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NONLINEAR AND TIME-VARYING HETEROGENEITY OF THE SPATIAL EFFECT OF G20 COUNTRIES' MONETARY POLICIES

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This study examines how nonlinear and time-varying heterogeneity of the spatial spillover effects of price-based and quantitative monetary policy instruments affect G20 countries' economic growth by building spatial panel smooth transition models with a trade geography weight matrix. We find spatial dependence between economic growth and monetary policy in G20 countries. Then, we use G7+Spain and BRICS to represent developed and emerging economies, respectively, and re-estimate the spatial fixed effect. G7 countries' quantitative monetary policy is not significant, and reduced interest rates do not improve GDP; however, both increased money supply and reduced interest rates improve BRICS countries' GDP. Furthermore, lower interest rates in G7 countries cannot improve GDP during bad times, but during good times, price-based monetary policy effectiveness is improved. Although economic conditions do not affect BRICS countries' quantitative regulation, they do influence price-based monetary policy's effects. Neighboring countries' price-based regulation brings different degrees of spillovers to domestic GDP using both linear and nonlinear models.

Keywords: G20 countries; monetary policy; spatial spillover effects; spatial panel smooth transition model; time-varying heterogeneity.

JEL Classifications: F14, C23, E52

1. Introduction

The Group of Twenty (G20) is one of the most important international economic cooperative forums in the world today. Its member countries include not only major developed countries such as the United States, Japan, Germany, the United Kingdom, and France, but also major emerging economies such as China, Russia, India, and South Africa. G20 member countries account for about 85% of the world's gross domestic product (GDP), with a population close to two-thirds of the global population. The G20 has adopted dialogues to explore various countries' monetary policies and promote stable development

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of the international financial and monetary system. A mechanism for informal dialogue exists within the framework of the Bretton Woods system, which aims to promote reform of the international financial system, ensure cooperation, and promote stability and sustained growth of the world economy.

However, the economic cycles of G20 countries are inconsistent, and their monetary policies also show non-coherent characteristics. On the one hand, for sustainable recovery of the economy, the United States both increased interest rates and reduced the size of the Federal Reserve (Fed) balance sheet to launch the process of monetary policy normalization. Central banks of other developed economies also began normalizing their monetary policies. Further, the European Central Bank reduced the size of its bond purchases in January 2018. Both the United Kingdom and Canada began raising interest rates in the second half of 2017 after maintaining low interest rates for many years. In addition, there is growing concern about when and how Japan will withdraw from the easy monetary policy. On the other hand, non-synchronization characteristics of central banks' monetary policies in emerging economies have become more obvious. In 2018, China maintained a prudent neutral monetary policy, whereas South Africa and Brazil chose a loose monetary policy to lower interest rates further. Argentina, affected by the depreciation of its currency, raised interest rates substantially. Therefore, under the inconsistent monetary policies of the G20 countries, the Fed's monetary policy changes remain an important external factor affecting the financial market trends of emerging economies. The spatial spillover effect from accelerated withdrawal of the United States' unconventional monetary policy and divergence of the monetary policies of developed economies will make emerging economies face several challenges as well as increase the difficulty of communication and coordination of monetary policies among countries.

The monetary policy's spillover effect refers to the impact of a country's monetary policy changes on other countries' economic growth, price levels, and exchange rates through channels such as trade and financial capital flows. With the acceleration of economic globalization, links among the major economies of the world are becoming increasingly close. When a country changes its macroeconomic policies, these policies' spillover effects quickly spread to neighboring regions and countries (Kelejian *et al*., 2006). The increase in international trade and cross-border financial flows means that countries are more susceptible than ever to economic shocks from both home and abroad. The subprime crisis showed how these shocks spread so rapidly that they engulfed the world economy (Feldkircher and Huber, 2016). Therefore, a country's economic growth impacts its neighboring countries. Similarly, when a country uses monetary policy tools, it affects the economic growth and monetary policies of its neighboring countries.

The spillover effect of the monetary policy mainly occurs through trade and financial channels. First, from the perspective of trade channels, although the depreciation of currency is conducive to promoting the export of emerging economies, it may be difficult to show this effect in the short term. Second, from the perspective of financial channels, depreciation of the currency not only aggravates the dollar debt burden of emerging economies but also undermines the balance sheet and affects the solvency and profitability of enterprises; this impacts the stock and bond markets. Along with an increase in the Fed's interest rate and appreciation of the US dollar, the attractiveness of US dollar assets rises, and emerging economies face a new round of international capital outflow pressure, which may lead to systemic risks for them. Meanwhile, the effectiveness of quantitative and price-based monetary policies also changes as the economic environment and monetary policy transmission mechanism change (Zhang and Jin, 2018). Therefore, the following questions remain. Does a country's economic growth bring positive or negative effects to its neighboring countries and regions? How much influence does its monetary policy have on the formulation and implementation of neighboring countries' monetary policies?

A review of the relevant literature shows that many scholars have used the vector autoregressive (VAR) model to study how the monetary policies of the world's major economies affect other countries' macroeconomic variables. For example, Kim (2001) used the VAR model to study the international transmission mechanism of the US monetary policy shock from the perspective of a flexible exchange rate. Kim studied whether the expansion of the US monetary policy would lead to other countries' recession or prosperity, and whether monetary expansion would improve or worsen the trade balance. Canova (2005) used the VAR model to study how the US monetary policy affects eight Latin American countries. The results showed that the US aggregate demand shock had minimal influence on US macroeconomic variables, whereas US monetary policy had a huge effect on the eight Latin American countries.

In addition, some scholars have studied the influence of monetary policy on macroeconomic variables by extending the VAR model. For example, Bernanke *et al*. (2005) studied the impact of macroeconomic variables of monetary and non-policy shocks using the novel structural factor-augmented VAR model. Gambacorta *et al*. (2014) estimated the macroeconomic effects of unconventional monetary policies in eight advanced economies using the panel VAR model. However, this classic VAR model requires six to eight variables during variable selection because of the limitation of estimation parameters. To break through this limitation, many scholars adopted the factor-augmented VAR model to study this problem, such as Borys *et al*. (2009), Chuku (2009), Chua (2012), Gabriel and Lutz (2017), and Munir and Qayyum (2014). However, simple models such as VAR, structural VAR, and factor-augmented VAR cannot measure the spatial relationship among sections. Therefore, some scholars introduced spatial factors into VAR models to create the spatial VAR (SpVAR) model. For example, Di Giacinto (2003) studied the asymmetric effects of monetary policy using a SpVAR model. Beenstock and Felsenstein (2007) studied the relationship between real income, population, real estate prices, and housing stock in nine regions of Israel for 1987–2004 using the SpVAR model.

Pesaran *et al*. (2004) proposed the global VAR (GVAR) model, which has been used widely in macroeconomic policy analysis. The GVAR model can measure interdependence among markets or countries that are connected by a weight matrix — an economic or geographic matrix. Elhorst *et al*. (2021) compared the expression and estimation methods of dynamic spatial panels and GVAR models, which have many similarities and correlations. From a structural perspective, traditional spatial econometrics is a special case of the GVAR model. Therefore, many scholars have used the GVAR model to study the influence of US monetary policy on other economies. This type of shock is spatial. For example, Eickmeier and Ng (2015) used the trade matrix as a GVAR-weighted variable to study how the US credit supply's impact was passed on to other economies. Georgiadis (2015) used the hybrid cross-section GVAR model to study asymmetry of the Euro monetary policy transmission. The results showed that the US monetary policy has brought huge output spillover effects to other parts of the world. Feldkircher and Huber (2016) used the Bayesian global VAR model to study the international spillover effects of US expansionary aggregate demand and supply shocks and tightened monetary policy shocks. The results showed that positive demand and supply shocks trigger an increase in real output, whereas tight monetary policy shocks reduce output across the region.

In recent years, the literature on how monetary policy affects macroeconomic variables has gradually extended to spatial correlation and heterogeneity. Some scholars explored the spatial correlation of monetary policy in the world's major economies. The implementation and effects of monetary policy may be affected by other countries. For example, Blinder *et al*. (2008) proposed that communication can be an important channel for central bank policy tools because it can improve the accuracy of monetary policy decision making and potentially help central banks achieve macroeconomic goals. National economic decisions influence each other by improving the commercial and financial relationships among countries. Even if each country's monetary policy efficiency differs according to the level of development, the monetary policy of developed countries' central banks will affect that of other countries. For example, any monetary policy tool of the Fed, European Central Bank, Bank of England, and Bank of Japan directly or indirectly influences the monetary policy of other countries (Arikan and Yalcin, 2017).

Nonlinear research on the spatial effects of monetary policies has focused on the policies' asymmetry in different economic cycles (Tenreyro and Thwaites, 2016) and the asymmetry of how different monetary policy instruments affect macroeconomic variables (Peng and Fang, 2016). In addition, policy variables may shift smoothly or jump with spatial heterogeneity. For example, Pijnenburg (2013) used spatial panel smooth transition regression (SPSTR) to study the heterogeneity of house prices. Wu and Liu (2017) used the dynamic spatial panel and spatial panel smooth transfer to study the bilateral trade balance between China and the Association of Southeast Asian Nations.

Compared with the literature mentioned above, this study makes the following contributions: First, the existing research discussed how monetary policy affects its regulation effect using the VAR model. However, whether the economic state is good or bad, this model of the asymmetry of monetary policy regulation is not applicable because linear regression such as VAR cannot examine the effects of monetary policy under different economic conditions. We solve this problem better by using the panel smooth transition regression (PSTR) model. Second, the existing research has hardly discussed the spatial spillover of monetary policy, even though the monetary policy of one country affects the GDP of other countries through trade channels, and financial channels, among others. Through the spatial econometric model, we can more clearly observe the impact of a country's monetary policy changes on other countries, so as to help the country prevent the harm caused by monetary policy spillovers. Third, the monetary policy regulation effects of the world's major economies are quite different. Therefore, we divide the sample into the

Group of Seven (G7) plus Spain and BRICS countries (Brazil, Russia, India, China, and South Africa) to examine the heterogeneity of monetary policy regulation and spatial spillovers.

The rest of this paper is organized as follows. Section 2 explains the specification of the SPSTR model based on time and the spatial interaction panel model. Section 3 illustrates the spatial dependence and nonlinear characteristics of G20 countries' monetary policies using a spatial-dependent test and nonlinear tests. Section 4 describes the data and analyzes the empirical results. Lastly, Section 5 concludes the paper.

2. Model Specification

2.1. *Linear spatial econometric model*

Compared with traditional econometrics, the spatial econometric model considers the effects of the dependent and independent variables on the dependent variable with a spatial weight matrix. Anselin (1988) systematically summarized several common spatial measurement models. Later, Baltagi (2008), Elhorst (2014), and other scholars proposed the spatial lag model (SLM) and spatial error model (SEM). Since then, LeSage and Pace (2009) perfected the SLM and SEM and proposed a spatial Durbin model (SDM) containing the lag terms of the spatially interpreted and spatial explanatory variables. Following Anselin (1988) and Elhorst (2014), we first specify a spatial model as follows:

$$\mathbf{Y}_{\mathrm{t}} = \delta \mathbf{W}\mathbf{Y}_t + \alpha \boldsymbol{\iota}_N + \mathbf{X}_t \boldsymbol{\beta} + \mathbf{W}\mathbf{X}_t \theta + \mu + \zeta_t \boldsymbol{\iota}_N + \mathbf{u}_t, \tag{1}$$

where $t = 1, 2, \ldots, T$ represents the time series, $\mathbf{Y}_t$ represents the dependent variable column vector, and $\mathbf{W}$ is the spatial weight matrix. Then, $\mathbf{W}\mathbf{Y}_t$ is expressed as an endogenous interaction spatial variable, and $\boldsymbol{\iota}_N$ is the $N \times 1$ th-order unit vector, which is related to the estimated constant term parameter α and time-period specific effects ξ_t. $\mathbf{X}_t$ is the $N \times K$ th-order exogenous explanatory variable matrix. β and θ are the $N \times 1$th-order unknown parameter vector that needs to be estimated. $\mu = (\mu_1, \cdots, \mu_N)^T$ is the constant term vector. In the fixed-effect model, dummy variables are introduced for each spatial unit and each time, and they are subject to independent and identical distribution. $\mathbf{u}_t$ is a random error vector.

2.2. *Nonlinear spatial econometric model*

Although Equation (1) shows the linear form of the spatial econometric model, monetary policy regulation is likely to be asymmetrical. For example, whether the GDP is good or bad, the effect of monetary policy regulation is different. Therefore, we consider nonlinear (transition) models for this purpose. In general, a transition model is mainly of three categories: the Markov regime transition, threshold regression, and smooth transition regression models. Based on the PSTR model by Gonzalez *et al*. (2017), this study incorporates spatial lag-dependent variables into the model to specify a SPSTR model, which can make ordinary panel models have endogenous interactions and thus ensure that exogenous parameters of the spatial panel model are no longer fixed to a value. The SPSTR model thus allows the estimated coefficient to change over time. Therefore, the PSTR model parameters can be transformed with different economic states, so that the spatial spillover effect of monetary policy is more dynamic.

Moreover, the panel threshold regression (PTR) proposed by Hansen (1999) and univariate smooth transition autoregression model (STAR) proposed by Teräsvirta (1994) laid an important theoretical foundation for the nonlinear regression model. The PTR model divides the sample data into different regimes by the threshold value, and the regression coefficients of different regimes are jumps. The PTR model is an instantaneous jump transition, but it often involves smooth transition. To characterize the parameters' heterogeneity between the cross-section units and the effects over time (Fouquau *et al*., 2008), nonlinear smoothing of the specific form of the transition model is as follows:

$$\mathbf{y}_{it} = \mu_i + \boldsymbol{\beta}_0'\mathbf{x}_{it} + \boldsymbol{\beta}_1'\mathbf{x}_{it}\mathbf{g}(\mathrm{q}_{it};\gamma,c) + \varepsilon_{it}, \tag{2}$$

for $i = 1,\ldots,N$ and $t = 1,\ldots,T$, where N and T denote the cross-section unit and time dimension in the panel model, respectively. $\mathbf{y}_{it}$ is the dependent variable, whereas $\mathbf{x}_{it}$ is a k-dimensional vector of time-varying exogenous variables, μ_i represents the fixed individual effect of each country, and ε_{it} is the random error term. $\boldsymbol{\beta}_0$ and $\boldsymbol{\beta}_1$ represent the linear coefficient and the nonlinear coefficient to be estimated, respectively. We follow Teräsvirta (1994) by setting and estimating the STAR model. Given the need for a bounded continuous function whose range converges between 0 and 1, a smooth transition in the form of a logistic function is more reasonable. This can make the transition of PTR mutation more soothing and gradual, so as to better describe the cross-sectional heterogeneity of panel data. The specific expression is as follows:

$$g(q_{it};\gamma,c) = \left\{1 + \exp\left[-\gamma\prod_{j=1}^{m}(q_{it} - c_j)\right]\right\}^{-1} \quad \text{with} \quad \gamma > 0 \quad \text{and} \quad \mathrm{c}_1 \le c_2 \le \cdots \le c_m, \tag{3}$$

where q_{it} represents economic growth as the transition variable. $c = (c_{1,\cdots,}\, c_m)'$ is an m-dimensional vector of location parameters, reflecting the threshold of the transition function. Slope parameter γ is a smooth transition coefficient, reflecting the speed of the transition. In practice, it is generally enough to consider $m = 1$ or $m = 2$. As these values allow for commonly encountered types of variation in the parameters, transition equation $g(q_{it};\gamma,c)$ appears as part of the nonlinear smooth transition and is usually interpreted as a regime-switching regression model. For $m = 1$, the model implies that the two extreme regimes are associated with low and high values of q_{it} with a single monotonic transition of the coefficients from $\boldsymbol{\beta}_0$ to $\boldsymbol{\beta}_0 + \boldsymbol{\beta}_1$ as q_{it} increases, where the change is centered around c_1. When $\gamma \to \infty$, $g(q_{it};\gamma,c)$ becomes an indicator function $I[q_{it} > c_1]$, which is defined as $I[A] = 1$ when event A occurs, and 0 otherwise. In this case, the PSTR model in Equation (2) reduces to the two-regime panel threshold model of Hansen (1999). For $m = 2$, the transition function achieves its minimum value at $(c_1 + c_2)/2$ and attains the value of 1 at both low and high values of q_{it}. When $\gamma \to \infty$, the model becomes a three-regime threshold model whose outer regimes are identical but differ from those of the middle regime. In general, when $m = 1$ and $\gamma \to \infty$, the number of distinct regimes remains two, with the transition function switching back and forth between zero and one at $c_1,\ldots,c_m$. Finally, for any value of m, the transition function in Equation (3) becomes constant when

$\gamma \to \infty$, in which case the model collapses into a homogenous or linear panel regression model with fixed effects.

To further evaluate the threshold effects of specific transition variables and the spatial spillover effects of monetary policy, we can specify a new SPSTR[1] model based on Equations (1)–(3):

$$\begin{aligned}\mathbf{Y}_t &= \delta\mathbf{W}\mathbf{Y}_t + \alpha\boldsymbol{\iota}_N + \mathbf{X}_t\beta + \mathbf{W}\mathbf{X}_t\theta + \zeta_t\boldsymbol{\iota}_N \\ &\quad + (\delta\mathbf{W}\mathbf{Y}_t + \alpha\boldsymbol{\iota}_N + \mathbf{X}_t\beta + \mathbf{W}\mathbf{X}_t\theta) \times G(q_{it};\gamma,c) + u_t, \end{aligned} \tag{4}$$

where $\mathbf{W}$ represents the spatial weight matrix, and element w_{ij} in the spatial weight matrix represents the spatial dependence of region i on region j. Therefore, the spatial weight matrix is an exogenous variable matrix that affects the change process of the endogenous variables studied. The spatial weight matrix is calculated from the geographic information of the object under study, such as the proximity rule, distance matrix, and threshold matrix. However, the matrix's construction directly affects the model's estimation results; therefore, it is important to construct a spatial weight matrix in spatial econometrics. Let the spatial weight matrix of n spatial regions be

$$\mathbf{W} = \begin{pmatrix} 0 & w_{1,2} & \cdots & w_{1,n-1} & w_{1,n} \\ w_{2,1} & 0 & \cdots & w_{2,n-1} & w_{2,n} \\ \vdots & \vdots & & \vdots & \vdots \\ w_{n-1,1} & w_{n-1,2} & \cdots & 0 & w_{n-1,n} \\ w_{n,1} & w_{n,2} & \cdots & w_{n,n-1} & 0 \end{pmatrix}, \tag{5}$$

where $\mathbf{W}$ is spatial weight matrix, and $w_{ii} = 0$. There are four main methods to create a spatial weight matrix based on geo-spatial association: adjacent, k-value adjacent, distance-based, and distance-attenuated spatial weight matrices. To reflect the geographical information of trade between G20 countries, we first obtain the trade distance based on the total import and export trade[2] of G20 countries, which can reflect the trade dependence and correlation of the world's major economies. Second, we calculate the spatial distance matrix of G20 countries, reflecting the geographical dependence of the world's major economies, and further combine it with the trade geographical weight matrix. The equation is as follows:

$$w_{ij} = 1/(\text{distance}_{ij} * \ \text{trade}_{ij}). \tag{6}$$

3. Data

3.1. *Variable selection*

Most of our data samples come from the EIU Viewpoint database for G20 countries and Spain (except for Argentina, Afghanistan, and the European Union). Argentina and

[1] The meaning of the expressions in Equation (4) is the same as that in Equations (1)–(3) and is not repeated here.
[2] The dataset comes from UN Comtrade: https://comtrade.un.org/db/.

Afghanistan are excluded because of missing data and large data deviations. Further, the European Union is excluded as it has the same monetary policy as the G20 countries of France and Germany, which, along with Spain, represent EU countries in this study. We select quarterly data from 2000–2019 as our sample (we only consider changes in monetary policy prior to COVID-19, which may impact our estimates, since COVID-19 has led to the start of helicopter money in many countries). Table 1 presents the relevant variables selected in this study (for more details on sources and selection of each variable, see Appendix A).

First, to examine the effectiveness of monetary policy regulation, we choose year-on-year GDP as the dependent variable.[3] However, the effectiveness of monetary regulation is quite different from that of quantitative and price-based tools, and the channels and mechanisms through which they affect the economy are also different. We select short-term (generally three-month) interest rates as a proxy variable for the price-based monetary policy, but the nature of this variable for each country is different (see Appendix A for

Table 1. Variable Description[a]

The Variable Code	Indicator Explanation	Data Source
DGDP	Percentage change in real GDP, over previous year	EIU Viewpoint
QGDP	Percentage change in real GDP, over previous period	
Total assets	Total assets of the central bank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets. Taking the logarithm of total assets	
M2	Percentage change in M1 plus quasi–money, over previous year	
M1	Percentage change in total supply of notes and coins plus demand deposits, over previous year	
RAT3	Money market interest rate (%; average)	
INVF	Net flows of direct investment	
IPI	Percentage change in index of industrial production, over previous year; construction is not included	
FSI	Stock of Market Index (Monthly)	Datastream
	Exchange rate (Monthly)	
	Government bond yield:10-year benchmark (end month)	
IMPORT	Classification: HS 2017	Comtrade
EXPORT	Classification: HS 2017	

Notes: DGDP, QGDP, M2, M1, RAT3, INVF, IPI are quarterly data, Total assets and FSI (financial stress index) are monthly data, we obtain quarterly data by averaging. Import and export data are annual data, and we calculated the average value for the sample period.

[a]Appendix B presents descriptive statistics of all variables for all samples and G7 plus Spain and BRICS countries.

[3]To ensure accuracy of the regression estimation results, we also select the previous period's GDP (quarterly GDP) as the transition variable for a smooth transition of the panel.

details). There are also differences in the quantitative monetary policy tools employed by different types of countries, especially developed and emerging economies. Emerging economies generally use money supply M1 or money supply M2 as proxy variables for quantitative monetary policy. However, developed countries have been in the low interest rate range for a long time, during which they have implemented several quantitative easing policies. For this reason, we choose the central bank's total assets as its quantitative monetary policy proxy variable and take the logarithm of total assets. In addition, we select M1 and M2 as robustness tests.

Second, to ensure the estimates' reliability, we select the net flows of direct investment industrial production index, and financial stress index as control variables. Specifically, we adopt Dovern and van Roye (2014) method of estimating the financial stress index and construct a single and continuous overall indicator reflecting financial market conditions through principal component analysis. The financial stress index includes volatility in stock market yields, foreign exchange yields, and government bond yields. By estimating the generalized autoregressive conditional heteroskedasticity (1, 1) model, stochastic volatility of the three market returns is obtained. All series use monthly average data, and after calculating it, the financial stress index is converted into quarterly data. For descriptive statistics of all variables, see Appendix B.

Finally, when selecting the spatial matrix of trade geographical weighting, the ArcGIS software is used to calculate each country's center coordinates, and an 18×18 geographic matrix is obtained (for G20 plus Spain, except Afghanistan, Argentina, and the European Union). From the UN Comtrade database, we use data of each country's import and export with all other countries in the sample (average for 2000–2019), add them to identify the total import and export, and use this to construct an 18×18 trade matrix. Based on the geographic and trade matrices, the $w_{ij} = 1/(\text{distance}_{ij} * \text{trade}_{ij})$ formula is used to calculate the geographically weighted spatial trade matrix.

Table 2. Panel Unit Root Test

	Pesaran CD Test			IPS Test	
	CD Test	p-Value	Correlation	Z-t-Tilde-bar	p-Value
DGDP	143.14	0.000	0.602	−12.1437	0.000
QGDP	84.94	0.000	0.401	−18.1263	0.000
Total Assets	80.54	0.000	0.447	−15.2188	0.000
M2	142.03	0.000	0.601	−15.2425	0.000
M1	82.11	0.000	0.392	−15.8972	0.000
RAT3	195.27	0.000	0.819	−15.3551	0.000
DIPI	101.18	0.000	0.438	−17.7157	0.000
INVF	76.43	0.000	0.409	−17.1482	0.000
FSI	178.65	0.000	0.749	−18.5192	0.000

Notes: Under the null hypothesis of cross-section independence CD $\sim N(0,1)$, Pesaran CD test is the cross-sectional dependence of the second-generation Pesaran (2007) test, IPS test is the first-generation Im *et al*. (2003) test.

3.2. *Unit root test*

Before performing parameter estimation, a unit root test must be performed to avoid spurious regression caused by non-stationary variables. The data are examined using the cross-sectional dependence of the second-generation Pesaran (2007) test and the test method of the first-generation Im *et al*. (2003) test. Table 2 presents the results. Whether it is the second- or first-generation unit root test, all variables have a *P*-value of 0, indicating that these variables can be entered directly into the model.

4. Specification Tests and Empirical Results

4.1. *Spatial dependence test and regression analysis*

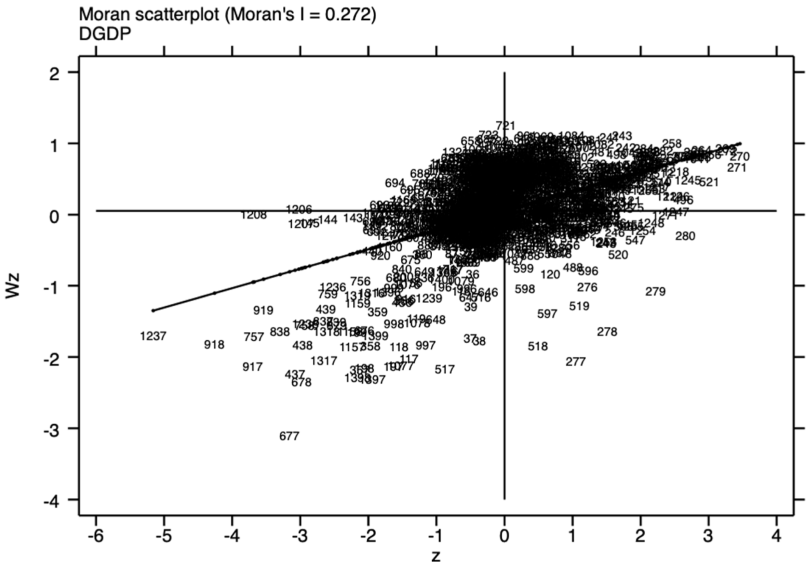
Before estimating Equation (1), we should examine whether G20 countries have spatial correlations in economic growth. The spatial dependence test is the basis for establishing a spatial econometric model. By observing its results, we can judge whether the research object is included in the scope of spatial measurement. Spatial autocorrelation refers to the similarity of values in similar areas. If one high-value area is close to another high-value area and a low-value area is adjacent to another low-value area, we call it positive spatial autocorrelation. If a high-value area is adjacent to a low-value area, it is negative spatial autocorrelation. If the high- and low-value areas are randomly distributed, there is no spatial autocorrelation. The specific form of Moran's I index is as follows:

$$I=\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i-\bar{x})(x_j-\bar{x})/S^2\sum_{i=1}^{n}(x_i-\bar{x})^2, \tag{7}$$

where $S^2=\sum_{i=1}^{n}(x_i-\bar{x})^2/n$ is the sample variance, $\bar{x}=\sum_{i=1}^{n}x_i/n$ is the sample mean, and w_{ij} is the (i,j)th element of the spatial weight matrix. $\sum_{i=1}^{n}\sum_{j=1}^{n}w_{ij}$ is the sum of all spatial weight matrices, x_i represents the economic growth of country i, and n is the total number of countries.

Based on the trade geography weight matrix, the spatial dependence of economic growth in G20 countries is estimated. A scatterplot of Moran's I index is shown in Figure 1. Moran's I index is 0.272 and the Z-value is 22.28, which is significant. Moreover, there is a positive spatial correlation between economic growth in various countries. However, Figure 1 shows that most of the dots in the scatterplot are concentrated in the first and third quadrants.

Table 3 examines the effect and spatial contagion of monetary policy through a spatial econometric model, where the first column is the spatial autoregressive (SAR) model, which contains the spatial dependence of economic growth. The second column is the SDM model, which also contains spatially weighted estimates of other independent variables. Moreover, developed countries have adopted some quantitative easing methods, such as the Securities Market Programme implemented by the European Central Bank in 2010. Therefore, the developed country samples in the first and second columns choose total assets as the proxy variable of quantitative monetary policy, and emerging economies continue to use the M2 indicator.



Notes: The Moran scatterplot is an illustration of the relationship between the values of the chosen attribute at each location and the average value of the same attribute at neighboring locations.

Figure 1. Moran's I Index Scatter Plot

First, whether in the SAR or SDM model, the increase in neighboring countries' GDP drives the increase in the country's GDP. Then, quantitative monetary policy rules have a positive effect on economic growth. However, note that if neighboring countries adopt quantitative monetary policy rules, it hurts their economic growth (W*QMP reflects the quantitative monetary policy of neighboring countries). This may be because the increase in neighboring countries' currency drives their demand, crowding out the domestic demand and causing the domestic economy to decline. It is worth noting that price-based monetary policy is not significant, which may be related to long-term low interest rates in developed countries.

Second, some control variables also have spatial effects. For example, the higher the industrial index of neighboring countries, the more negative the domestic economy's growth. A possible explanation is that the higher the neighboring countries' industrialization index, the lower the prices of the products they produce; this has a negative effect on other countries' demand for their products and is not good for their GDP. Moreover, if the neighboring countries' financial stress index is higher, the premium cost may be higher; this lowers the cost of a domestic company, which is beneficial to economic growth. This shows that changes in economic variables in many neighboring countries have spillover effects on their own GDP.

Furthermore, to illustrate that our estimation results are robust, we replace the proxy variables of the quantitative monetary policy and compare the estimated coefficients by using the SAR and SDM models. Comparing the coefficients estimated by the SAR and SDM models, the direction and significance of the monetary policy coefficients have not changed significantly. Comparing and replacing the columns of quantitative monetary

Table 3. Parameter Estimates for Spatial Models G20 plus Spain

	Baseline		Robust (QMP=M2)		Robust (QMP=M1)	
	(1)	(2)	(3)	(4)	(5)	(6)
*W**GDP	0.445***	0.625***	0.417***	0.606***	0.435***	0.608***
	(24.2245)	(23.7581)	(22.2636)	(21.9898)	(23.6002)	(22.1842)
QMP	0.0271***	0.0443***	0.0405***	0.047***	0.0273***	0.032***
	(5.572)	(7.7577)	(8.5315)	(8.8929)	(6.8811)	(7.8554)
RATE	0.0068	−0.0037	−0.0152*	−0.0181*	−0.0015	−0.0034
	(0.86569)	(−0.3493)	(−1.787)	(−1.6608)	(−0.17937)	(−0.32438)
IPI	0.3612***	0.3725***	0.3584***	0.3722***	0.3561***	0.3698***
	(44.43)	(47.441)	(44.5416)	(47.8081)	(43.535)	(46.7199)
INVF	0.0021	0.0004	0.002	0.0001	0.0026	0.0003
	(1.1464)	(0.18256)	(1.1058)	(0.071017)	(1.407)	(0.13346)
FSI	−0.197*	−0.2885**	−0.1682*	−0.2621***	−0.1567**	−0.2579**
	(−1.9315)	(−2.7009)	(−1.6707)	(−2.4663)	(−1.5376)	(−2.4049)
*W** QMP		−0.0425***		−0.0226**		−0.0129
		(−5.0052)		(−2.6765)		(−1.6399)
*W**RATE		0.0204		0.0106		0.0021
		(1.5124)		(0.73116)		(0.14245)
*W**IPI		−0.1627***		−0.1658***		−0.1653***
		(−8.3998)		(−8.5036)		(−8.3334)
*W**INVF		0.0063*		0.0069**		0.0084**
		(2.0475)		(2.237)		(2.6386)
*W**FSI		0.3384*		0.3932**		0.4262**
		(1.688)		(1.9784)		(2.096)

Notes: *, **, *** indicate significant values at 10%, 5%, and 1%, respectively, t-test in parentheses. The dependent variable is GDP. QMP stands for quantitative monetary policy rules, in the baseline, with QMP representing the total asset variable. Since developed countries have adopted quantitative easing, we choose the central bank's total asset as its quantitative monetary policy proxy variable. Emerging economies still use M2 as a proxy variable for quantitative monetary policy.

policy regulation (columns (3)–(6)), the direction and significance of the estimated coefficients of quantitative monetary policy variables remain unchanged. These results suggest that our estimates and models are robust. Only in the third and fourth columns are the interest rates correlated with economic growth at the 10% level. What is the reason for this phenomenon? It is possible that different types of countries have different monetary policy effectiveness. Further, we split all country samples into G7 plus Spain and BRICS countries, representing developed and emerging economies, respectively.

Table 4 presents the results of spatial differences in the monetary policy in different economies, where G7 plus Spain represents advanced economies (columns (1)–(2)) and BRICS represents emerging economies (columns (5)–(6)). Columns (3)–(4) replace the quantitative monetary policy with M1 and M2 as the robustness tests.

First, from the perspective of G7 plus Spain, the quantitative monetary policy is not significant and robust, and the price-based monetary policy is positive for economic

Table 4. Parameter Estimates for Developed and Emerging Economies

	G7 plus Spain (QMP=Total Assets)		G7 plus Spain (M2, Robust)	G7 plus Spain (M1, Robust)	BRICS (M2)	
	(1)	(2)	(3)	(4)	(5)	(6)
*W**GDP	0.477***	0.6500***	0.639***	0.619***	0.504***	0.617***
	(19.6669)	(24.708)	(23.6525)	(21.865)	(17.9317)	(21.4657)
QMP	−0.0343	0.2501	−0.0079	0.0056	**0.0403*****	**0.0634*****
	(−0.95861)	(0.75061)	(−0.58129)	(1.0745)	**(6.3299)**	**(6.2049)**
RATE	0.1421***	0.5385***	0.5432***	0.5518***	−0.0721***	−0.062*
	(5.9587)	(9.9736)	(10.0467)	(10.0272)	(−4.072)	(−1.8481)
IPI	0.2071***	0.2073***	0.209***	0.2073***	0.2472***	0.284***
	(23.3791)	(23.5276)	(23.688)	(23.5709)	(15.5798)	(16.9331)
INVF	0.0009	0.0014	0.0016	0.0016	0.0001	0.0048
	(0.74726)	(1.1972)	(1.3326)	(1.3453)	(0.022293)	(0.73515)
FSI	−10.2321***	−14.6924***	−13.1813***	−12.7786***	0.1162	−0.0504
	(−3.7299)	(−3.956)	(−3.694)	(−3.5915)	(1.2406)	(−0.42835)
W* QMP		−0.3126	0.0398**	0.0216**		−**0.0333*****
		(−0.93221)	(2.4054)	(2.7678)		(−**2.9935**)
W*RATE		−**0.495*****	−**0.4994*****	−**0.4759*****		−0.0015
		(−**8.6379**)	(−**8.7956**)	(−**8.2741**)		(−0.041327)
W*IPI		−0.0932***	−0.0844***	−0.0866***		−0.1107
		(−6.9231)	(−6.0712)	(−6.2929)		(−5.0235)
W*INVF		0.0006	0.0013	0.0016		−0.0025
		(0.3161)	(0.68426)	(0.87796)		(−0.34482)
W*FSI		6.4211	6.8503	6.4171		0.2426
		(1.4798)	(1.6309)	(1.5304)		(1.4655)

Notes: This table divides the G20 countries into G7 plus Spain and BRICS countries, in which the first column and the fifth column are the SAR model estimation results of the two types of SAR economies. Columns (2) and (6) are the estimated results of SDM for the two types of economies, respectively. Columns (3) and (4) replace the quantitative monetary policy tools of G7 plus Spain with M2 and M1, respectively, to examine the robustness of the estimates.

growth. This is likely because G7 countries cannot improve through a rate cut when the economy is down. However, if other G7 countries raise interest rates, it will cause their domestic GDP to decline. (The estimated coefficient for W*RATE is −0.495.) When neighboring countries implement M1 or M2, the domestic economy also grows, but the influence coefficient is small. Similarly, an increase in the production index of neighboring countries hurts their economic growth, which is consistent with the sample of all countries.

Second, columns (5) and (6) of Table 4 show the spatial effect of monetary policy in the BRICS countries. Both quantitative and price-based monetary policies are significant, because they raise interest rates, improve economic recession, and increase the money supply to boost the economy. Moreover, from the spatial effect perspective, the rate hike of BRICS countries does not affect their economies, which shows that the price-based monetary policy spillovers of emerging economies are very weak. If other BRICS countries issue additional currencies, it will cause a decline in their own GDP.

Furthermore, to better explain the effectiveness of different types of national monetary policies, we consider that the effectiveness of the economy is different in different states, such as those experiencing good or bad times in terms of GDP. Therefore, we examine the asymmetric effects of monetary policy through nonlinear models.

4.2. *Linearity and no remaining nonlinearity tests*

Before using the panel smooth transition model, we test whether these variables have nonlinear effects. This is significant to explain statistics and economics. Statistically, the homogeneity tests (linearity and no remaining nonlinearity tests) verify that the data-generating process has nonlinear characteristics to avoid invalidity of the estimation of Gonzalez *et al*. (2017). From an economic perspective, such tests are useful to verify economic theories, such as the nonlinear characteristics of macroeconomic variables.

Following Luukkonenetal (1988) and Hansen (1996), we carry out first-order Taylor expansion of Equation (4) around zero to construct a linear regression model of the auxiliary regression equation, so as to test whether nonlinearity exists. The expansion formula is as follows:

$$y_{it} = \mu_i + \beta_0^{T*} x_{it} + \beta_1^{T*} q_{it} + \cdots + \beta_m^{T*} x_{it} q_{it}^m + \mu_{it}^*, \tag{8}$$

where parameter vectors $\beta_1^*, \ldots, \beta_m^*$ are multiples of γ and $u_{it}^* = u_{it} + R_m \beta_1^T x_{it}$, and R_m is the remainder of the Taylor expansion. Consequently, testing in Equation (2) is equivalent to testing null hypothesis $H_0^* : \beta_1^* = \ldots = \beta_m^* = 0$ in Equation (8). Since previous studies have documented that the F-version of the test has better size properties in a small sample than do asymptotic-based statistics (Dijk *et al*., 2002), if the null hypothesis is rejected, the model is nonlinear.

Test results of the Wald tests (LM), Fisher test (LMF), and likelihood ratio tests (LRTs) are shown in Table 5. In the first line of testing, null hypothesis $H_0 : r = 0$ means that there is no transition equation, that is, there is no nonlinear model; alternative hypothesis $H_1 :$ $r = 1$ means that there is a transition equation. In Table 5, $m = 1$ means there is one transition position, and $m = 2$ means there are two transition positions.

First, for G7 plus Spain, the LM and LMF tests and LRT all reject the null hypothesis but accept the alternative hypothesis. Further, we test whether there are multiple transition equations. In the next test, all three tests (LM, LMF, and LRT) reject null hypothesis $H_0 : r = 1$, indicating more than one transition equation. However, we compare the size of the test statistic and conclude that it is optimal to have one transition equation ($r = 1$). When we choose the number of transition equations, we also need to consider the economic intuition. If there are more than one (or two) transition equations, it is difficult to explain the economic meaning of the coefficient estimates. Similar to the BRICS countries, choosing one transition location ($r = 1$) is optimal. Second, we test that there are several best transition positions. The LM test and LRT indicate that two transition positions are better than one, but the LMF test shows that one transition position is better in the G7 plus Spain sample. In this case, one transition position is more concise and can better reflect the difference in monetary policy between the economy under the two regional systems of

Table 5. Nonlinear Test

	Statistics	G7 plus Spain $m=1$	G7 plus Spain $m=2$	BRICS $m=1$	BRICS $m=2$
Linearity test $H_0: r=0; H_1: r=1$	Wald Tests (LM)	140.625	175.713	20.853	66.065
	P-Value	(0.000)	(0.000)	(0.035)	(0.000)
	Fisher Test (LMF)	15.898	10.494	1.920	3.354
	P-Value	(0.000)	(0.000)	(0.036)	(0.000)
	LRT Tests (LRT)	158.791	205.418	21.416	72.207
	P-Value	(0.000)	(0.000)	(0.029)	(0.000)
Nonlinear test $H_0: r=1; H_1: r=2$	Wald Tests (LM)	41.724	68.211	44.477	28.150
	P-Value	(0.000)	(0.000)	(0.000)	(0.171)
	Fisher Test (LMF)	3.798	3.188	4.117	1.208
	P-Value	(0.000)	(0.000)	(0.000)	(0.238)
	LRT Tests (LRT)	43.146	72.127	47.150	29.190
	P-Value	(0.000)	(0.000)	(0.000)	(0.140)

Notes: This table examines the nonlinear tests of G7 plus Spain and the BRICS countries. If the Linearity test is rejected, it means that the model may have nonlinearity. The transition equation and the number of transition positions are considered together with reference statistics and economic intuition.

good and bad times. In this situation, where the statistical test is ambiguous, choosing one transition position can more clearly explain the asymmetric effects of monetary policy in good and bad economic conditions. Therefore, in the G7 plus Spain sample, we choose one transition position ($m = 1$). Similarly, in selecting the transition location of BRICS countries according to the statistical and economic significance, choosing two transition positions ($m = 2$) are optimal.

Table 6 shows the nonlinear estimation results of the spatial effects of monetary policy in two types of economies. As with the previous setting, we use M2 as the robustness test of quantitative monetary policy in G7 countries. The estimation results in Table 6 needs to be viewed in conjunction with the transition probability in Figure 2.

First, consistent with the linear estimates, quantitative monetary policy in G7 countries is insignificant. Moreover, Table 6 and the left-side transition probability in Figure 2 explain that, in a bad economy, cutting of interest rates by G7 countries does not improve the economy. This result corresponds exactly to the interest rate estimates for G7 countries in Table 4. However when the economy is experiencing a good time, raising interest rates can ease its overheating. This shows that the price-based monetary policy of G7 countries is asymmetric in good and bad economic situations.

For BRICS countries, the transition probability graph shows a U-shaped pattern, indicating that when the economic growth rate is below 1.5% year-on-year, it transfers from the high- to the low-regime, and when the economic growth exceeds 1.5%, it transfers from the low- to the high-regime. Combined with the estimated coefficients in Table 2, the estimated coefficient of the price-based monetary policy of BRICS countries is 0.153 ($-0.9561 + 1.1091 \times 1$) at the worst moment of the economy, implying that GDP is in bad

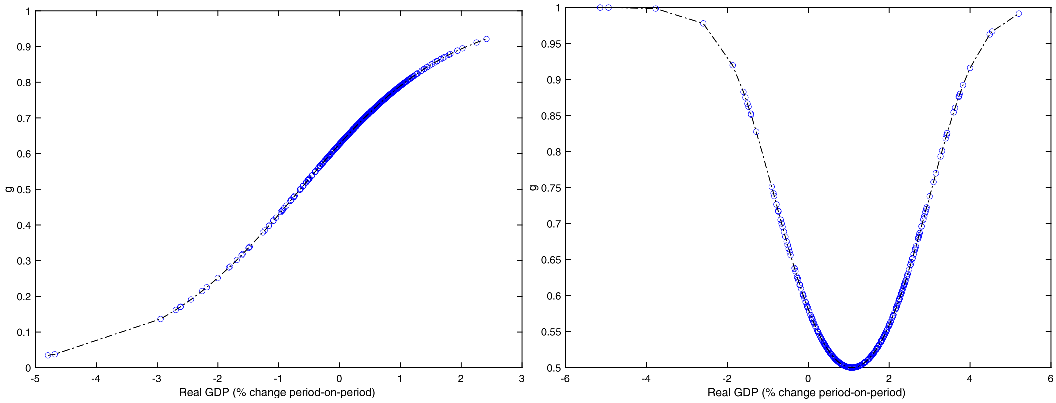
Table 6. Parameter Estimates for the S-PSTR

	G7 plus Spain (QMP=Total Assets)		G7 plus Spain (M2, Robust)		BRIICS	
	β_0	β_1	β_0	β_1	β_0	β_1
W*GDP	0.67666***	−0.12022	0.6776***	−0.1213	1.1351***	−0.57754***
	(4.4598)	(−0.37223)	(4.1123)	(−0.3558)	(5.9672)	(−2.6193)
QMP	−0.86548	2.2556	0.0151	−0.0159	0.15873*	−0.11371
	(−0.7904)	(0.95904)	(0.39004)	(−0.18522)	(1.8804)	(−1.1433)
RATE	**1.1644***	**−1.3622***	**1.1982***	**−1.4072***	**−0.95611***	**1.1091***
	(4.8891)	**(−2.5252)**	**(5.0176)**	**(−2.6767)**	**(−4.5898)**	**(4.3428)**
IPI	0.17865***	−0.0018636	0.18***	−0.0047	0.12919	0.17914
	(5.6636)	(−0.024703)	(5.8396)	(−0.0649)	(1.2888)	(1.4831)
INVF	0.0058876	−0.010849	0.0058	−0.0104	−0.16774***	0.18993***
	(1.153)	(−1.0251)	(1.1129)	(−0.97622)	(−3.8454)	(3.8395)
FSI	−20.604***	46.0257**	−22.0537***	49.9154**	1.548	−2.22
	(−2.6696)	(2.0525)	(−2.875)	(2.2988)	(1.7859)	(−1.8001)
W* QMP	0.87996	−2.2151	0.0078	0.0454	−0.12113	0.12602
	(0.7971)	(−0.93939)	(0.094746)	(0.69975)	(−1.3069)	(1.1388)
W*RATE	**−1.4806***	**2.1629***	**−1.5397***	**2.2268***	**1.1351***	**−0.57754***
	(−5.194)	**(3.528)**	**(−5.5382)**	**(3.8371)**	**(5.9672)**	**(−2.6193)**
W*IPI	−0.11414*	0.017296	−0.1155*	0.0218	0.15873*	−0.11371
	(−2.0171)	(0.1361)	(−1.9058)	(0.16675)	(1.8804)	(−1.1433)

Table 6. (*Continued*)

	G7 plus Spain (QMP=Total Assets)		G7 plus Spain (M2, Robust)		BRIICS	
	β_0	β_1	β_0	β_1	β_0	β_1
W*INVF	0.0060293	−0.013726	0.0061	−0.0131	−0.95611*	1.1091*
	(0.61854)	(−0.66776)	(0.62212)	(−0.64386)	(−4.5898)	(4.3428)
W*FSI	−12.8013	26.6661	−12.5117	25.4511	0.12919	0.17914
	(−1.1673)	(0.8511)	(−1.0996)	(0.80958)	(1.2888)	(1.4831)
γ	0.8142		0.8034		0.2803	
c	0.7080		0.6467		−1.0794	
					−1.0793	
RSS	320.824		320.874		356.784	

Notes: *, **, *** indicate significant values at 10%, 5%, and 1%, respectively, t-test statistic in parentheses. β_0 is a linear estimated value, β_1 is a nonlinear estimated value, and the final estimated value is transferred between $\beta_0 + \beta_1 * G$, which needs to be combined with the logistic regression probability value of the transfer equation.



Notes: The transition probability plots from left to right are G7 plus Spain and BRICS. The abscissa uses real GDP (% change period-on-period) to represent the economic situation, and the ordinate is the probability value of the logistic function.

Figure 2. Transition Probability Plot for Logistic Function

times and that cutting interest rates will not improve the GDP. However, as the economic situation improves, the effect of interest rate cuts on stimulating the economy gradually increases. At the transfer threshold of approximately 1.5%, an estimated value of -0.4016 $(-0.9561 + 1.1091 \times 0.5)$ can be calculated. Further, when the chain QGDP (over the previous period) growth is another 1.5–5%, raising interest rates is effective in slowing down the overheating of the economy, but this effect decreases with the increase in the QGDP. In sum, the effectiveness of BRICS countries' price-based monetary policy is very dependent on their economic growth. However, the estimated value of β_1 for the nonlinear part of quantitative monetary policy is not significant, indicating that issuing money is effective regardless of whether the GDP is good or bad.

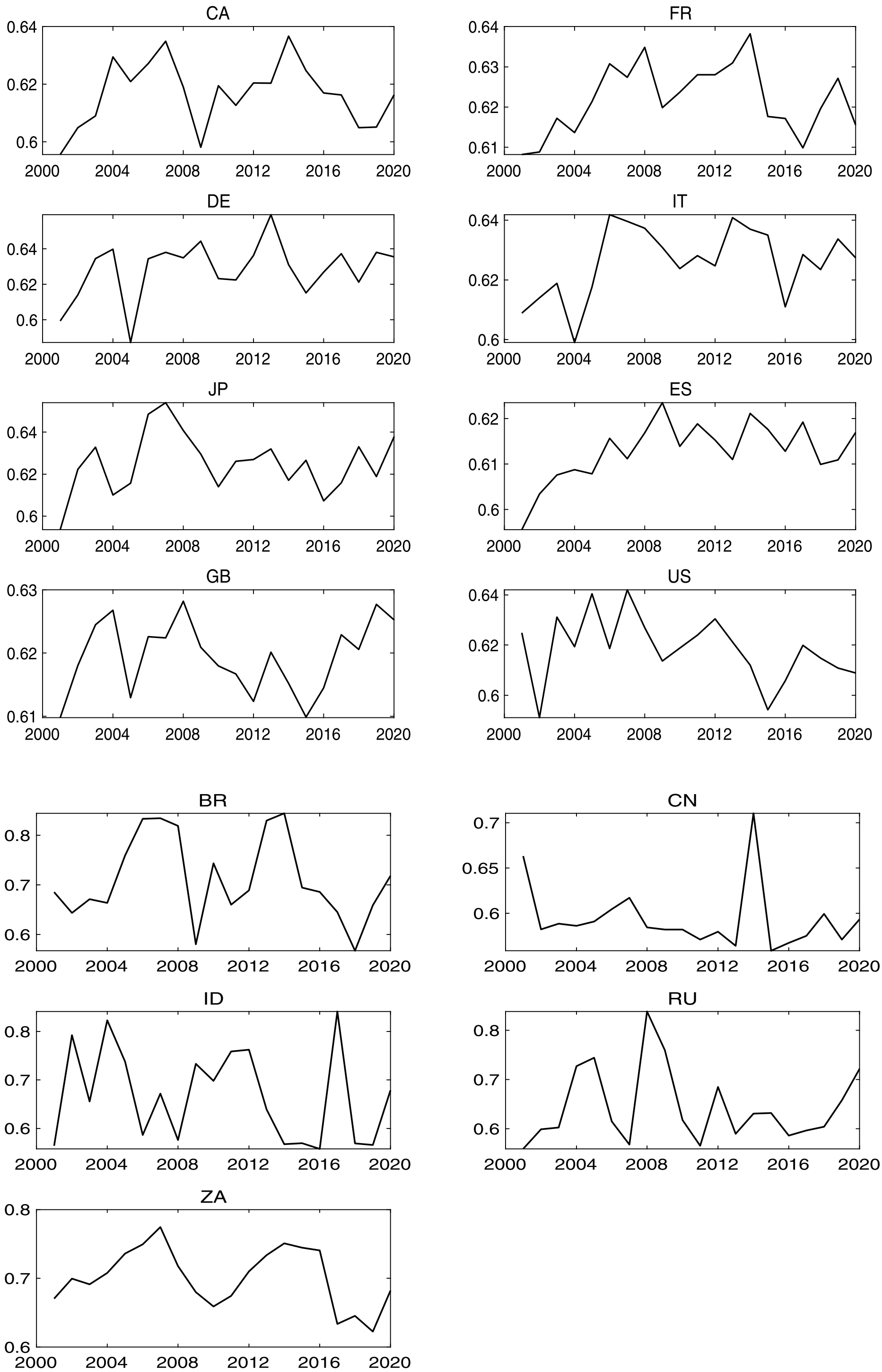
Second, from the perspective of the spatial effect, the quantitative monetary policy has no spatial effect for either G7 or BRICS countries. However, the price-based monetary policy has spatial spillover effects for G7 countries; if neighboring countries raise interest rates when the economy is bad, there are negative spillovers to the home country. If the GDP is good, the interest rate hike in neighboring countries has little impact on the country.

In sum, the monetary policies of G7 and BRICS countries have not only spatial effects but also nonlinear characteristics. When the economy is in different states, the monetary policy's effectiveness differs, quantity-based regulation of neighboring countries does not affect the country, and price-based regulation brings spillover effects to the country's GDP, which is affected by different economic conditions.

4.3. *Dynamic path of spatial effects*

The effectiveness of monetary policy is different for each country in different periods or stages. Using the PSTR model, we can calculate the time-varying elastic coefficients of different variables for each country.

Figure 3 shows the spatial dependence of GDP, that is, the impact of neighboring countries' GDP on the GDP of the home country. The first eight graphs represent G7 plus



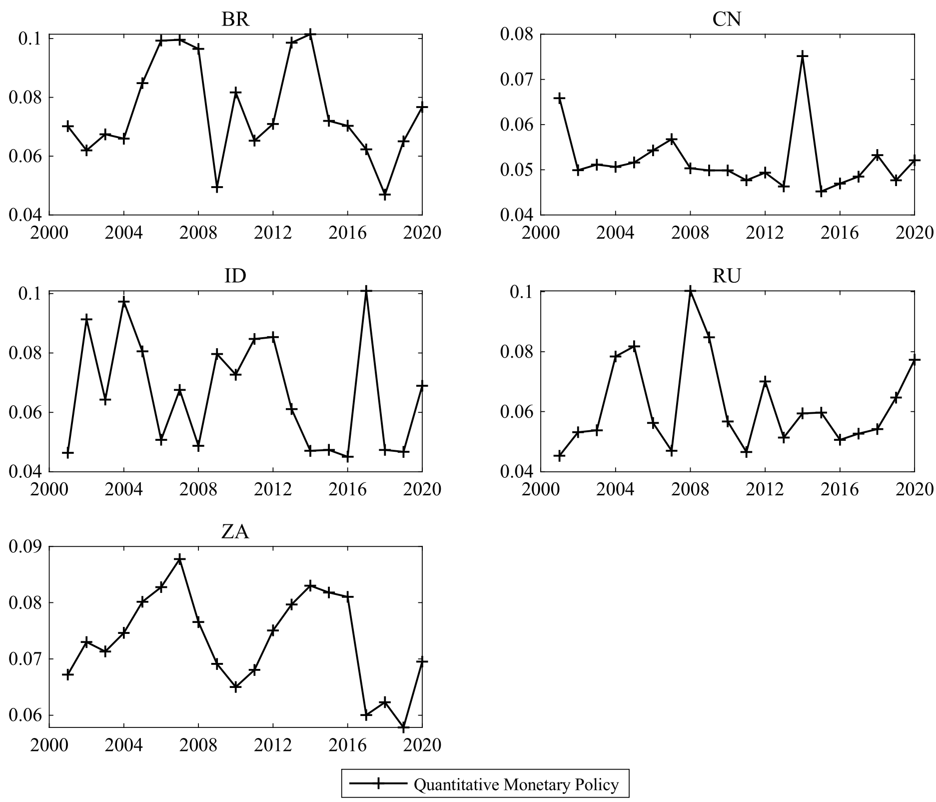
Notes: The eight countries in the first four rows are G7 plus Spain, and the last three rows are the BRICS countries.

Figure 3. Time-varying Coefficient Elasticity of Endogenous Interaction Effects

Spain, and the last five graphs represent BRICS countries. First, the GDP of neighboring countries is highly positively correlated to their own countries, and BRICS countries' GDP spatial dependence is higher than that of the G7 countries. However, judging from Figure 3, the fluctuation of BRICS countries' time-varying GDP spatial dependence is significantly higher than that of the G7 countries (except for South Africa, the amplitude of other countries is 0.55–0.85).

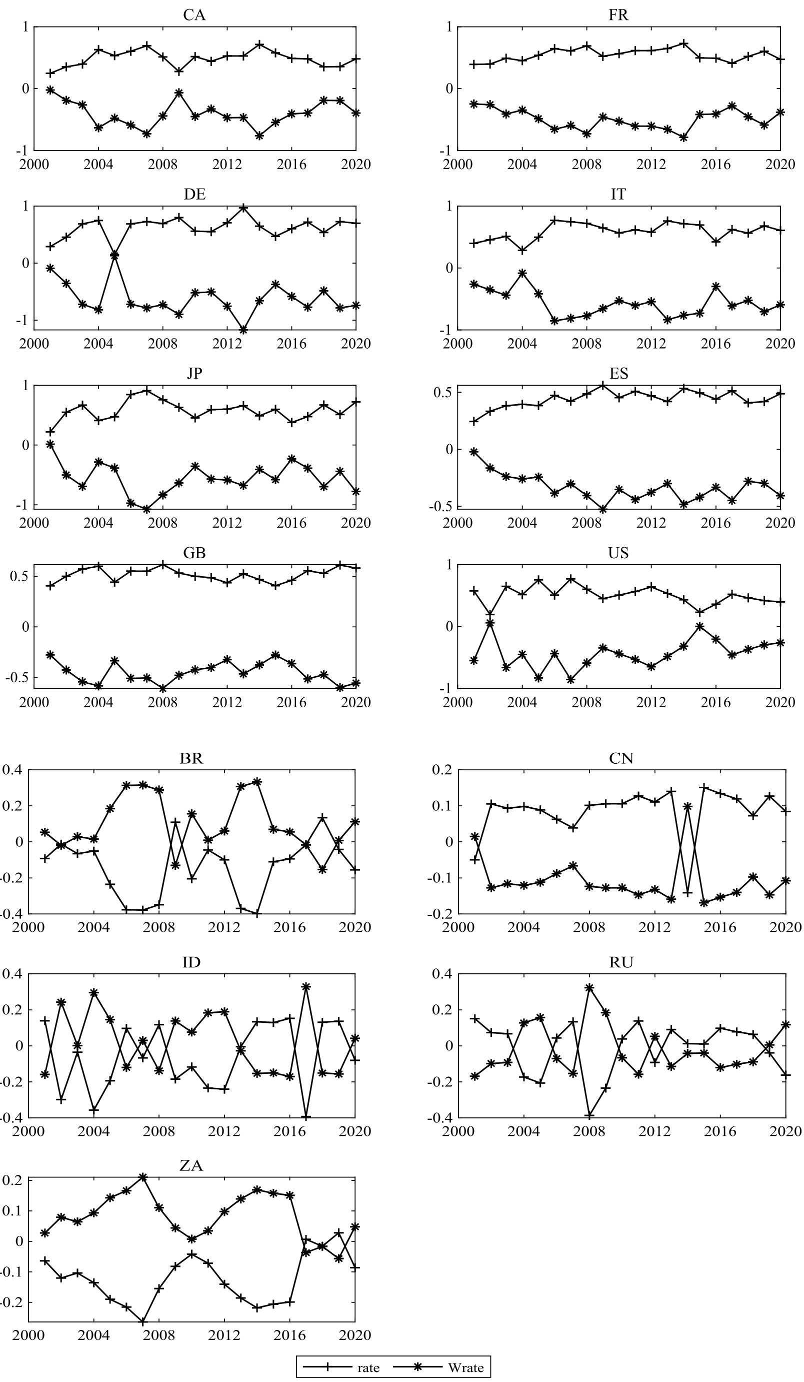
Figure 4 shows the elastic graph of the time-varying coefficient of BRICS countries' quantitative monetary policy. The coefficients fluctuate greatly in each country according to different times, but we can get some useful information from this graph. The effect of M2 between years was good (the coefficient was about 0.1), but its coefficient dropped significantly to about 0.05 in 2009, which indicates a financial crisis. The effect of Brazil's M2 on GDP was improved in 2010. South Africa was similar: the effect of its M2 was always good and improving before 2008; after that, its effect on GDP gradually declined until 2011, when it began to change.

Figure 5 shows the elastic graph of the estimated coefficients of interest rate estimates for G7 and BRICS countries. The horizontal line with a cross represents the impact of



Notes: Since the estimated coefficients for the G7 countries are not significant, we report only the results for BRICS countries.

Figure 4. Elasticity Diagram of Time-varying Coefficient of Quantitative Monetary Policy of BRICS Countries



Notes: The horizontal line with a cross is the estimated coefficient of short-term interest rates, and the horizontal line with an asterisk is its spatial effect, that is, the impact of interest rate changes in neighboring countries based on the country's gross domestic product.

Figure 5. Time-varying Coefficient Elasticity and Spatial Effects of Price-based Monetary Policy Tools

short-term interest rates on GDP, and the horizontal line with stars represents the impact of neighboring countries' interest rate changes on the home country's GDP. The estimated coefficients of interest rates in the G7 countries are all positive. This result may be because the economy is in a bad time, and it is difficult to improve it by reducing interest rates. However, raising interest rates can help ease overheating of the economy in good times (in Section 3.2, Figure 3 shows the differences in regulation of interest rate instruments under different GDP states). In addition, in the G7 sample, an increase in interest rates in neighboring countries brings a large negative spillover to the home country's GDP, but this phenomenon is not obvious in BRICS countries (except that a rate hike in BRICS countries has a large spillover to China's GDP).

5. Conclusion

Effective use and implementation of monetary policy tools ensure stable development of the entire economic and financial system. Changes in monetary policy in the world's major economies affect the economic growth of other countries. This involves both endogenous and exogenous interactions. The change in central banks' monetary policies causes changes in economic indicators. In turn, changes in economic indicators cause dynamic changes in central banks' policies. With globalization of the world economic system, the economic focus of G20 countries has been moving eastward from the Pacific to Asian countries, indicating that China's economic growth has had a significant impact.

This study examines how nonlinear and time-varying heterogeneity of the spatial spillover effects of price-based and quantitative monetary policy instruments affect G20 countries' economic growth by building spatial panel smooth transition models with a trade geography weight matrix and spatial fixed-effect models. The results show that the GDP of G20 countries is affected by not only their own monetary policy control but also the monetary policies of neighboring countries. If G20 countries issue additional currency, it brings a negative spillover to the GDP of neighboring countries. However, the spatial spillover effect of interest rates is not significant. Some control variables of neighboring countries also spillover to home countries' GDP, such as the increase in the neighboring countries' industrialization index, which also has a negative impact on domestic GDP. As the effect of monetary policy regulation likely differs for different economies, we divide the G20 sample into G7 plus Spain and BRICS countries for re-examination. Further analysis shows that the quantitative monetary policy of G7 countries is not significant, and it does not improve the economy when interest rates are reduced. We consider that this may be related to good and bad GDP. We then use GDP as a transfer variable and use a nonlinear model to examine the asymmetry and spatial effects of monetary policy. The SPSTR model shows that G7 countries cannot improve their GDP by lowering short-term interest rates when the economy is not good, whereas the reduction in neighboring countries' interest rates can improve their own economies. For BRICS countries, quantitative monetary policy regulation is not affected by the economic environment, but when the GDP is not good, interest rate cuts can improve their economy; however, with an improvement in GDP, the regulation effect gradually deteriorates. Whether it is for the G7 or BRICS countries, quantitative monetary policy has no spatial effect. However, neighboring countries' price regulation impacts BRICS countries.

In summary, monetary policy among the world's major economies has a simultaneous impact on both the time and spatial dimensions. Therefore, when formulating monetary policy, countries should consider neighboring countries' monetary policy tendencies and the international economic situation. Moreover, there are differences between developed and emerging economies, so quantitative and price monetary policies have not only regional asymmetric effects but also staged differential effects. This requires countries to formulate monetary policies while considering whether their country is a developed or emerging economy, the economic regime in which their country is located, and whether the monetary policy of other countries may impact it. In addition, in the context of the US contraction into the interest rate hike cycle, emerging economies should develop ideas regarding the use of the monetary policy. Therefore, while steadily advancing the price monetary policy, it is necessary to pay attention to the use of the quantitative monetary policy.

This study also has some limitations. For example, we only explore the asymmetry of monetary policy regulation when the economic state is good or bad. In fact, the asymmetry of monetary policy regulation and spillover may be related to a country's financial development, degree of opening to the outside world, and degree of industrialization, among others, but each country has different characteristics, and the spillover and regulation of monetary policy in developed countries are very important. Developed countries may depend on the degree of their financial development and developing countries may depend on the degree of opening to the outside world. This needs to be discussed further in future research.

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Conflicts of Interest

No potential conflict of interest was reported by the authors.

Appendix A

	DGDP							
	Australia AU	Brazil BR	Canada CA	China CN	France FR	Germany DE	India IN	Indonesia ID
Source	Derived from Australian Bureau of Statistics, National Income, Expenditure and Product	Derived from Fundaçâo Instituto Brasileiro de Geografia e Estatistica; EIU Calculation	Derived from Statistics Canada	National Bureau of Statistics	Derived from INSEE	Derived from Deutsche Bundesbank	Derived from Central Statistical Organization, India	Derived from Badan Pusat Statistik
Definition	Percentage change in real GDP, over previous year.	Percentage change in real GDP, over previous year	Percentage change in real GDP, over previous year.	Real GDP, 2010 prices	Percentage change in real GDP, over previous year.	Percentage change in real GDP, over previous year.	Percentage change in real GDP, over previous year.	Percentage change in real GDP, over previous year.
Note	Seasonally adjusted; Calendar years. Includes statistical discrepancy. Seasonally adjusted.	Seasonally adjusted.	Includes a statistical discrepancy due to chaining residual. Seasonally adjusted annual rate (SAAR).	There are some discrepancies between the annual and quarteriy series as NBS has not yet updated the historic quarterly series in line with revisions to the annual one.	Seasonally adjusted.	Working-day and seasonally adjusted	Seasonally adjusted.	Includes statistical discrepancy, Seasonally adjusted

(*Continued*)

	DGDP									
	Italy IT	Japan JP	Mexico MX	Russia RU	South Africa ZA	South Korea KR	Spain ES	Turkey TR	United Kingdom GB	United States of America US
Source	Derived from INDS; EuroStat	Derived from Cabinet Office, Japan	Derived from Instituto Nacional de Estadistica Geografia e Informática	RosStat	Derived from South African Reserve Bank	Derived from Bank of Korea	Derived from Instituto Nacional de Estadistica	State Institute of Statistics	Derived from Office for National Statistics	Derived from Bureau of Economic Analysis
Definition	Percentage change in real GDP, over previous year.	Percentage change in real GDP, over previous year.	Percentage change in real GDP, over previous year.	Percentage change in real GDP, over previous year.	Percentage change in real GDP, over previous year.	Percentage change in real GDP, over previous year.	Percentage change in real GDP, over previous year.	Percentage change in real GDP, over previous year.	Percentage change in real GDP, over previous year.	Percentage change in real GDP, over previous year.
Note	Seasonally adjusted	Non-seasonally adjusted		Includes statistical discrepancy; Seasonally adjusted.	Seasonally adjusted	Includes statistical discrepancy. Seasonally adjusted.	Break in GDP series in 1995 due to adoption of new ESA2010 system of national accounts by the Instituto Nacional de Estadistica. Working-day adjusted. Includes a statistical discrepancy. Seasonally adjusted.	Seasonally adjusted Se asonafiy adjusted.	Seasonally adjusted.	Seasonally adjusted

RAT3								
	Australia AU	Brazil BR	Canada CA	China CN	France FR	Germany DE	India IN	Indonesia ID
Source	IMF, International Financial Statistics	Tullet Prebon Information	OECD	National Interbank Funding Center	Statistical Office of the European Communities; ECB	Statistical Office of the European Communities; ECB	Reserve Bank of India	Bank Sentral Republik Indonesia
Definition	Money market interest rate (%; average)	3-month implied cash deposit mid rate (%; av)	3-Month Prime Corporate Paper Rate (%; average)	Shibor: 1-Week (%; average)	EA 11-19: 3-Month EURIBOR Rate (%; average)	EA 11-19: 3-month EURIBOR rate (%; average)	Mumbai interbank offer rate [MIBOR]: 3 month rate (%; average)	Jakarta Interbank IDR Offer Rate [JIBOR]: 3 Months (%; average)
Note	Weighted Avg of Loans Outstanding	Weighted average rate paid on loans between financial institutions involving firm sales of or repurchase agreements based on federal securities in the Special Settlement and Custody System			Break in series: Data prior to 1999 reflects 3-month money market rate		3 months rate	Jakarta Interbank rate: 3 month; Data prior to 2005 from IMF

(*Continued*)

	RAT3									
	Italy IT	Japan JP	Mexico MX	Russia RU	South Africa ZA	South Korea KR	Spain ES	Turkey TR	United Kingdom GB	United States of America US
Source	Statistical Office of the European Communities; ECB	Association of Call & Discount Companies/ Nikkei	International Monetary Fund	Central Bank of the Russian Federation	IMF, International Financial Statistics	Bank of Korea	Statistical Office of the European Communities; ECB	Banks Association of Turkey	Intercontinental Exchange	Federal Reserve
Definition	EA 11-19: 3-Month EURIBOR Rate (%; average)	Call rate: uncollateralized 3 months (%; average;)	Money Market Rate: 3-Month Bankers Acceptances (%; average)	Interbank credit rates [MIACR]: 3 months (%; average)	Lower margin of inter-bank deposits at call (%; average)	Call Money Rate, Overnight Intermediated Transactions (%; average)	EA 11-19: 3-month EURIBOR rate (%; average)	Reference ask rate: 3-month (%; average)	3-month London interbank offered rate (%; average)	3-month AA nonfinancial commercial paper (%; average)
Note	Break in series: Data prior to 1999 reflect Italys 3- month money market rate		As of March 1995, rate reflects a weighted average between financial organisations.				3-month Euribor from 1999		Reference rate for many floating rate loans and mortgages.	Rate for firms with AA rating.

	M2							
	Australia AU	Brazil BR	Canada CA	China CN	France FR	Germany DE	India IN	Indonesia ID
Source	Reserve Bank of Australia	Derived from Banco Central do Brasil	Derived from Bank of Canada	Derived from IMF, International Financial Statistics	Derived from Banque de France	Derived from Deutsche Bundesbank	Derived from Reserve Bank of India	Derived from IMF, International Financial Statistics
Definition	Percentage change in Ml plus quasi-money at end-period, over previous year.	Percentage change in M2 at end-period, over previous year.	Percentage change in Ml plus quasi-money at end-period, over previous year.	Percentage change in Ml plus quasi-money at end-period, over previous year.	Percentage change in Ml plus quasi-money at end-period, over previous year.	Percentage change in M1 plus quasi–money at end–period, over previous year	Percentage change in Ml plus quasi-money at end-period, over previous year.	Percentage change in Ml plus quasi-money at end-period, over previous year.
Note	Historical data is M3 data series from RBA Non-seasonally adjusted.							

(*Continued*)

	M2									
	Italy IT	Japan JP	Mexico MX	Russia RU	South Africa ZA	South Korea KR	Spain ES	Turkey TR	United Kingdom GB	United States of America US
Source	Derived from Banca dItalia	Derived from Bank of Japan	Derived from Banco de Mexico	IMF, International Financial Statistics	Derived from IMF, International Financial Statistics	Derived from Bank of Korea	Derived from IMF, International Financial Statistics	Derived from-Central Bank of Turkey	Derived from Bank of England	Derived from Federal Reserve
Definition	Percentage change in Ml plus quasi-money, over previous year.	Percentage change in Ml plus quasi-money over previous year.	Percentage change in Ml plus quasi-money at end-period, over previous year.	Money Supply ["National Definition"]: M2 (NSA)	Percentage change in Ml plus quasi-money at end-period, over previous year.	Percentage change in Ml plus quasi-money at end-period, over previous year.	Percentage change in Ml plus quasi-money and other liquid assets at end-period, over previous year.	Percentage change in Ml plus quasi-money at end-period, over previous year. Derived from line 34 and 35 in IFS.	Percentage change in M4 at end-period, over previous year.	Percentage change in Ml plus quasi-money, over previous year.
Note		Period average		Non-seasonally adjusted.	Non-seasonally adjusted.			Non-seasonally adjusted.	Headline broad money (M4) figures from Bank of England include "intermediate other financial corporations" (IOFCs) that specialise in intermediation between banks, giving a distorted underlying M4 growth.	Period Average.

	Ml							
	Australia AU	Brazil BR	Canada CA	China CN	France FR	Germany DE	India IN	Indonesia ID
Source	Reserve Bank of Australia	Derived from Banco Central do Brasil	Derived from Bank of Canada	Derived from IMF, International Financial Statistics	Derived from Banque de France	Derived from Deutsche Bundesbank	Derived from Reserve Bank of India	Derived from IMF, International Financial Statistics
Definition	Percentage change in total supply of notes and coins plus demand deposits at end-period, over previous year.	Percentage change in total supply of notes and coins plus demand deposits at end-period, over previous year.	Percentage change in total supply of notes and coins plus demand deposits at end-period, over previous year.	Percentage change in total supply of notes and coins plus demand deposits at end-period, over previous year.	Percentage change in total supply of notes and coins plus demand deposits at end-period, over previous year.	Percentage change in total supply of notes and coins plus demand deposits at end-period, over previous year.	Percentage change in total supply of notes and coins plus demand deposits at end-period, over previous year.	Percentage change in total supply of notes and coins plus demand deposits at end-period, over previous year.
Note	Non-seasonally adjusted.							

(*Continued*)

	Ml									
	Italy IT	Japan JP	Mexico MX	Russia RU	South Africa ZA	South Korea KR	Spain ES	Turkey TR	United Kingdom GB	United States of America US
Source	Derived from Banca dItalia	Derived from Bank of Japan	Derived from Banco de Mexico	Derived from IMF, International Financial Statistics	Derived from IMF, International Financial Statistics	Derived from Bank of Korea	Derived from IMF, International Financial Statistics	Derived from Central Bank of Turkey	Derived from Bank of England	Derived from Federal Reserve
Definition	Percentage change in total supply of notes and coins plus demand deposits, over previous year.	Percentage change in total supply of notes and coins plus demand deposits over previous year.	Percentage change in total supply of notes and coins plus demand deposits at end-period, over previous year.	Percentage change in total supply of notes and coins, other depository corporations required reserves, CBR bonds held by other depository corporations at end-period, over previous year. Derived from Line 19maa in IFS.	Percentage change in total supply of notes and coins plus demand deposits at end-period, over previous year.	Percentage change in total supply of notes and coins plus demand deposits at end-period, over previous year.	Percentage change in total supply of notes and coins plus demand deposits at end-period, over previous year.	Percentage change in total supply of notes and coins plus demand deposits at end-period, over previous year. Derived from line 34 in IFS.	Percentage change in total supply of notes and coins, M0, over previous year.	Percentage change in total supply of notes and coins plus demand deposits, over previous year
Note		Period average		Non-seasonally adjusted.	Non-seasonally adjusted.			Non-seasonally adjusted.	Excludes reserve balances; av; non- seasonally adjusted.	Period Average.

	INVF							
	Australia AU	Brazil BR	Canada CA	China CN	France FR	Germany DE	India IN	Indonesia ID
Source	IMF, International Financial Statistics	Banco Central do Brasil, Boletim	IMF, International Financial Statistics	IMF, International Financial Statistics	Derived from IMF, International Financial Statistics	Derived from IMF, International Financial Statistics	IMF, International Financial Statistics	Bank Sentral Re publik Indonesia
Definition	Net flows of direct investment.	Net flows of direct investment.	Net flows of direct investment.	Net flows of direct investment.	Net flows of direct investment.	Net flows of direct investment.	Net flows of direct investment.	Net flows of direct investment.
Note								

(*Continued*)

	INVF									
	Italy IT	Japan JP	Mexico MX	Russia RU	South Africa ZA	South Korea KR	Spain ES	Turkey TR	United Kingdom GB	United States of US
Source	Derived from IMF, International Financial Statistics	IMF, International Financial Statistics	Derived from IMF, International Financial Statistics	Central Bank of the Russian Federation	IMF, International Financial Statistics	IMF, International Financial Statistics	IMF, International Financial Statistics	IMF, International Financial Statistics	Derived from IMF, International Financial Statistics	IMF, International Financial Statistics
Definition	Net flows of direct Net flows of direct investment Derived from lines 78be d and 78bdd in the IFS.	Net flows of direct investment.	Net flows of direct investment.	Net flows of direct investment.	Net flows of direct investment.	Net flows of direct investment.	Net flows of direct investment. Derived from lines 78bed and 78bdd in the IFS.	Net flows of direct investment. Derived from lines 78bed and 78bdd in the IFS.	Net flows of direct investment.	Net flows of direct investment.
Note	Break in series, before 2005 IMF Balance of Payments Manual 5, after 2005 IMF Balance of Payments Manual 6.	Break in series, before 2005 IMF Balance of Payments Manual 5, after 2005 IMF Balance of Payments Manual 6.		Annual data from IMF; quarterly data from Central Bank.	Break in series, before 2005 IMF Balance of Payments Manual 5, after 2005 IMF Balance of Payments Manual 6.		Break in series, before 2005 IMF Balance of Payments Manual 5, after 2005 IMF Balance of Payments Manual 6.	Break in series, before 2005 IMF Balance of Payments Manual 5, after 2005 IMF Balance of Payments Manual 6.	Break in series, before 2005 IMF Balance of Payments Manual 5, after 2005 IMF Balance of Payments Manual 6.	

	DIPI							
	Australia AU	Brazil BR	Canada CA	China CN	France FR	Germany DE	India IN	Indonesia ID
Source	Derived from I Australian Bureau of Statistics, Australian Economic Indicators	Derived from IBGE, Instituto Brasileiro de Geografia e Estatistica/ Brazil	Derived from IMF, International Financial Statistics and Statistics Canada	Derived from National Bureau of Statistics	Derived from INSEE	Derived from Statistiches Bundesbank	Derived from Central Statistical Organisation of India	Badan Pusat Statistik, Indonesia
Definition	Percentage change in index of industrial production Industrial Production over previous year, (Q3 2012 Q2 2013=100)	Percentage change in index of industrial production, over previous year.	Percentage change in index of industrial production over previous year.	Percentage change in value added of industrial production over previous year.	Percentage change in index of industrial production (excluding construction), over previous year.	Percentage change in index of industrial production include consfruction, over previous year.	Percentage change in index of industrial production, over previous year.	Percentage change in index of industrial production, over previous year.
Note	Seasonally adjusted.	Includes manufacturing and extractive industries; excludes construction and utilities Seasonally adjusted.	Seasonally adjusted; break in series- data prior to 2007 from IMF and post 2007 from Statistics Canada.	Non-seasonally adjusted	Excludes construction. Working-day adjusted. Seasonally adjusted.	Seasonally and working day adjusted, 2015=100	Non-seasonally adjusted.	

(*Continued*)

	DIPI									
	Italy IT	Japan JP	Mexico MX	Russia RU	South Africa ZA	South Korea KR	Spain ES	Turkey TR	United Kingdom GB	United States of America US
Source	OECD Main Economic Indicators	Derived from Ministry of Economy, Trade and Industry,	Instituto Nacional de Estadfstica Geografia e Informatic a	State Committee of the Russian Federation	Derived Statistics South Africa	Derived from Korean National Statistics Office.	Derived from Ministerio De Economia Y Hacienda	Derived from OECD, Main Economic Indicators	Derived from Office for National Statistics.	Derived from Federal Reserve
Definition	Percentage change in index of industrial production, seasonally adjusted, over	Percentage change in index of industrial production, over previous year.	Percentage change in index of industrial production, over previous year (average).	Percentage change in index of industrial production over previous year.	Percentage change in index of manufacturing production, over previous year.	Percentage change in index of industrial production, over previous year.	Percentage change in index of industrial production, over previous year.	Percentage change in index of industrial production, over previous year.	Percentage change in industrial production index, over previous period (2010=100)	Percentage change in index of industrial production, over construction is not included.
Note		SA, 2010=100		Seasonally adjusted.	Seasonally adjusted	Seasonally adjusted	Seasonallly and Working-day adjusted	Seasonally adjusted.	Seasonally adjusted.	

TOTAL ASSET								
	Australia AU	Canada CA	China CN	France FR	Germany DE	India IN	Indonesia ID	Italy IT
Source	OECD	Statistics Canada	EIU estimates	Eurostat	Eurostat	EIU estimates	EIU estimates	Eurostat
Definition	Total assets of the central bank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets.	Total assets of the central bank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets.	Total assets of the central bank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets.	Total assets of the central bank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets.	Total assets of the central bank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets.	Total assets of the central bank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets.	Total assets of the central bank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets.	Total assets of the central bank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets.
Note	Financial balance sheet series include the domestic economy only. Transactions conducted with nonresidents are recorded in the Rest-of-World section. Not comparable with Bank Performance indicators which include foreign transactions.	Financial balance sheet series include the domestic economy only. Transactions conducted with nonresidents are recorded in the Rest-of-World section. Not comparable with Bank Performance indicators which include foreign transactions.	Financial balance sheet series include the domestic economy only. Transactions conducted with nonresidents are recorded in the Rest-of-World section. Not comparable with Bank Performance indicators which include foreign transactions.	Financial balance sheet series include the domestic economy only. Transactions conducted with nonresidents are recorded in the Rest-of-World section. Not comparable with Bank Performance indicators which include foreign transactions.	Financial balance sheet series include the domestic economy only. Transactions conducted with nonresidents are recorded in the Rest-of-World section. Not comparable with Bank Performance indicators which include foreign transactions.	Financial balance sheet series include the domestic economy only. Transactions conducted with nonresidents are recorded in the Rest-of-World section. Not comparable withBank Performance indicators which include foreign transactions.	Financial balance sheet series include the domestic economy only. Transactions conducted with nonresidents are recorded in the Rest-of-World section. Not comparable with Bank Performance indicators which include foreign transactions.	Financial balance sheet series include the domestic economy only. Transactions conducted with nonresidents are recorded in the Rest-of-World section. Not comparable with Bank Performance indicators which include foreign transactions.

(*Continued*)

TOTAL ASSET								
	Japan JP	Mexico MX	Russia RU	South Africa ZA	South Korea KR	Turkey TR	United States of America US	United Kingdom GB
Source	OECD, Bank of Japan	OECD	The Central Bank of the Russian Federation		OECD	Central Bank of the Republic of Turkey	OECD	OECD
Definition	Total assets of the central bank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets.	Total assets of the central bank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets.	Total assets of the central bank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets.	Total assets of the central bank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets.	Total assets of the central bank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets.	Total assets of the centralbank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets.	Total assets of the central bank (monetary authority). Equal to the sum of currency and deposits, securities, and loan assets.	Total assets of the financial sector (domestic financial institutions, including the central bank). Equals the sum of total liabilities of the domestic household, government and non-financial sectors.
Note	Break in series data prior to 2005 derived from OECD. Financial balance sheet series include the domestic economy only. Transactions conducted with non-residents are recorded in the Rest-of-World section. Not comparable with Bank Performance indicators w	Financial balance sheet series include the domestic economy only. Transactions conducted with non-residents are recorded in the Rest-of-World section. Not comparable with Bank Performance indicators which include foreign transactions.	Includes "other depository corporation". Financial balance sheet series include the domestic economy only. Transactions conducted with non-residents are recorded in the Rest-of-World section. Not comparable with Bank Performance indicators which include	Financial balance sheet series include the domestic economy only. Transactions conducted with non-residents are recorded in the Rest-of-World section. Not comparable with Bank Performance indicators which include foreign transactions.	Financial balance sheet series include the domestic economy only. Transactions conducted with non-residents are recorded in the Rest-of-World section. Not comparable with Bank Performance indicators which include foreign transactions.	Financial balance sheet series include the domestic economy only. Transactions conducted with non-residents are recorded in the Rest-of-World section. Not comparable with Bank Performance indicators which include foreign transactions.	Financial balance sheet series include the domestic economy only. Transactions conducted with non-residents are recorded in the Rest-of-World section. Not comparable with Bank Performance indicators which include foreign transactions.	Financial balance sheet series include the domestic economy only. Transactions conducted with non-residents are recorded in the Rest-of-World section. Not comparable with Bank Performance indicators which include foreign transactions.

	QGDP					
	Canada CA	France FR	Germany DE	Italy IT	Japan JP	Spain ES
Source	Derived from Statistics Canada	Derived from INSEE	Derived from Deutsche Bundesbank	Derived from INDS; EuroStat	Derived from Cabinet Office, Japan	Derived from Instituto Nacional de Estadística
Definition	Percentage change in real GDP, over previous period.	Percentage change in real GDP, over previous period.	Percentage change in real GDP, over previous period.	Percentage change in real GDP, over previous period.	Percentage change in real GDP, over previous period.	Percentage change in real GDP, over previous period.
Note	Seasonally adjusted	Seasonally adjusted	Working-day and seasonally adjusted	Seasonally adjusted	Seasonally adjusted	Seasonally and working day adjusted data

(*Continued*)

	QGDP						
	United Kingdom GB	United States of America US	Brazil BR	China CN	India IN	Russia RU	South Africa ZA
Source	Derived from Office for National Statistics	Derived from Bureau of Economic Analysis	Derived from Fundaçâo Instituto Brasileiro de Geografia e Estatística; EIU Calculation	National Bureau of Statistics	Derived from Central Statistical Organization, India	RosStat	Derived from South African Reserve Bank
Definition	Percentage change in real GDP, over previous period.	Percentage change in real GDP, over previous period.	Percentage change in real GDP, over previous period.	Percentage change in real GDP, over previous period from SA series.	Percentage change in real GDP, over previous period.	Percentage change in real GDP, over previous period.	Percentage change in real GDP, over previous period.
Note	Seasonally adjusted	Seasonally adjusted	Seasonally adjusted.	Seasonally adjusted; There are some discrepancies between the annual and quarterly series as NBS has not yet updated the historic quarterly series in line with revisions to the annual one.	Seasonally adjusted.	Published rate. Seasonally adjusted.	Seasonally adjusted; change in the annualised level compared to the previous quarter

Appendix B

Table B.1. Descriptive Statistic

	G20+Spain			G7+Spain			BRICS		
Variable	*N*	mean	sd	*N*	mean	sd	*N*	mean	sd
DGDP	1440	3.131	3.303	640	1.506	2.043	400	4.308	3.434
QGDP	1440	0.748	1.090	640	0.351	0.721	400	1.039	1.046
Total assets	1440	14.47	9.188	640	13.42	1.194	—	—	—
DMN2	1440	10.73	10.70	640	5.722	4.003	400	12.25	5.756
DMN1	1440	11.67	12.00	640	7.435	8.074	400	12.38	6.704
RAT3	1440	5.249	5.968	640	1.687	1.816	400	7.631	4.489
DIPI	1440	2.448	5.860	640	0.342	5.245	400	3.695	5.870
INVF	1440	0.328	22.88	640	−6.830	29.82	400	10.10	15.74
FSI	1440	0.107	0.428	640	0.0197	0.0142	400	0.248	0.742

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