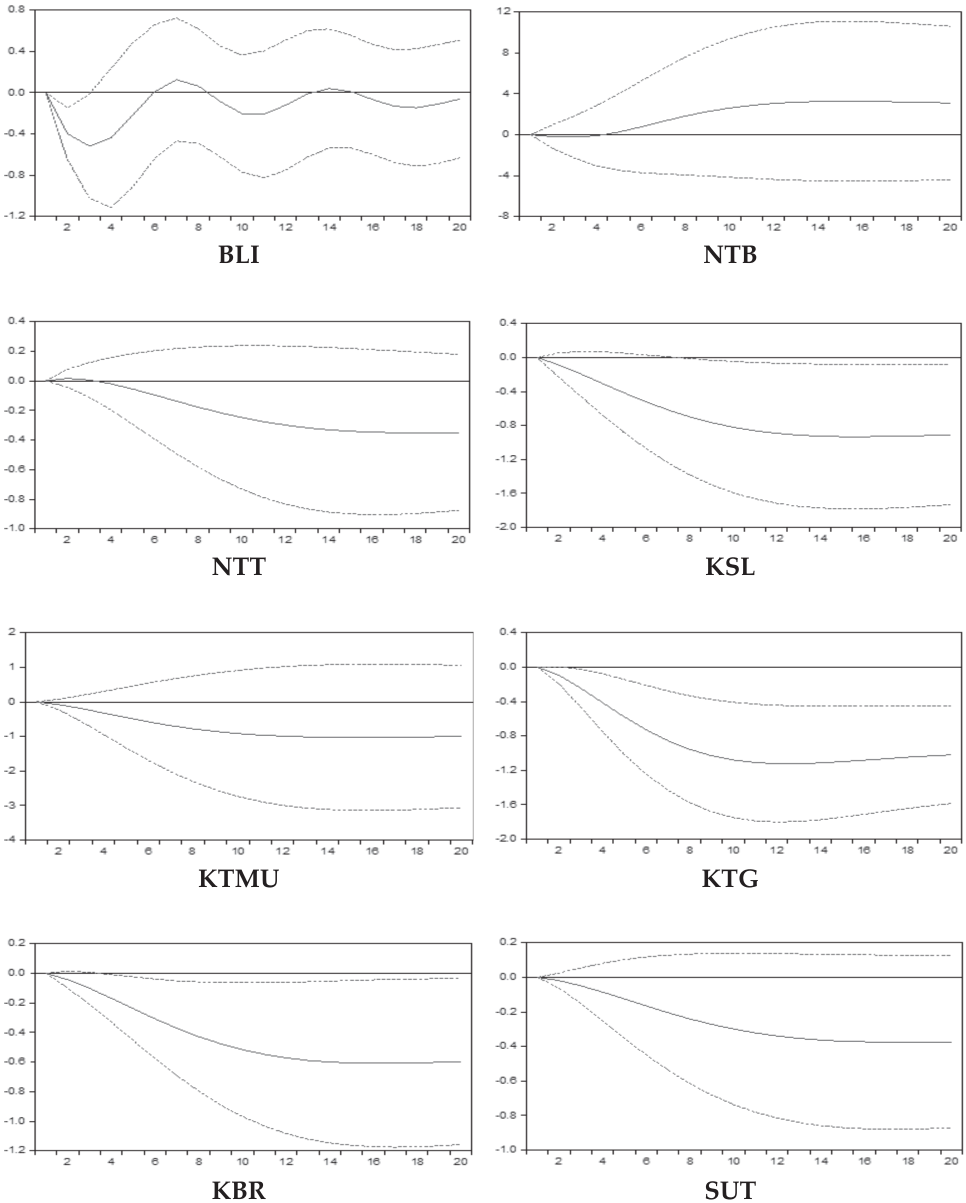
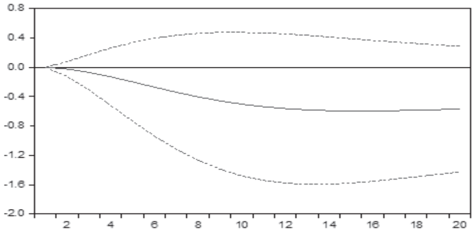
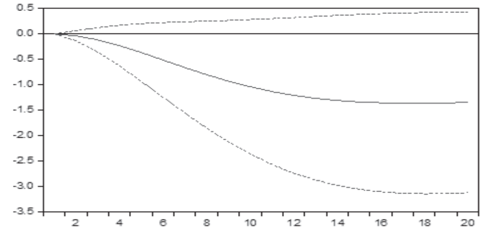


Figure 1.
Impulse Response of Output Gap to a 1 Percentage Point Interest Rate Increase (Accumulated) (Continued)



SSL



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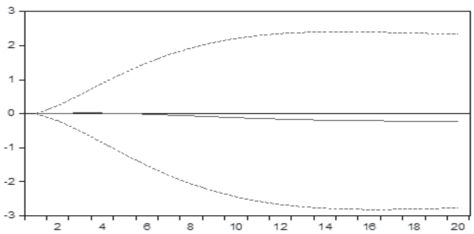

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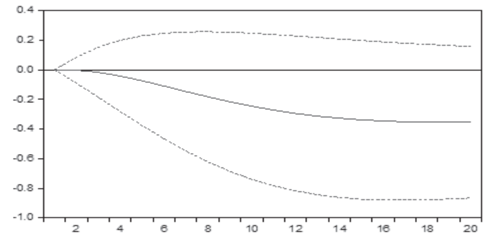

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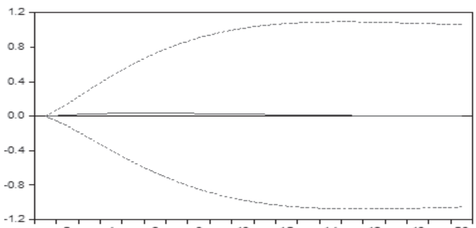

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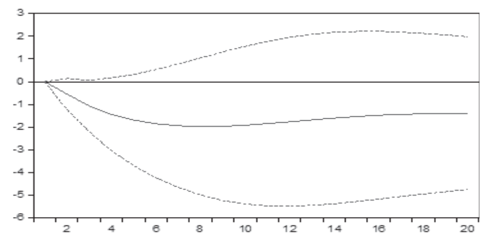

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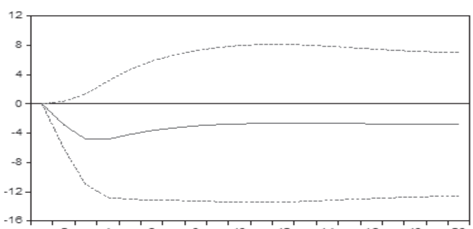
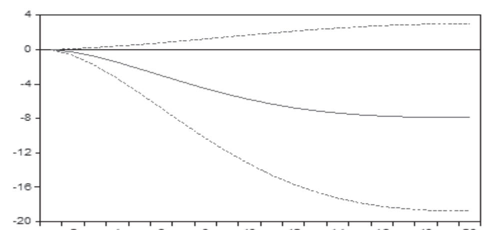


PAP



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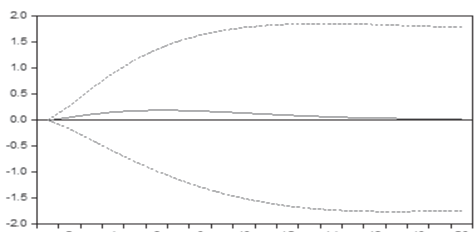

SBR

Table 3.
Recapitulation of Impulse Response for Each Province

This table provides information on the recapitulation of impulse responses of regional output gap to 1% interest rate rise derived from VAR estimation. The direction, magnitude, and timing of each province out gap's response to monetary policy shock are reported. The direction is from accumulated impulse response function while the magnitude and the timing are from the point of estimate of impulse response function.

No.	Province	Direction (The Long Run Response, +/-)	Magnitude (The Biggest Response, %)	Timing (Quarter(s) of the Biggest Response Occurred)
1	Nanggroe Aceh Darussalam (NAD)	+	0,14542	4
2	Sumatera Utara (SUT)	-	-0,05857	5
3	Kepulauan Riau (KPR)	-	-0,12680	7
4	Riau (RIA)	-	-0,05227	7
5	Sumatera Barat (SBR)	-	0,07065	2
6	Jambi (JMB)	-	-0,09716	7
7	Sumatera Selatan (SSL)	-	-0,07587	6
8	Bangka Belitung (BBL)	-	-0,16028	5
9	Bengkulu (BKL)	-	-0,06631	6
10	Lampung (LPG)	-	-0,04878	6
11	DKI Jakarta (DKI)	-	-0,05484	6
12	Banten (BTN)	-	-0,05339	7
13	Jawa Barat (JBR)	+	0,03322	3
14	Jawa Tengah (JTN)	-	-0,04616	6
15	D.I. Yogyakarta (DIY)	-	-0,07937	5
16	Jawa Timur (JTM)	-	-0,06580	6
17	Bali (BLI)	-	0,22423	6
18	Nusa tenggara Barat (NTB)	+	0,11937	4
19	Nusa Tenggara Timur (NTT)	-	-0,04156	7
20	Kalimantan Selatan (KSL)	-	-0,11214	4
21	Kalimantan Timur dan Utara (KTMU)	-	-0,12920	5
22	Kalimantan Tengah (KTG)	-	-0,16836	4
23	Kalimantan Barat (KBR)	-	-0,07028	5
24	Sulawesi Utara (SUT)	-	-0,04053	6
25	Sulawesi Selatan (SSL)	-	-0,07164	6
26	Sulawesi Tenggara (STG)	-	-0,14744	7
27	Sulawesi Tengah (STH)	-	-0,02637	9
28	Gorontalo (GOR)	-	-0,03686	7
29	Maluku (MAL)	+	0,01486	2
30	Maluku Utara (MUT)	-	-0,54045	2
31	Papua (PAP)	-	-2,87427	2
32	Papua Barat (PBR)	-	-0,78660	6
33	Sulawesi Barat (SBR)	+	0,05762	3

From the long-run accumulated impulse response, most regional level output gaps respond negatively to a contractionary monetary policy, five provinces' output gaps respond positively namely Nanggroe Aceh Darussalam, Jawa Barat, Nusa Tenggara Barat, Maluku, Sulawesi Barat. For those provinces that respond positively to the interest rate rise, this result seems contradictory to the prevailing consensus on the structural relationship between the interest rate and output. Nevertheless, some empirical findings have supported these results. Uhlig (2005) found that contractionary monetary policy increases real GDP, and they argued that monetary policy shock has an ambiguous impact on real GDP.

Further, Crowe and Barakchian (2010) stated that examining the impact of monetary policy shock is sensitive to the period being observed. This finding is quite tricky to explain. However, there are some suggestions to justify this empirical case of Indonesia. First, the agriculture and mining sectors are the main contributors to their total GDRP, in which the output commodities are mainly export-oriented. Contractionary monetary policy, theoretically, will appreciate domestic currency and benefit those provinces. The expected monetary policy rise will give an incentive to increase the productivity and investment to those sectors and move up the aggregate output. Second, a contractionary monetary policy may lead to a real interest rate decline in provinces where the inflation rate is higher than the policy interest rate. However, a more rigorous study is required to explain this issue.

Afterward, in terms of the magnitude of the response, some provinces have higher sensitivity of output gap response compared to other province's response or national level output gap responses to a monetary policy change. Top three highest impulse responses from the point of estimates of impulse response function occurred in Papua, Papua Barat, and Maluku Utara; while the lowest responses were found in Maluku, Sulawesi Tengah, and Jawa Barat. The asymmetric of time responses can be seen from the number of quarters when the biggest response takes place. Ten provinces had the biggest response during four quarters after the shock. The remaining provinces had their biggest responses occurred in more than four quarters after the shock. The heterogeneous responses of provincial output gap to a monetary policy shock presumably could be explained by idiosyncratic variation across provinces and determined by strong spatial autocorrelation, which will be explained with spatial analysis in the following sub-section.

C. Spatial Analysis Results

C.I. Spatial Correlation Test

Further analysis was done to identify what factors allegedly explain those heterogeneous responses of the output gap to a monetary policy shock. First, we conduct SLM estimation by using OLS. Then, Global Moran's I test on the OLS residuals is performed to confirm the presence of spatial dependence. Table 4 reports the calculation results of the Moran's I index for each dependent variable, the short-run response (the 4^{th}-quarter value), the long-run response (the 20^{th}-quarter value), and the biggest response. The results suggest that the global Moran's I index is positive, and all results are statistically significant at 1% level. The positive spatial correlations between the responses mean that the responses have statistically significant positive spillover effects.

Table 4.
Global Moran's I Index Testing Results

This table presents information on the Global Moran's I test result. We performed the test on each dependent variable (short-run respond, long-run response, and the biggest response). The second column represents the value of the I index. Note: [a] The *p*-value in the sixth column is obtained from one-tailed test; * LM tests are statistically significant at 10% significance level.

Variable(s)	I	E(I)	SD(I)	Z	*p*-value[a]	LM error*	LM lag*
The Short Run Response	0.167	-0.031	0.035	5.691	0.000	Significant	Significant
The Long Run Response	0.119	-0.031	0.047	3.169	0.000	Significant	Significant
The Biggest Response	0.159	-0.031	0.031	6.058	0.000	Significant	Significant

The Moran's I test results indicate the presence of spatial correlation in the response of a monetary policy shock to the regional output gap. Therefore, the analysis of the factors that explain those asymmetric responses with spatial econometric models is appropriate. To determine the most suitable spatial model, we run a LM test. For the short-run, long-run, and the biggest response, the results of the LM test reported in Table 4 suggest that both spatial error and spatial lag model are statistically significant at 10% level.

C.II. Spatial Econometrics Regression Results

Thereafter, to choose the best model, we run both the SEM and SAR models. The results of the OLS and spatial model estimations are reported in Table 5**.** In selecting the best model between SEM and SAR, we can consider several criteria such as the log-likelihood values (Ryu *et al*., 2017) and AIC (Lee and Ghosh, 2009). The model with a higher log-likelihood or smaller AIC is preferable. According to the results reported in Table 5, the SEM model is more appropriate than SAR for the short-run, long-run, and the biggest responses.

The parameters of spatial regression are all statistically significant when we consider the short-run and the biggest response of the regional output gap to a monetary policy shock as the dependent variable. The coefficients of explanatory variables in those regressions also show the anticipated sign. Since the SEM model is more appropriate in the short-run and the biggest response case, our discussions are based on the results reported in the columns (2) and (8) of Table 5, respectively.

Furthermore, spatially correlated error (lambda) in the short-run and the biggest response regression are statistically significant at 1% and 5% levels, respectively. According to Vega and Elhorst (2012), the interpretation of the SEM coefficient is similar to the OLS parameters since it has no indirect spillover effect. It means that β_i represents each explanatory variable elasticity of impulse response. For instance, in the short-run responses, a 1% increase in the share of the manufacturing sector in regional output (economic structure) will increase the response of the regional output gap to a monetary policy shock by 0.05%. Since our purpose is to investigate how each explanatory variable can explain the heterogeneous response of the output gap to a monetary policy shock, we focus on the interpretation of the direction and the significance of the parameters.

First, our results show that the share of the manufacturing sector to regional output significantly and positively affects the short-run and the biggest responses of the regional output gap to a monetary policy shock. The structure of the economy plays a significant role in influencing the impact of monetary policy on real economic activities. The different shares of the manufacturing sector to regional output will lead to distinct responses to monetary policy. This further verifies the interest rate transmission channel as a wide range of studies has suggested.

This finding supports the existing literature that the manufacturing sector is more sensitive to monetary policy change. This circumstance prevails for both developing countries and developed countries. Alam and Waheed (2006) found empirical evidence in the case of Pakistan in which the major economic sectors, such as manufacturing, mining, wholesale, retail, and financial sectors, are more responsive to monetary policy shock. The study considering the case of India (Nachane *et al*., 2001; Sengupta, 2014) and Indonesia (Ridhwan *et al*., 2011) also confirm the role of manufacturing proportion across the region as a significant variable explaining different responses of monetary policy shock to output gap among regions. In developed economies like the Netherlands and the USA, it has been found that regions with higher manufacturing shares tend to have a higher response to the contractionary monetary policy (Arnold and Vrugt, 2002; Carlino and DeFina, 1998; Pizzuto, 2020).

Second, we also find evidence that economic size significantly matters in influencing the response of monetary policy shock on the regional output gap in the short-run and the biggest response for 20 quarters. The negative coefficient implies that the provinces with relatively bigger output sizes tend to have a lower regional output gap response to a monetary policy shock. Monetary policy shock is more likely to create less output volatility in the provinces with bigger output sizes. Supporting the argument of Reed and Ghossoub (2012), the region with higher output is associated with less dependence on cash and inflation in more developed economies tend to have a positive impact on the economy. Thus, the adverse effect of contractionary monetary policy shock will be absorbed so that the output in the developed regions will tend to be more stable.

Third, financial depth is empirically shown to be positively and significantly impacting the short-run and the biggest response of the regional output gap to monetary policy shock. This suggests that the share of the financial sector to the economy will magnify the response of the real economic activities to a policy change. The provinces with a relatively more significant portion of the financial sector tend to have a more considerable magnitude impact of monetary policy change on the output gap in the short-run and the biggest impact for 20 quarters.

This finding also verifies the significant role of the monetary policy's credit and interest rate transmission channel in influencing real economic activities. Mishra and Montiel (2013) suggested that financial structure is an essential factor in determining the transmission of monetary policy. Several studies have confirmed that better financial development will lead to a more effective monetary policy transmission (Raddatz, 2006; Krause and Rioja, 2006). In contrast, other studies conclude that financial development decreases the impact of monetary policy shock on output (Ma and Lin, 2016; Ma, 2018). However, Ma (2018) highlighted that this condition occurs in the low stage of economic development. In the case of higher economic development, financial development tends to intensify the impact of monetary policy on output growth.

Table 5.
Estimated Regression Model to Explain the Sources of the Asymmetric Response of Monetary Policy Shock

This table displays the result of estimation by using three different dependent variables, namely the short-run response, the long-run response, and the biggest response. Columns (1), (4), and (7) reports results from an OLS model. The remaining columns represent results obtained using spatial econometrics models either by the SEM or SAR model with the maximum likelihood method. The spatial weight matrix used in the regression is calculated using the max-min distance band. *p*-values are given in parentheses. *, **, and *** indicates statistically significant at the 10%, 5%, and 1% level, respectively.

Explanatory Variables	Dependent Variables								
	The Short Run Response (The 4th-Quarter, %)			The Long Run Response (The 20th-Quarter, %)			The Biggest Response (%)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS	SEM	SAR	OLS	SEM	SAR	OLS	SEM	SAR
Economic Structure (ES)	0.05184**	0.05331***	0.04848**	-0.04777	-0.09322**	-0.07321*	0.03173**	0.03328***	0.03040***
	(0.04012)	(0.00366)	(0.01383)	(0.29688)	(0.02080)	(0.07917)	(0.03061)	(0.00164)	(0.00789)
Economic Size (EZ)	-0.09338	-0.09565**	-0.09198*	0.09246	0.12484	0.13626	-0.05962*	-0.06394***	-0.06138**
	(0.12385)	(0.02453)	(0.05565)	(0.40698)	(0.14431)	(0.16840)	(0.09093)	(0.00908)	(0.02809)
Financial Depth (FD)	0.00976**	0.00869***	0.00888***	0.00119	-0.00685	-0.00305	0.00604**	0.00553***	0.00566***
	(0.02021)	(0.00405)	(0.00624)	(0.87334)	(0.30345)	(0.65713)	(0.01369)	(0.00148)	(0.00271)
Trade Openness (TO)	-0.00933	-0.00809*	-0.00856*	-0.00448	0.00085	-0.00094	-0.00534	-0.00476*	-0.00500*
	(0.12302)	(0.07554)	(0.07435)	(0.68543)	(0.92586)	(0.92346)	(0.12709)	(0.06925)	(0.07259)
Constant	-1.30281***	-1.47740**	-1.08157***	-0.11640	0.84502	0.67892	-0.79809***	-0.89636**	-0.67950***
	(0.00741)	(0.01806)	(0.00386)	(0.89103)	(0.37851)	(0.42846)	(0.00487)	(0.01329)	(0.00178)
Lambda									
Constant		0.76719***			0.66389***			0.77175***	
		(0.00008)			(0.00613)			(0.00005)	
Sigma									
Constant		0.67427***	0.68797***		1.32227***	1.37274***		0.38875***	0.40006***
		(0.00000)	(0.00000)		(0.00000)	(0.00000)		(0.00000)	(0.00000)
Rho									
Constant			0.72691***			0.47319*			0.71336***
			(0.00078)			(0.07144)			(0.00132)
Observations	33	33	33	33	33	33	33	33	33
R^2	0.20753			0.13242			0.22459		
Adjusted R^2	0.09432			0.00848			0.11381		
Log-likelihood	-38.45866	-35.30510	-35.74907	-59.04401	-57.02873	-57.70637	-20.39825	-17.15898	-17.79243
AIC	86.91731	84.61019	85.49814	128.08802	128.05747	129.41273	50.79649	48.31796	49.58486

Fourth, we show the influence of trade openness on impacting the output gap responses to a monetary policy change. Trade openness is significant in the short-run and the biggest response; this result is different from Ridhwan *et al*. (2011) that found the effect of the trade openness is statistically insignificant. Thus, we can conclude that the international activities at the regional level and exposure to global markets significantly impact the response of the output gap to policy change at the regional level. This confirms the existing exchange rate transmission channel of monetary policy in Indonesia.

The negative sign of the trade openness' coefficient suggests that the higher level of trade openness, the lesser the effectiveness of monetary policy in narrowing the output gap. A similar result of the negative trade openness' coefficient was also found in a study by Coric *et al*. (2016). A previous study on Ghana (Ahiakpor *et al*., 2019) also supports our findings that higher trade openness tends to reduce the impact of monetary policy on the output gap. Monetary policy shock will affect the exchange rate, which also causes the exchange rate pass-through to import good's prices. Such a mechanism makes the level of inflation to have a higher response than the output gap to the monetary policy shock.

Lastly, the regression output obtained from the long-run response of output gap to monetary shock illustrates that almost all parameters are statistically insignificant. The log-likelihood and AIC values suggest that the SEM is preferable to SAR. In this result, the lambda is also statistically significant, indicating spatial correlation among error terms. The output shows that only the Economic Structure (ES) coefficient is statistically significant, but the sign is the opposite to our prediction. Nevertheless, the insignificance of the most factors we observe to account for the long-run response of the output gap to monetary shock needs a more comprehensive, theoretical, and empirical approach for future research.

D. Robustness Check

To further verify our results, we conduct robustness checks by using two methods. First, we modify the spatial weight matrix in our analysis. In our previous analysis, we constructed the inverse distance spatial matrix by using the max-min distance range as the band. For the robustness check, we revamp the spatial weight matrix by using inverse Euclidean distance, which is the straight-line distance between two points in Euclidean space. In the second robustness check, we also apply numerous estimation methods, such as Maximum Likelihood (ML) and Generalized Spatial Two-Stage Least Square (GS2SLS) to estimate the baseline model. The results are presented in Table 6.

Our robustness check findings are consistent with the earlier reported results. More specifically, the short-run and the biggest response-based results in which all the explanatory variables (*ES*, *EZ*, *FD*, and *TO*) significantly affect the impact of monetary policy on the regional output gap. The magnitude of the parameter for each variable is also found statistically similar with the initial findings. Furthermore, even after altering the spatial weight matrix and the estimation methods, the result of long-run response regression shows that all the explanatory variables are statistically insignificant.

Table 6.
Results of Robustness Check Estimations

This table presents robustness check findings. All the SEM is performed using an inverse Euclidean distance spatial weight matrix. Results reported in columns (1), (3), and (5) are based on maximum likelihood, whereas results reported in columns (2), (4), and (6) are based on GS2LS method. *p*-values are given in parentheses. *, **, and *** indicates statistically significant at the 10%, 5%, and 1% level, respectively.

Explanatory Variables	Dependent Variables					
	The Short Run Response (The 4th-Quarter, %)		The Long Run Response (The 20th-Quarter, %)		The Biggest Response (%)	
	(1)	(2)	(3)	(4)	(5)	(6)
	SEM	SEM_GS2SLS	SEM	SEM_GS2SLS	SEM	SEM_GS2SLS
Economic Structure (ES)	0.05447***	0.04902***	-0.04808	-0.05019	0.03463***	0.03130***
	(0.00622)	(0.00515)	(0.24221)	(0.22609)	(0.00223)	(0.00116)
Economic Size (EZ)	-0.08489**	-0.08362**	0.09899	0.10463	-0.05882**	-0.05763**
	(0.04668)	(0.03876)	(0.34271)	(0.30775)	(0.01562)	(0.01068)
Financial Depth (FD)	0.00825***	0.00738***	0.00275	0.00428	0.00538***	0.00482***
	(0.00702)	(0.00777)	(0.71910)	(0.53410)	(0.00200)	(0.00163)
Trade Openness (TO)	-0.00826*	-0.00753*	-0.00460	-0.00456	-0.00511*	-0.00476*
	(0.08072)	(0.09102)	(0.64819)	(0.65288)	(0.05815)	(0.05548)
Constant	-1.24320***	-1.09364***	-0.20407	-0.30239	-0.77852***	-0.68255***
	(0.00294)	(0.00147)	(0.78969)	(0.69301)	(0.00105)	(0.00025)
Lambda						
Constant	0.84977***	1.32382	-0.10280	-0.03732	0.85284***	1.42176
	(0.00000)	(0.78459)	(0.66764)	(0.90751)	(0.00000)	(0.82318)
Sigma						
Constant	0.58607***		2.06576***		0.19085***	
	(0.00005)		(0.00006)		(0.00005)	
Observations	33	33	33	33	33	33
Wald Chi^2	8.24642		4.5395		10.4078	
Prob>Chi^2	0.0830		0.3379		0.0341	

V. CONCLUSION

This paper provides the empirical verification of the prevailing asymmetric impacts of monetary policy shock on output gap in the case of Indonesia. More specifically, we use data for 33 Indonesian provinces over the period 2005Q1 to 2019Q4. We conduct our empirical analysis using the standard VAR estimation method. The estimated responses from the impulse response function show that the regional output gap responds to a monetary policy change heterogeneously in terms of direction, magnitude, and timing.

Specifically, the five province's output gaps respond positively to a contractionary monetary policy, while the remaining respond negatively. Some province's output gaps responded relatively stronger to the policy shock than the others, and ten provinces had the biggest response during the four quarters after the shock. The other provinces had their biggest responses in more than four quarters after the shock. Further, the spatial analysis proves the regional output gap response to a monetary innovation is related to the spatial dependence among provinces in Indonesia.

Lastly, we found that variation in the share of the manufacturing sector to regional output, financial depth, relative economic size, and trade openness size across provinces in Indonesia is responsible for the heterogeneous responses of the regional output gap to monetary policy shock in the short-run and the biggest responses. Moreover, the findings indirectly verify the significant role of interest rate, credit, and exchange rate channel of the monetary policy transmission mechanism in Indonesia.

This study also suggests that there is a challenge to conform a nationwide monetary policy stance in the presence of regional economic heterogeneity. Cross-region variation has been shown to be a source of asymmetric response of monetary policy at the provincial level. The different responses to a monetary policy shock across regions also imply the deficiency of monetary policy to serve as a counter-cyclical measure for regional economies. Hence, the asymmetric impacts of monetary policy between provinces in Indonesia would raise the concern of the persistent divergence in the regional economic performance.

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