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# The spillover effects of China's monetary policy shock: Evidence from B&R countries

Yong Chen [a], Dingming Liu [b,c], Ziguan Zhuang [d,*]

[a] School of Finance, Southwestern University of Finance and Economics, Research Laboratory Building, 555 Liutai Avenue, Wenjiang District, Chengdu 611130, China
[b] Wang Yanan Institute for Studies in Economics, Xiamen University, Economics Building, Xiamen 361005, China
[c] International Trade Department, School of Economics, Xiamen University, China
[d] School of Finance, Zhongnan University of Economics and Law, 182# Nanhu Avenue, East Lake High-tech Development Zone, Wuhan 430073, China

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ABSTRACT

This paper examines the international spillover effects of China's monetary policy shock on macro and financial variables in 26 countries along the Belt and Road (B&R) from 2000 to 2019. We find that a surprise Chinese monetary tightening brings about a widening in the short-term interest rate spread, a drop in the equity price, nominal depreciation against the RMB and real depreciation, and an improvement in the trade balance, on average, across the 26 B&R countries. Moreover, substantial heterogeneous effects emerge in the responses of the foreign real exchange rate and the trade balance in different groups in terms of the 26 countries' trade weights with China, capital openness, and national income levels. Finally, all the empirical evidence reveals that the expenditure switching effect plays an important role in facilitating the international transmission of China's monetary policy shock.

## 1. Introduction

How does a domestic monetary policy affect foreign economies? From a theoretical point of view, there are various transmission channels. The traditional Mundell-Flemming-Dornbusch model focuses on the trade channel. Domestic monetary tightening depreciates the foreign exchange rate, thus boosting the foreign trade balance by shifting demand from domestic to foreign products and increases foreign output (the expenditure switching effect). On the other hand, a contractionary domestic monetary policy shock decreases domestic demand for foreign goods, which decreases foreign exports and depresses foreign output via the open-economy IS curve (the income absorption effect). Moreover, standard open-economy DSGE models emphasize the financial channel. If the domestic country is a large open economy, a rise in the domestic interest rate can bring up foreign interest rates indirectly via an increase in world interest rates, which induces substitution in favor of future goods, and a decrease in foreign output (Svensson and van Wijnbergen, 1989; Galí and Monacelli, 2005). There is a large amount of empirical literature on monetary policy cross-border transmissions, in which the importance of different transmission channels varies across countries. For example, (Dekle and Hamada, 2015) examine the spillover effects of Japan's monetary policy, and their results comply with the expenditure switching effect. Dedola et al. (2017) and Potjagailo (2017) investigate the spillover effects of U.S. and European monetary policies, respectively, and the results are consistent with a mixture of the income absorption effect and the financial channel.

* Corresponding author.
*E-mail addresses:* chenyongtxt.cn@gmail.com (Y. Chen), dmliu@xmu.edu.cn (D. Liu), ziguanzhuang@zuel.edu.cn (Z. Zhuang).

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Although China is becoming one of the major players in global trade and the world economy, there are still limited studies on how the country's monetary policy would affect the economic and financial development of other countries. Among them, (Cho and Kim, 2021; Johansson, 2012; Ko and Mehrotra, 2009) investigate the effects of China's monetary policy shock on a subset of Asian countries. (Huang et al., 2014) explore the effects of the People's Bank of China (PBoC)'s balance sheet expansion on 15 foreign countries. (Vespignani, 2015) examines the influence of China's monetary supply (M2) on the Euro erea. All these studies usually use short-run restrictions to identify the monetary policy shock and focus either on a limited set of countries or on a limited set of foreign variables, which reach inconlusive results about the spillover effects of China's monetary policy. For example, (Cho and Kim, 2021) focus on nine East Asian countries and find that with a monetary expansion in China, the exchange rates of East Asian economies appreciate against the RMB; the trade balance worsens in the short run, but improves in the medium and long run. However, (Huang et al., 2014) show that China's monetary expansion has insignificant effects on the trade balance, interest rate, and bilateral exchange rate against the RMB for some Asian countries.

This paper estimates the effects of China's monetary policy shock on a broad set of macro and financial variables in 26 Belt and Road (B&R) countries. China proposed the B&R Initiative in September 2013 and has sought to deepen connectivity and cooperation on a transcontinental scale, notably by improving infrastructure and strengthening trade and investment links.[1] We focus on the B&R countries because they have been highly correlated with the Chinese economy over the sample period we consider, which is one of the reasons that they join the B&R Initiative, and the economic and trade links between these countries and China have been further strengthened since the B&R Initiative. Therefore, their long-standing economic and trade relationships with China make the B&R countries good candidates to study the spillover effects of China's monetary policy. We carry out our analysis in two steps. First, inspired by the work of (Dedola et al., 2017; Mandler et al., 2021; Yong and Dingming, 2019), we implement the large Bayesian vector autoregressive (BVAR) model identified with sign restrictions to estimate China's monetary policy shock. Then, we investigate the international spillover effects of China's monetary policy shock via the local projection approach proposed by Jordà, 2005.

Specifically, in the first step, when trying to estimate the Chinese monetary policy shock series in a structural vector autoregressive (VAR) framework, two challenges arise. First and foremost, the PBoC faces multiple target constraints and has to implement multiple monetary policy instruments to achieve multiple regulatory objectives (Sun, 2020). Therefore, more variables are needed to capture the complete changes in China's monetary policy. The aforementioned empirical studies on China's monetary policy spillovers are based on small-scale VARs, typically including only around four to six of the most important macroeconomic aggregates. Such limited information sets may imply omitted-variables biases in the estimated parameters, potentially affecting both forecasting and structural analysis.[2] The second challenge concerns the identification of China's monetary policy shock in a large VAR setting. Because we include multiple monetary policy instruments and several financial variables in the VAR model, it is difficult to specify a single monetary policy instrument or clarify the chronological ordering of all the variables affected by China's monetary policy shock.

The two challenges motivate our approach of the large BVAR model identified with sign restrictions to estimate China's monetary policy shock, which has several advantages. First, in the VAR estimation step, the large BVAR model allows us to add as many monetary instrument variables, intermediate targets, and macro and financial variables as possible to proxy the information set of the PBoC.[3] Second, in the identification step, with the sign restriction approach, we need only assume that the monetary policy shock has empirically plausible effects consistent with "textbook" monetary theory, which requires neither the specification of a monetary policy instrument nor assumptions about the chronological order of the impacts of the shock on the VAR model variables.

After estimating China's monetary policy shock, the next step is essential in this paper. In order to investigate the international transmission of China's monetary policy, we construct panel data on macro and financial variables in 26 B&R countries. We then implement the local projection method and project the foreign variables on the shock identified in the first step to estimate the average effects of China's monetary policy shock on foreign variables. There is increasing literature that focuses on the effects of monetary policies in different states of the economy using the local projection method (Cloyne and Hürtgen, 2016; Tenreyro and Thwaites, 2016). Compared with the VAR-based marginal approach in the previous study (Cho and Kim, 2021; Huang et al., 2014), the local projection method is more robust to model miss-specification. Moreover, to further explore the transmission mechanism and investigate the heterogeneous effects of China's monetary policy shock, we group the 26 B&R countries based on the following country characteristics: 1) the size of the country's trade volume with China, 2) the degree of capital openness, 3) the degree of trade openness, 4) the exchange rate regime (floating vs. fixed), and 5) the level of national income (advanced vs. emerging countries).

Our main findings are as follows. First, China's monetary policy shock has significant spillover effects on macro and financial variables in the B&R countries. Surprise Chinese tightening brings about a widening in the short-term interest rate spread, a drop in

[1] The B&R Initiative has two main components: the Silk Road Economic Belt, which links China to Central and South Asia and onward to Europe, and the New Maritime Silk Road, which links China to the nations of Southeast Asia, the Gulf countries, East and North Africa, and on to Europe (World Bank, 2019).

[2] A recurrent problem that is ascribed to the omitted-variables biases is, for example, the so-called price puzzle, i.e., if the central bank monitors and responds to a larger information set than that of the VAR, what is referred to as a policy shock is actually a combination of a genuine policy shock and some endogenous policy reactions, which leads to the counter-intuitive empirical result that a surprise monetary tightening leads to an increase in the price level.

[3] (He et al., 2013) and (Fernald et al., 2014) use large-scale variables and a factor-augmented VAR (FAVAR) model to analyze the effects of the monetary policy in China. A potential advantage of the Bayesian approach over the factor model approach is that estimation and inference can be conducted in (nonstationary) levels; factor model applications, in contrast, typically work with data that have been transformed to achieve stationarity, destroying the potential influence of long-run, cointegrating relationships.

equity price, nominal depreciation against the RMB and real depreciation, and an improvement in the trade balance, on average, across the 26 B&R countries. These empirical results, to some extent, reveal the importance of the expenditure switching effect in facilitating the international transmission of China's monetary policy shock. With regard to output, we find that China's monetary tightening does not bring about a significant decline in industrial production of the B&R countries on impact, which differs from the findings in (Cho and Kim, 2021; Huang et al., 2014; Ko and Mehrotra, 2009; Vespignani, 2015), and we ascribe the insignificant response of industrial production in our study to the mixed results of the (positive) expenditure switching effect and the possible (negative) effects of other mechanisms. Second, substantial heterogeneous effects emerge in the responses of the foreign exchange rate and the trade balance in different groups in terms of their trade weights with China, capital openness, and national income levels. Specifically, the real exchange rate depreciates more in countries with high trade weights with China; thus, the trade balance exerts a larger improvement in these countries, and the heterogeneous patterns are in accordance with the expenditure switching effect.

The paper is organized as follows. We describe our empirical approach in Section 2 and present the data in Section 3. We discuss the Chinese monetary BVAR results and the local projection results for all 26 B&R countries and for the country groups in Section 4. We conclude in Section 5.

## 2. The model and the estimation method

We proceed with the estimation in two steps. First, we estimate China's monetary policy shock using the large BVAR model identified with "textbook" sign restrictions. Second, we obtain impulse responses of China's monetary policy shock on economic and financial variables in the B&R countries using the local projection approach.

### 2.1. The large BVAR model

In the VAR model, we include large dimensional variables to approximate the PBoC's information set. However, as the number of endogenous variables increases, the parameters of the VAR model to be estimated will explode, raising the "curse of dimensionality" problem. Following Giannone et al., 2015, we use the large BVAR model to circumvent this problem. In a nutshell, we use informative priors to shrink the richly parameterized VAR model toward a more parsimonious one, and we select the appropriate degree of shrinkage by treating the prior-hyper-parameters of the VAR model parameters as functions of any other (low-dimensional) hyper-parameters, setting a prior for them and using the data to evaluate their posterior.

Specifically, let $Y_t$ be a large vector of $n$ variables. We estimate the following reduced-form VAR($p$) model:

$$Y_t = c + \sum_{\ell=1}^{p} B_\ell Y_{t-\ell} + \varepsilon_t, \quad \varepsilon_t \sim \mathscr{N}(0, \Sigma), \tag{1}$$

where $c$ is an $n \times 1$ vector, $\{B_\ell\}_{\ell=1}^{p}$ are $n \times n$ autoregressive matrices capturing the lagged responses of the endogenous variables, and $\varepsilon_t$ is an $n \times 1$ vector of the reduced-form errors, which follows a normal distribution with zero mean and variance-covariance matrix $\Sigma$. Defining $B(c, B_1, \ldots, B_p)'$ and $\beta$=$vec(B)$, where $vec(\cdot)$ is the vector operator, we set a normal-inverse-Wishart prior for $\beta$ and $\Sigma$ as follows:

$$\Sigma \sim \mathscr{IW}(S, n+2), \tag{2}$$

$$\beta \mid \Sigma \sim \mathscr{N}(b(\gamma), \Sigma \otimes \Omega(\gamma)), \tag{3}$$

where the prior of $\Sigma$ follows an inverse Wishart distribution with the scale matrix $S$ and the degree of freedom $n+2$. We assume that the scale matrix $S = diag\{s_i\}_{i=1}^{n}$ is diagonal and the value of $s_i$ is fixed using the variance in the residuals from a $p$-th order univariate autoregressive model for each variable in $Y_t$. The degree of freedom $n+2$ is chosen to be the minimum value to ensure the existence of the prior mean of $\Sigma$. The conditional prior of $\beta$ follows a normal distribution with the mean $b(\gamma)$ and the scale matrix $\Omega(\gamma)$ as functions of some low-dimensional hyper-parameters $\gamma$. For the specific setting of the conditional prior for $\beta$, we combine the Minnesota prior, the sum-of-coefficients prior, and the dummy-initial-observation prior. The Minnesota prior treats all the equations in the VAR model as centering on the random walk process with drift, which is the essential assumption to achieve Bayesian shrinkage. The sum-of-coefficients prior and the dummy-initial-observation prior are incorporated to circumvent the unit root and cointegration problems, respectively. Because there is no closed-form solution for the posterior distribution of the hyper-parameters $\gamma$, we use the Markov chain Monte Carlo (MCMC) algorithm to simulate the posterior distribution of the hyper-parameters $\gamma$ and the VAR coefficients $(\beta, \Sigma)$. Additional details about the selection of the priors and the simulation of the posterior can be found in Giannone et al. (2015) (Giannone et al., 2015).

### 2.2. Identifying the monetary policy shock

Define $u_t \sim \mathscr{N}(0, \mathrm{I}_n)$ as the $n \times 1$ vector of mutually orthogonal structural shocks, where $\mathrm{I}_n$ is the $n$-dimensional identity matrix. Identifying $u_t$ amounts to finding some linear mapping $A$ with $\varepsilon_t = Au_t$. The key restriction that the relation $\varepsilon_t = Au_t$ imposes on $A$ is $\mathbb{E}[\varepsilon_t \varepsilon_{t'}] = \mathbb{E}[A u_t u_{t'} A'] \Rightarrow \Sigma = AA'$. However, this restriction is not sufficient to pin down a unique $A$ matrix, because for any $n \times n$ matrix $\widetilde{A}$ satisfying $\Sigma = \widetilde{A}\widetilde{A}'$ and $n \times n$ orthogonal matrix $Q$ such that $QQ' = \mathrm{I}_n$, the alternative matrix $A = \widetilde{A}Q$ also satisfies $\Sigma = AA'$. Thus, for some arbitrary matrix $\widetilde{A}$ with $\Sigma = \widetilde{A}\widetilde{A}'$ (e.g., the lower triangular Cholesky factor of $\Sigma$), identifying $u_t$ reduces to choosing an orthogonal matrix $Q$ such that the corresponding structural shocks $u_t^Q Q' \widetilde{A}^{-1} \varepsilon_t$ satisfy some ad hoc identification constraints. In this study, we need to identify only the monetary policy shock, so we need to choose only one orthonormal vector $q_m$; i.e., $q_{m'} q_m = 1$, such that the corresponding monetary policy shock $u_t^m q_m' \widetilde{A}^{-1} \varepsilon_t$ satisfies the identification constraints.

To identify the monetary policy shock, we adopt (Uhlig, 2005) sign restriction method that restricts the sign of the impulse responses of selected variables to the identified shock. Specifically, from Eq. (1), the vector moving average representation of $Y_t$ is $Y_t = \sum_{h=0}^{\infty} \Theta_h \varepsilon_{t-h}$, where $\Theta_h$ is the reduced form (Wold) impulse response of $\varepsilon_t$ to $Y_t$ at horizon $h$, and the corresponding structural vector moving average representation of $Y_t$ is $Y_t = \sum_{h=0}^{\infty} \Theta_h A u_{t-h} = \sum_{k=0}^{\infty} \Psi_h u_{t-h}$, where $\Psi_h = \Theta_h A = \Theta_h \widetilde{A} Q$ is the structural impulse response of $u_t$ to $Y_t$ at horizon $h$, and the impulse response of the monetary policy shock $u_t^m$ to $Y_t$ at horizon $h$ is $\psi_h \Theta_h \widetilde{A} q_m$. The sign restriction approach achieves identification through imposing signs on the selected element(s) of $\psi_h$. Referring to the settings of (Chen and Liu, 2018a; Chen and Liu, 2018b), we define and identify a (contractionary) monetary policy shock with the sign restrictions specified in Table 1.[4] It is important to emphasize that our goal is not to impose as few sign restrictions as possible to obtain new evidence of the effects of a monetary policy shock. Instead, we impose plausible, "textbook" sign restrictions on the overall domestic effects of a monetary policy shock.

Notably, the sign restrictions in Table 1 are broadly consistent with the findings in the monetary theoretical and empirical literature, and we do not impose any sign restrictions on controversial variables (e.g., house prices and expectation indices). Moreover, the sign restrictions in Table 1 are exclusive: The signs of the output, price, and interest rate allow us to distinguish the monetary policy shock from other shocks, such as demand shocks or supply shocks (Chen and Liu, 2018a).

### *2.3. Cross-border transmission of the monetary policy shock*

The procedure above allows us to obtain the posterior distribution of China's monetary policy shock, and we use the shock series to estimate the average spillover effects of China's monetary policy shock on macro and financial variables in the B&R countries via the local projection method. Specifically, we estimate the following panel regression model:

$$y_{i,t+h} = \alpha_{i,h} + \beta_h u_t^m + \delta_h(L) Z_{i,t} + e_{i,t+h}, \quad h = 0, \dots, H, \tag{4}$$

where $y_{i,\ t+h}$ is the macro or financial variable in country $i$, $\alpha_{i,\ h}$ is the country-specific fixed coefficient to control for country-specific effects, and $u_t^m$ is China's monetary policy shock series. We project all the B&R country variables on the same shock $u_t^m$ to obtain its average effect. Under the assumption that $u_t^m$ is exogenous, $\beta_h$ captures the average response of $y_t$ across countries to a one-standard-deviation innovation in $u_t^m$ in period $h$. $\delta_h(L) = \delta_1^h L + \dots + \delta_q^h L^q$, $0 \le h \le H$ are polynomials of order $p$ in the lag operator $L$. $Z_{i,\ t}$ contains other control variables, which include the shock $u_t^m$ and the dependent variable $y_{i,\ t}$ in general. In addition, considering that there are some common effects that likely affect both China and B&R countries, we control for these effects by including several U.S. and global time series in $Z_{i,\ t}$. First, we include (Wu and Xia, 2016) shadow policy rate to zero out the effects of the U.S. monetary policy.[5] Second, we control for global common factors, such as the world demand for commodities and the oil price index. The measure of the world demand for commodities is the index of global real economic activity in industrial commodity markets estimated by (Kilian, 2019). The oil price index is the crude oil price index provided by the IMF.

Next, to further explore the transmission mechanism and investigate the heterogeneous effects of China's monetary policy shock, we divide the sample countries into different groups according to certain country characteristics and compare the effects of China's monetary policy shock on foreign variables in different groups. The local projection method can easily accommodate state dependence by extending Eq. (4) as follows:

$$y_{i,t+h} = \sum_j I_j \left( \alpha_{i,h}^j + \beta_h^j u_t^m + \delta_h^j(L) Z_{i,t} \right) + e_{i,t+h}, \quad h = 0, \dots, H, \tag{5}$$

where $I_j$, $j \in \{0, 1\}$ are two dummy variables that indicate whether country $i$ is in group 0 or group 1. The regression coefficients $\beta_h^j$ in Eq. (5) vary by group, and we use $\beta_h^0 - \beta_h^1$ to measure the differences in the average effects of China's monetary policy shock on foreign variables across different groups. A detailed empirical algorithm to implement the two steps is presented in Appendix A.

[4] In terms of the criteria for setting the sign restrictions, (Canova and Paustian, 2011) point out that the sign restriction approach is effective in capturing the true data-generating process, provided that the identified shock has a large variance, or that the imposed sign restrictions are abundant. As a monetary policy shock is usually considered one of the secondary sources of output and inflation fluctuations, we must ensure that enough sign restrictions are imposed to make the identified monetary policy shock meaningful.

[5] As the sample period covers late 2008 to December 2015, a period when the Fed maintained the federal funds rate (FFR) at the zero lower bound, we may not successfully control for the U.S. monetary policy by using the FFR as a control variable.

**Table 1**
Sign restrictions.

| Variable type | Variable | Sign | Restriction periods |
|---|---|---|---|
| Monetary policy | 7-Day interbank offered rate | + | 1–6 |
| | M2 growth | − | 1–6 |
| Macro variables | Real GDP, consumption, investment<br>CPI, GDP deflator | − | 1–6 |
| | Nominal effective exchange rate | + | 1 |
| Financial variables | Stock price index | − | 1 |

Note: The impulse responses of the selected endogenous variables to monetary tightening are set to be positive (+) or negative (−) given the restriction period. The exchange rate is indirectly quoted, with a positive sign indicating appreciation.

## 3. Data description

### 3.1. Chinese data

We include in the VAR model 24 monthly variables that span from January 2000 to December 2019.[6] The variables can be divided into five categories: monetary and banking variables, macro variables, financial variables, expectation indices, and fiscal policy variables.

Specifically, we use the growth rate of M2 as a proxy for the PBoC's intermediate monetary target (Chen et al., 2018). Regarding the multiple-instrument operating regime of China's monetary policy, we use the 7-day interbank offered rate (Repo7), the required reserve ratio, and the benchmark lending rate as proxies for the PBoC's monetary policy instruments (Sun, 2020). We also add the growth rate of total new commercial bank loans and saving deposits in the monetary and banking category. The macro variables include the real GDP, real consumption, real investment, CPI, producer price index (PPI), and GDP deflator. We also include several open economy variables, i.e., the ratio of nominal net exports to nominal GDP, the real effective exchange rate (REER), and the nominal effective exchange rate (EER). The financial variables include the Shanghai and Shenzhen A-share stock price indices and the real house price. The expectations indices include the consumer expectations index, the consumer confidence index, the CEIC leading index, and the macro leading index. Finally, following (Rossi and Zubairy, 2011), who suggest that the fiscal policy should always be controlled for when analyzing the monetary policy, we use the real government spending and nominal budget balance to nominal GDP to control for the fiscal policy. In the 24 variables, the GDP and its components and the GDP deflator are obtained from (Chang et al., 2016), and all the other variables are obtained from the CEIC database. The data series are graphed in Fig. B.1 in Appendix B.

### 3.2. Foreign data

To explore the spillover effects of China's monetary policy shock on the macro and financial variables in B&R countries, we collect monthly data of seven variables from 26 B&R countries, considering data availability and reliability.[7] The variables include the money market interest spread,[8] (real) stock price index (deflated by the CPI), bilateral nominal exchange rate against RMB, REER, nominal trade balance (scaled by the average of the sum of imports and exports over the whole sample period), industrial production, and CPI. The foreign data also span from January 2000 to December 2019. The data are obtained from the CEIC database, the EIU DataServices, and the World Bank database.

In addition, to further analyze the role of countries' structural characteristics and choice of policy regime in influencing China's monetary policy shock, we group the 26 countries based on the following country characteristics: 1) the size of the country's trade volume with China, 2) the degree of capital openness, 3) the degree of trade openness, 4) the exchange rate regime (floating vs. fixed), and 5) the level of national income (advanced vs. emerging economies). The detailed criteria for each group are as follows. [1)].

1) Trade weight with China: Referring to (Ilzetzki et al., 2013), we group the 26 sample countries based on the ratio of their trade volume (exports and imports) with China to their GDP from 2013 to 2019. Specifically, the ratio in each country is first averaged across time, and then the median is obtained across countries. Countries with a mean ratio greater than the sample median are defined as high trade weight countries, while countries with a mean less than the sample median are defined as low trade weight countries.

2) Capital openness: Referring to (Dedola et al., 2017), we use the Chinn-Ito (Chinn and Ito, 2006) index from 2000 to 2019 to measure the degree of capital openness in the 26 countries. The Chinn-Ito index in each country is first averaged across time, and then

[6] The starting point of the sample period is dictated by data availability. Before the late 1990s, reliable macroeconomic data are not available for China, and (Chen et al., 2018) argue that in 1999, the PBoC officially switched its monetary policy from controlling bank credit to controlling M2 growth, and the intermediate target of monetary policy has been M2 growth since 2000. We choose December 2019 as the ending point because starting in January 2020, the COVID-19 pandemic spread around the world and made the variables in the sample countries behave erratically.

[7] The 26 sample countries are (in alphabetical order): Austria, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Iran, Italy, Kazakhstan, South Korea, Latvia, Lithuania, Luxembourg, Malaysia, New Zealand, Poland, Portugal, Romania, Russia, Singapore, Slovakia, Slovenia, South Africa, Thailand, and Turkey.

[8] Money market interest spread of the $i$-th country = China's money market interest rate − the money market interest rate of the $i$-th country.

its median is obtained across countries. Countries with a mean index greater than the sample median are defined as open capital countries, while countries with a mean less than the sample median are defined as closed capital countries.

3) Trade openness: We use (Ilzetzki et al., 2013) methodology to group the 26 sample countries based on the magnitude of their average total trade volume (exports and imports) to their GDP ratio from 2000 to 2019. If the average ratio in a country exceeds 60%, the country is defined as an open country; otherwise, it is defined as a closed country.

4) Exchange rate regimes: Referring to (Ilzetzki et al., 2019), we divide the exchange rate regime arrangements of the 26 countries into two groups: fixed and floating. (Ilzetzki et al., 2019) classify the exchange rate regimes of 194 sample countries into 15 categories. We use their latest classification results and group the countries in category 11 (Moving band that is narrower than or equal to $+/-$ 2%), category 12 (De facto moving band $+/-$ 5%), category 13 (Freely floating), and category 14 (Freely falling) as floating exchange rate regimes. The remaining countries in categories 1 to 10 are classified as fixed exchange rate regimes.

5) National income levels: We divide the 26 countries into advanced and emerging economies based on the IMF World Economic Outlook (2018) (International Monetary Fund, 2018). Referring to Dedola et al. (2017) (Dedola et al., 2017), we use the latest classification results to group income levels.

The detailed grouping results for the 26 countries are shown in Table 2, which reports the list of countries comprising the respective groups.

## 4. Empirical results

### *4.1. The domestic effects of China's monetary policy shock*

We begin by presenting the impulse response functions (IRFs) of selected variables to a contractionary monetary policy shock in Fig. 1. It is clear from Fig. 1 that the estimated IRFs of the variables with sign restrictions are stronger and longer-lasting compared to the identification hypothesis in Table 1, and the IRFs of the variables without sign restrictions are largely consistent with the relevant economic theory and empirical facts.

Specifically, the Repo7 rises persistently for the first 10 months, and the hike in the Repo7 is associated with a decline in the M2 growth, which is also significant for the first 10 months. The responses of the Repo7 and M2 growth are consistent with the definition and the intermediate target of a contractionary monetary policy. The growth in banking loans (which we leave unrestricted) declines, which is in line with the hike in the Repo7 and the decline in the M2 growth. Then the monetary policy shock triggers changes in the macro and financial variables, and most variables respond as would be expected according to standard textbook predictions: The Chinese GDP, consumption, investment, and price indices in all categories fall on impact and in later periods. The responses of the national income and price indices are consistent with the ultimate goals of a contractionary monetary policy. In terms of the open-economy variables, the trade balance (which we leave unrestricted) exerts a (although short-lived and insignificant) decline, and the nominal and real exchange rates appreciate. As for the financial variables, the downward adjustments of the stock price indices are consistent with the hike in the Repo7 and the decline in the M2 growth, and the downward adjustments of the stock price indices last much longer than those imposed by

**Table 2**
Country classifications.

| Trade weights with China | | Capital openness | | Trade openness | | Exchange rate regime | | Income level | |
|---|---|---|---|---|---|---|---|---|---|
| high = 1 | low = 0 | high = 1 | low = 0 | high = 1 | low = 0 | floating = 1 | fixed = 0 | advanced = 1 | emerging = 0 |
| Czech Republic | Austria | Austria | Bulgaria | Austria | Cyprus | Iran | Austria | Austria | Bulgaria |
| Hungary | Bulgaria | Czech Republic | Croatia | Bulgaria | Iran | Korea | Bulgaria | Cyprus | Croatia |
| Iran | Croatia | Estonia | Cyprus | Croatia | Italy | Malaysia | Croatia | Czech Republic | Hungary |
| Kazakhstan | Cyprus | Hungary | Iran | Czech Republic | New Zealand | New Zealand | Cyprus | Estonia | Iran |
| Korea | Estonia | Italy | Kazakhstan | Estonia | Portugal | Poland | Czech Republic | Italy | Kazakhstan |
| Malaysia | Italy | Latvia | Korea | Hungary | Russia | Russia | Estonia | Korea | Malaysia |
| New Zealand | Latvia | Lithuania | Malaysia | Kazakhstan | South Africa | South Africa | Hungary | Latvia | Poland |
| Russia | Lithuania | New Zealand | Poland | Korea | Turkey | Thailand | Italy | Lithuania | Romania |
| Singapore | Luxembourg | Portugal | Slovak | Latvia | | Turkey | Kazakhstan | Luxembourg | Russia |
| Slovak | Poland | Romania | South Africa | Lithuania | | | Latvia | New Zealand | South Africa |
| Slovenia | Portugal | Russia | Thailand | Luxembourg | | | Lithuania | Portugal | Thailand |
| South Africa | Romania | Singapore | Turkey | Malaysia | | | Luxembourg | Singapore | Turkey |
| Thailand | Turkey | Slovenia | | Poland | | | Portugal | Slovak | |
| | | | | Romania | | | Romania | Slovenia | |
| | | | | Singapore | | | Singapore | | |
| | | | | Slovak | | | Slovak | | |
| | | | | Slovenia | | | Slovenia | | |
| | | | | Thailand | | | | | |

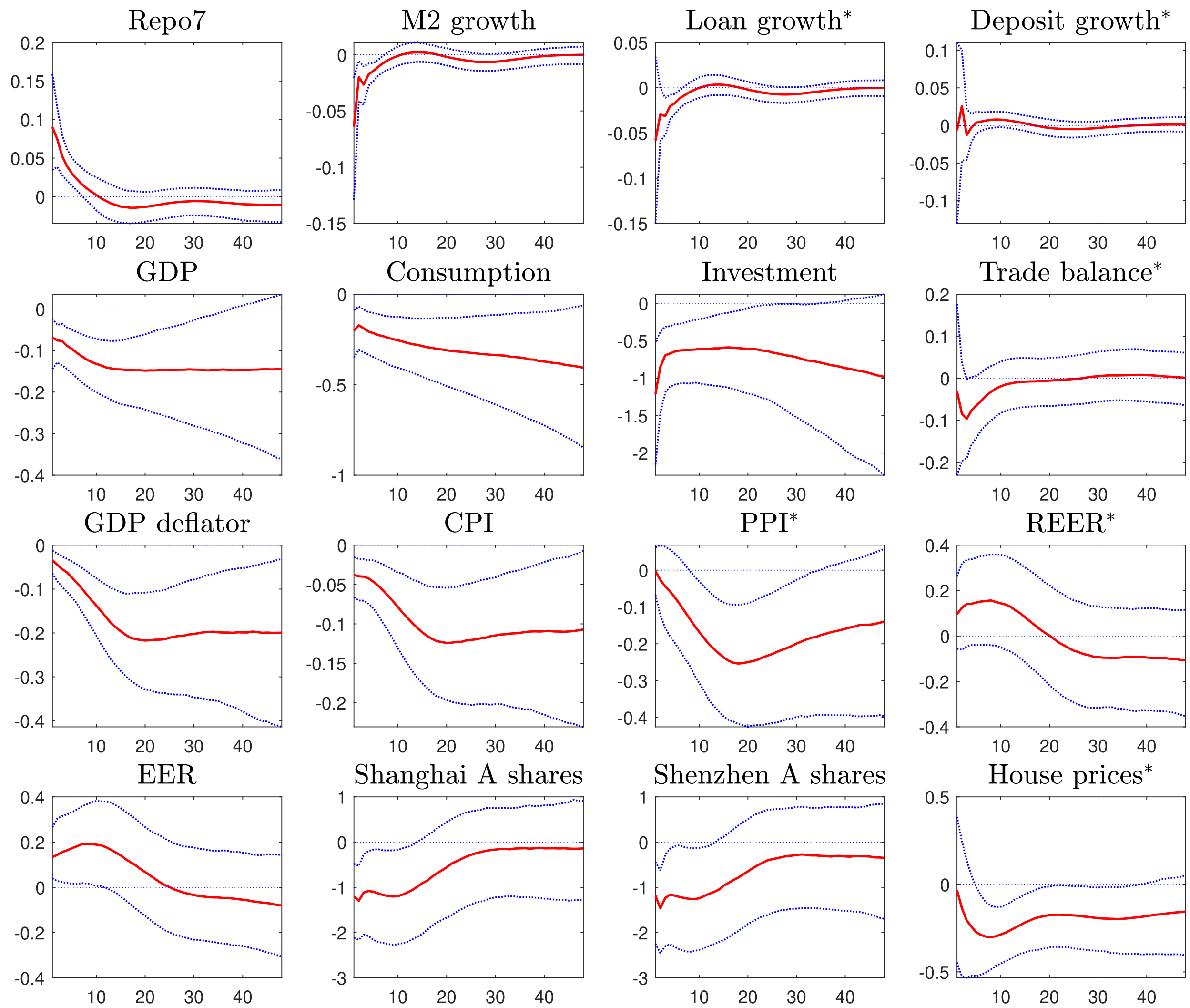


**Fig. 1.** IRFs from the BVAR model.
Note: The red solid lines are the median impulse responses, and the blue dotted lines are the boundaries of the 68% posterior coverage intervals. Variable names with the "*" superscript indicate those left unrestricted in the sign restrictions.

the sign restrictions. In the meantime, the contractionary monetary policy shock also depresses house prices.

Next, as the following research relies heavily on the monetary policy shock series obtained from the BVAR model ($u_t^m$), we compare it with the monetary policy stance index (Sun-MP index) constructed by Sun (2018) (Sun, 2018) to examine how well the $u_t^m$ reflects the shifts in the Chinese monetary policy stance. (Sun, 2018) uses a narrative approach to construct a (quarterly) index reflecting the PBoC's monetary policy stance. The blue bars in Fig. 2 show the values of the Sun-MP index, with different values reflecting the monetary policy stance as easing (−2), loosening (−1), neutral (0), loosely tightening (1), and strictly tightening (2). The solid red line in Fig. 2 is the quarterly cumulative ($u_t^m$) series from the BVAR model. The positive and negative movements of the red line reflect the tightening and easing of the BVAR estimated monetary policy stance, and the turning points reflect the shift in the stance. From Fig. 2, it is clear the monetary policy shock series reflects well the overall tightening from 2004 to 2008, the overall easing from 2008 to 2011, from 2014 to 2017, and from 2018 to 2019, as well as the change in the stance over time.

In summary, these exercises together lend reasonable support to our use of the large BVAR model identified with sign restrictions to estimate China's monetary policy shock. Next, we use the monetary policy shock series as an explanatory variable and estimate local projection models, Eq. (4) and Eq. (5) to investigate its international spillover effects.

### *4.2. The spillover effects of China's monetary policy shock on the B&R countries*

We now investigate the average spillover effects of China's monetary policy shock on the 26 B&R countries. Fig. 3 illustrates the IRFs obtained based on the full sample local projection, Eq. (4). In Fig. 3, the solid red lines are the ordinary least square (OLS)

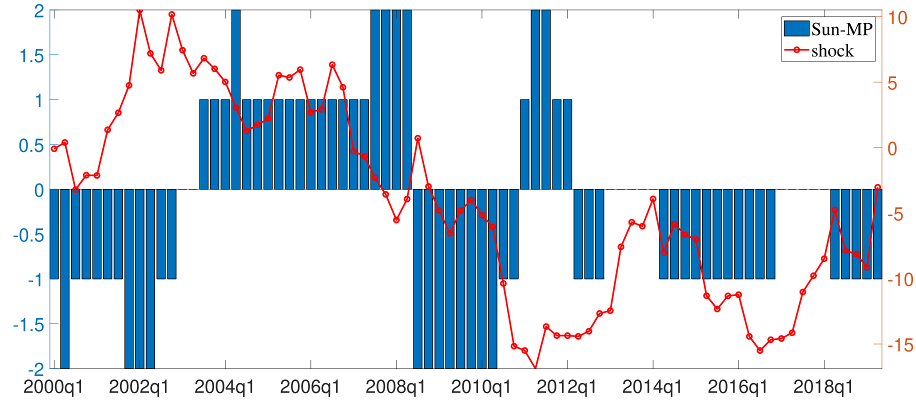


**Fig. 2.** Monetary policy shock series vs. the Sun-MP index.
Note: The solid red line represents the quarterly cumulative monetary policy shock series, whose positive and negative movements reflect the tightening and easing of China's monetary policy stance, and the turning points reflect the shift in the stance. The blue bars show the values of the Sun-MP index, with different values reflecting the monetary policy stance as easing (−2), loosening (−1), neutral (0), loosely tightening (1), and strictly tightening (2).

estimates; the dark areas are the coverage of the 68% error bands, calculated with the heteroskedasticity and autocorrelation consistent (HAC) standard error proposed by (Driscoll and Kraay, 1998).

The key findings based on Fig. 3 are as follows. First, the short-term interest rate spread widens significantly. This finding is consistent with the implication of a contractionary monetary policy shock in China, that is, that the shock leads to an increase in the Chinese short-term interest rate and that the (average) short-term interest rates in the B&R countries react less than one-to-one to the Chinese rate, leading to a widening of the interest rate spread, and triggering the following effects. Second, the foreign stock price index is depressed while the bilateral nominal exchange rate and the REER depreciate significantly. The widening of the interest rate spread leads to a decline in the relative returns of foreign equities and relative weakening of the attractiveness of foreign equities, thus causing equity prices to fall. Moreover, in line with the widening of the interest rate spread and the increase in the relative return on RMB assets, the demand for RMB relative to foreign currencies increases, which leads to a depreciation of foreign currencies and an erosion of the real purchasing power of foreign currencies. Finally, regrading the macro variables, the depreciation in the REER boosts the trade balance. The consumer price index increases significantly. The expenditure switching effect can, to some extent, explain the results above: The widening in the short-term interest rate spread triggers the nominal foreign exchange rate depreciation, and the bilateral RMB depreciation transmits into abroad-based real depreciation, thus improving the foreign trade balance.

Concerning the response of the output, unlike the results from the spillover effects of U.S. (Dedola et al., 2017) and European

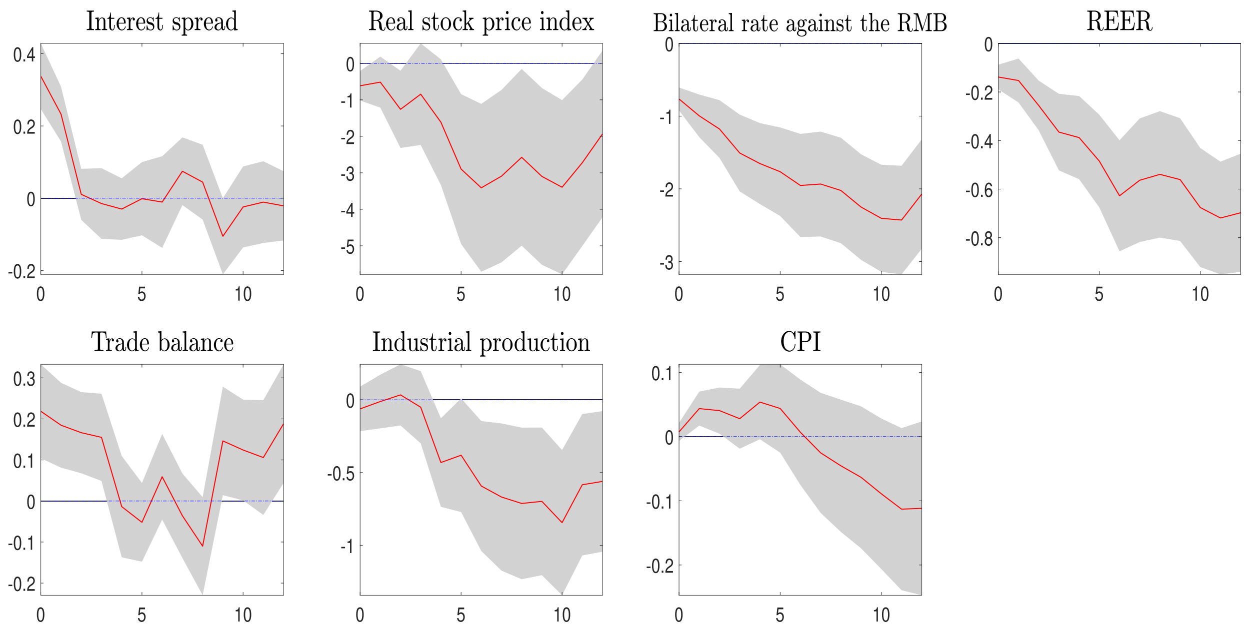


**Fig. 3.** IRFs from the local projections.
Note: The solid red lines are the OLS estimates; the dark areas are the coverage of the 68% error bands, calculated with the HAC standard errors.

(Potjagailo, 2017) monetary policies, China's monetary tightening does not bring about a significant decline in industrial production of the B&R countries on impact. We ascribe the inconclusive result to two reasons: First, different from the US and European Union where the financial channel plays an important role, China's financial influence on the B&R countries is still limited since the capital account in China is less open and the financial market is less integrated with the global market. Therefore, interest rates in foreign countries do not fully follow the rise in China after China's monetary tightening, which reduces the negative effect of China's monetary tightening on the foreign output. Second, since China is a major global player in international trade, the positive expenditure switching effect on output through the trade channel after a contractionary monetary policy shock counteracts the possible negative effects of other mechanisms, such as the income absorption effect, which leads to an inconclusive effect of China's monetary policy shock on the output in the B&R countries.

### *4.3. Country characteristics and the heterogeneous effects of China's monetary policy shock*

In the following, we explore whether there are heterogeneous effects of China's monetary policy shocks across the sample countries' structural characteristics and choice of policy regime by dividing the 26 B&R countries into several groups. The results are obtained from the extended panel regression, Eq. (5).

#### *4.3.1. Trade weight with China*

We present the results by splitting countries based on their trade weight with China, because the previous average results show that trade is a possible important mechanism in China's monetary policy spillover. The results are displayed in Fig. 4. The solid red lines are the OLS responses in the group with high trade weights with China, and the dark areas are the coverage of the 68% error bands. The solid blue lines are the OLS responses in the group with low trade weights with China, and the dotted blue lines are the boundary of the 68% error bands.

Several interesting results shown in Fig. 4 need elaboration. First, the responses of the interest spread, stock price index, and bilateral nominal exchange rate are largely the same across the two groups (the error bands of the three variables in different groups overlap). Second, although the REER depreciates in both groups, it depreciates more severely in high trade weight countries. The quantitative difference in the real depreciation is then transmitted to the quantitative difference in the trade balance, whose response is significantly larger in countries with high trade weights with China. The patterns of consistent REER and trade balance responses in the same group and heterogeneous REER and trade balance responses in different groups further confirm the importance of the expenditure switching effect in shaping China's monetary policy spillover. Third, the qualitative responses of industrial production differ across the two groups. China's monetary tightening leads to a moderate expansion, on average, in countries with high trade weights, and a moderate depression, on average, in countries with low trade weights. Thus, in the high trade weight group, due to the larger positive response of the trade balance, the expenditure switching effect plays a more important role in shaping the spillover of China's monetary policy shock to foreign output.

#### *4.3.2. Other country characteristics: capital openness, trade openness, currency regime, and income level*

We turn next to the analysis of the effects of other country-specific dimensions on the transmission of China's monetary policy shock

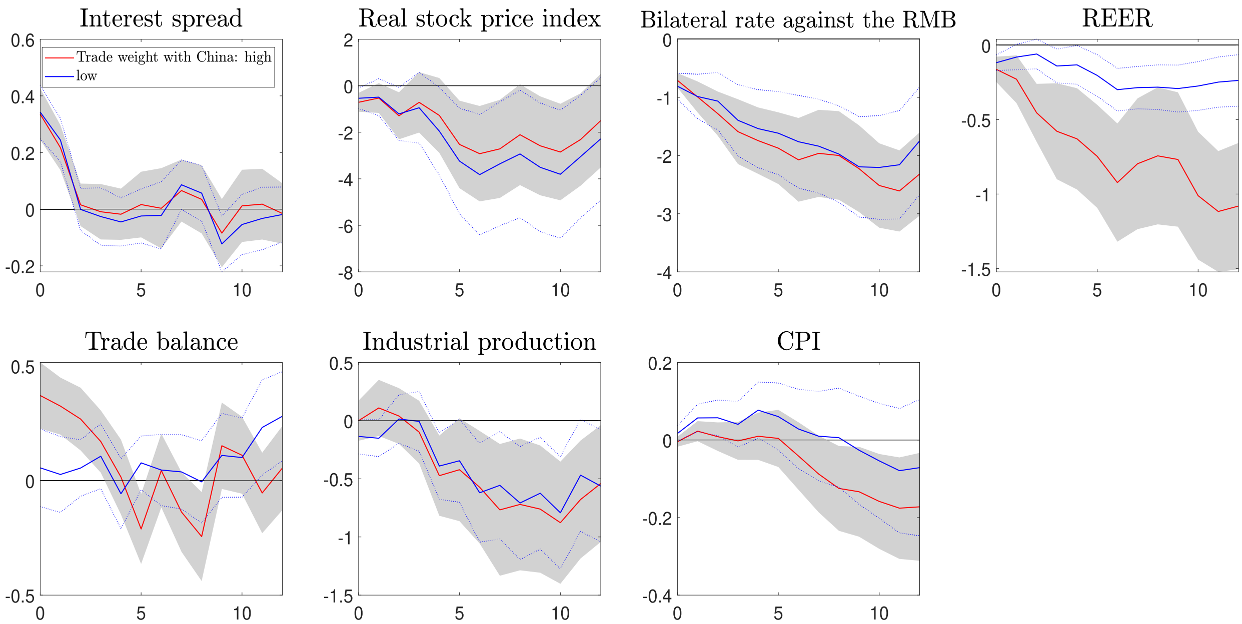


**Fig. 4.** IRFs of countries with different trade weight levels with China.
Note: The solid red lines are the OLS responses in group 1 (see Table 2), with the dark areas the coverage of the 68% error bands. The solid blue lines are the OLS responses in group 0, with the dotted blue lines the boundary of the 68% error bands.

to explore some of the possible asymmetric responses across groups. The graphs of the IRFs are shown in Appendix C to save space.

The findings from Figs. C.1 to C.4 are as follows: First, the responses of the interest spread, stock price index, and bilateral nominal exchange rate are largely the same across all of the country groups. The same reaction of the interest rates differential and the stock market index indicate that the financial channel seems to be less relevant in explaining the spillover effects of China's monetary policy shock. Second, the REER depreciates more severely in countries with low capital openness, low trade openness, and floating exchange regimes and in emerging economies. Third, the qualitative responses of industrial production differ across countries with different levels of capital openness. China's monetary tightening leads to a moderate expansion, on average, in countries with low capital openness, and a moderate depression, on average, in countries with high capital openness.

## 5. Conclusion

In this paper, we first identify China's monetary policy shock in the framework of a large BVAR model identified with sign restrictions and then investigate the spillover effects of China's monetary policy shock on B&R countries through the local projection method. In addition, we group the sample countries according to different characteristics and estimate the response of foreign variables in different groups in an attempt to explore the heterogeneity of the spillover effects and the resulting transmission mechanism.

The empirical results show that China's monetary policy shock has significant spillover effects on macro and financial variables in B&R countries. Specifically, a surprise Chinese monetary tightening brings about a widening in the short-term interest rate spread, a drop in the equity price, nominal depreciation against the RMB and real depreciation, and an improvement in the trade balance on average, across the 26 B&R countries, which reveal the importance of expenditure switching effect in facilitating the international transmission of China's monetary policy shock. Moreover, the role of countries' structural characteristics and the choice of policy regime influence the degree of externalities that China's monetary policy shock imposes abroad and the heterogeneous patterns are in accordance with the expenditure switching effect.

The main policy implications of our findings are twofold. With the ongoing B&R Initiative, the trade, capital, and financial links between China and B&R countries have become increasingly close, and China's monetary policy will increasingly affect the macro and financial conditions in related countries. Therefore, the PBoC should take a global perspective and conduct its monetary policy prudently with the goal of promoting common economic growth. On the flip side, the B&R countries should pay attention to the impact of China's monetary policy on their exchange rate and trade balance, especially countries that have strong trade links with China. Moreover, as China's capital account becomes more open and the financial market becomes more integrated with the B&R countries, other spillover channels of China's monetary policy shocks to the B&R countries are likely to prevail in the future, such as the financial channel. Thus, the B&R countries need to monitor these changes to respond more effectively to China's monetary policy.

## CRediT authorship contribution statement

**Yong Chen:** Software, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Dingming Liu:** Conceptualization, Investigation, Writing – review & editing. **Ziguan Zhuang:** Formal analysis, Investigation, Writing – review & editing.

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## Appendix A. Empirical algorithm

To implement the estimation and identification methods discussed in Section 2, we follow three steps in the empirical exercise:

1. In the first step, we estimate a VAR(2) model in Eq. (1) to obtain $n_1 = 5000$ draws from the conditional posterior of $(\beta, \Sigma)$. The lag order $p = 2$ is in accordance with the Hannan-Quinn criterion.[9]
2. In the second step, we perform sign restrictions to identify the monetary policy shock $q_m$ and to obtain $u_t^m$. First, we take a random draw of $(\widehat{\beta}, \widehat{\Sigma})$ from the $n_1$ samples constructed from step 1 and generate a candidate orthonormal vector $\widehat{q}_m$.[10] Then, we calculate the impulse responses $\widehat{\psi}_h$ according to $(\widehat{\beta}, \widehat{\Sigma}, \widehat{q}_m)$ and compare the signs of $\widehat{\psi}_h$ with those in Table 1. If all of the signs match, we regard $\widehat{q}_m$ as feasible and store it; if not, we discard $\widehat{q}_m$ and proceed to another draw until we obtain $n_2 = 2000$ feasible $q_m$ vectors. Among the feasible draws $\{(\beta^{(s)}, \Sigma^{(s)}, q_m^{(s)})\}_{s=1}^{n_2}$, we construct the monetary policy shock series $u_t^m$ through its median $u_t^m = median_{1 \le s \le n_2}\left\{ \left(q_m^{(s)}\right)' \left(\widetilde{A}^{(s)}\right)^{-1} \varepsilon_t^{(s)} \right\}$.[11]

[9] Based on the Akaike information criterion, we take $p = 6$ for the robustness check, and the empirical results are robust to this alternative lag order.
[10] $q_m$ is constructed as follows: First, an orthogonal matrix $Q$ is constructed using the $QR$ decomposition method, and then the first column of the $Q$ matrix is taken as $q_m$.
[11] The choice of the median is robust to the presence of outliers that could unduly influence the aggregation otherwise.

3. In the third step, we estimate the local projection models in Eq. (4) and (5), where $y$ is taken one by one from the seven foreign variables described in Section 3.2. As the residuals ($e_{i,\ t+h}$) of the regressions, Eq. (4) and (5), are serially correlated, we use the heteroskedasticity and autocorrelation consistent (HAC) standard error proposed by Driscoll and Kraay (1998) (Driscoll and Kraay, 1998) to correct for the serial correlation of the residuals.

## Appendix B. Time series of the Chinese Data

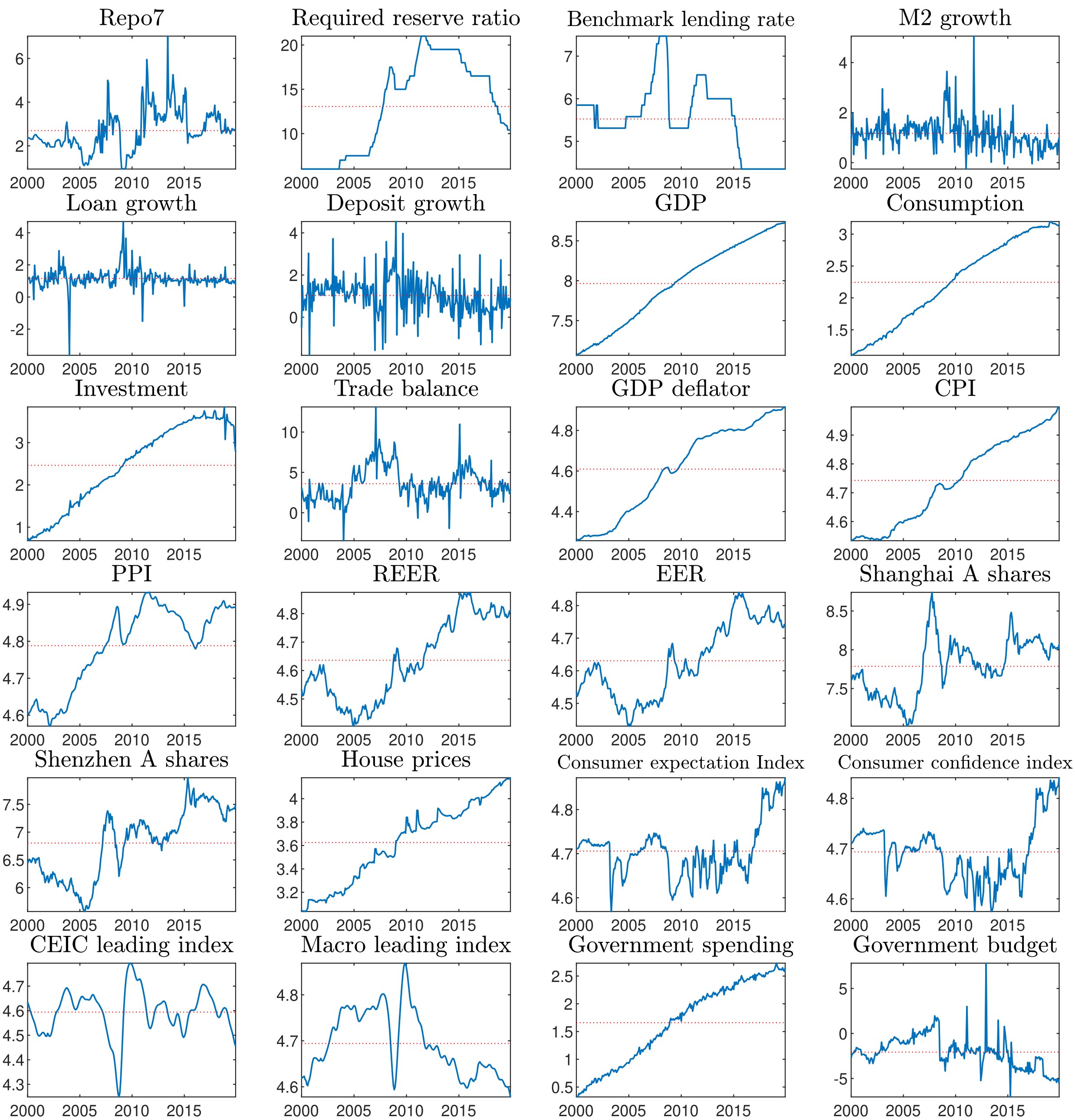


**Fig. B.1.** Data used to estimate the Chinese monetary policy shock.

## Appendix C. IRFs of other country characteristics: capital openness, trade openness, currency regime, and income level

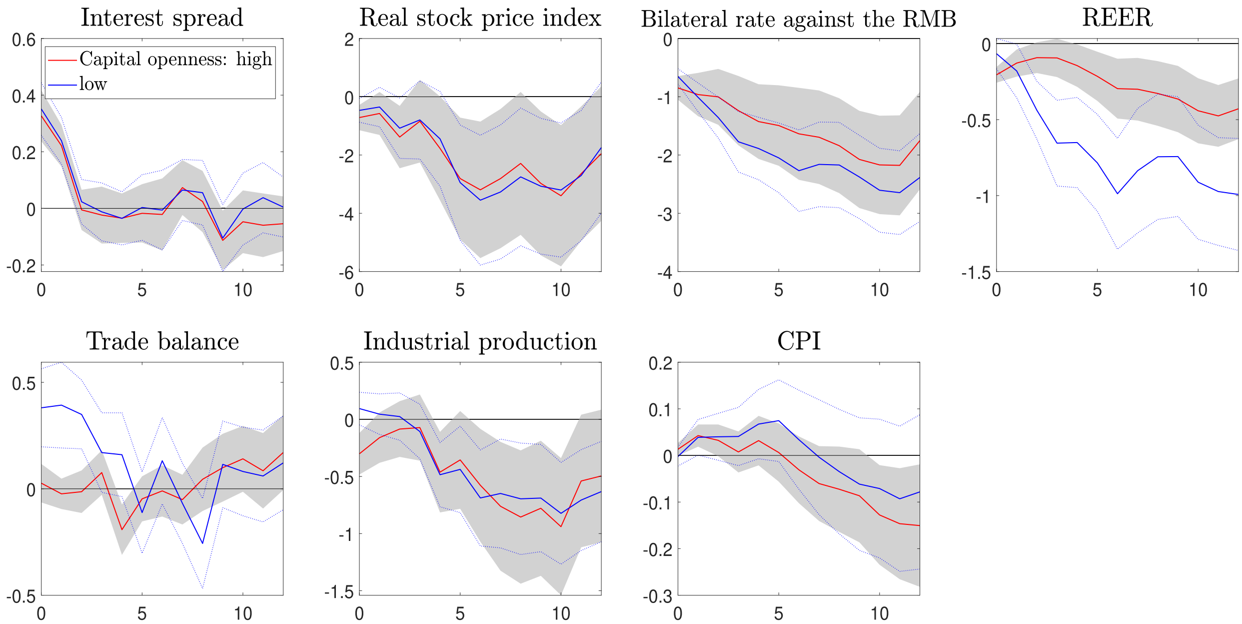


**Fig. C.1.** IRFs of countries with different levels of capital openness. Note: See Fig. 4.

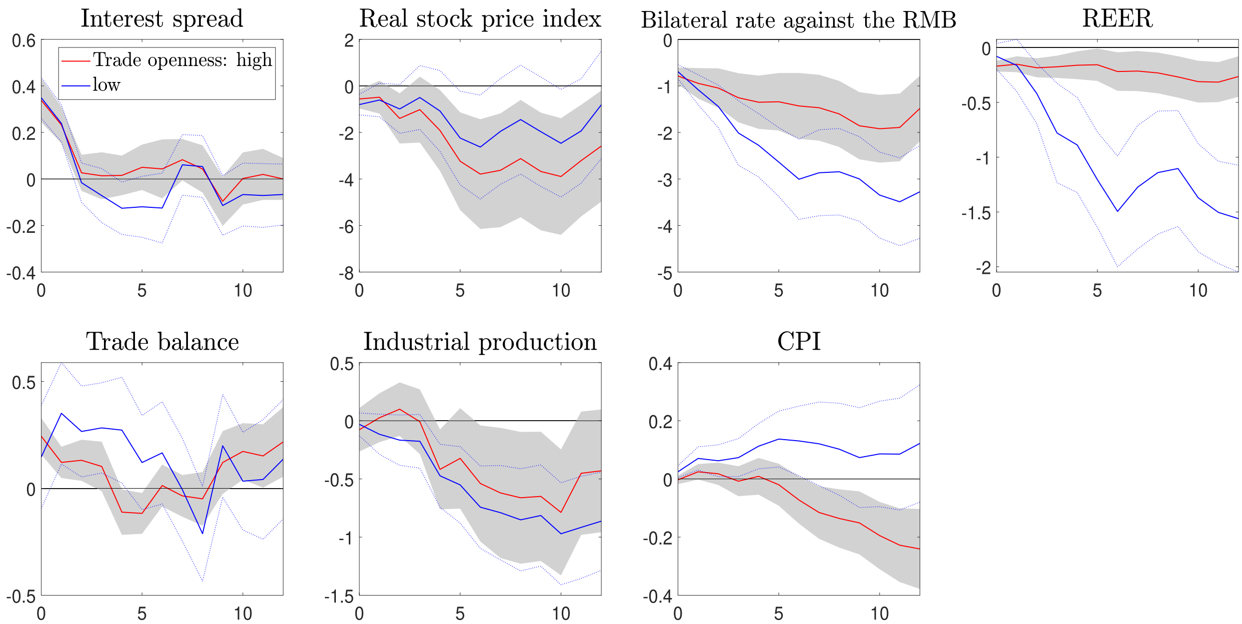


**Fig. C.2.** IRFs of countries with different levels of trade openness. Note: See Fig. 4.

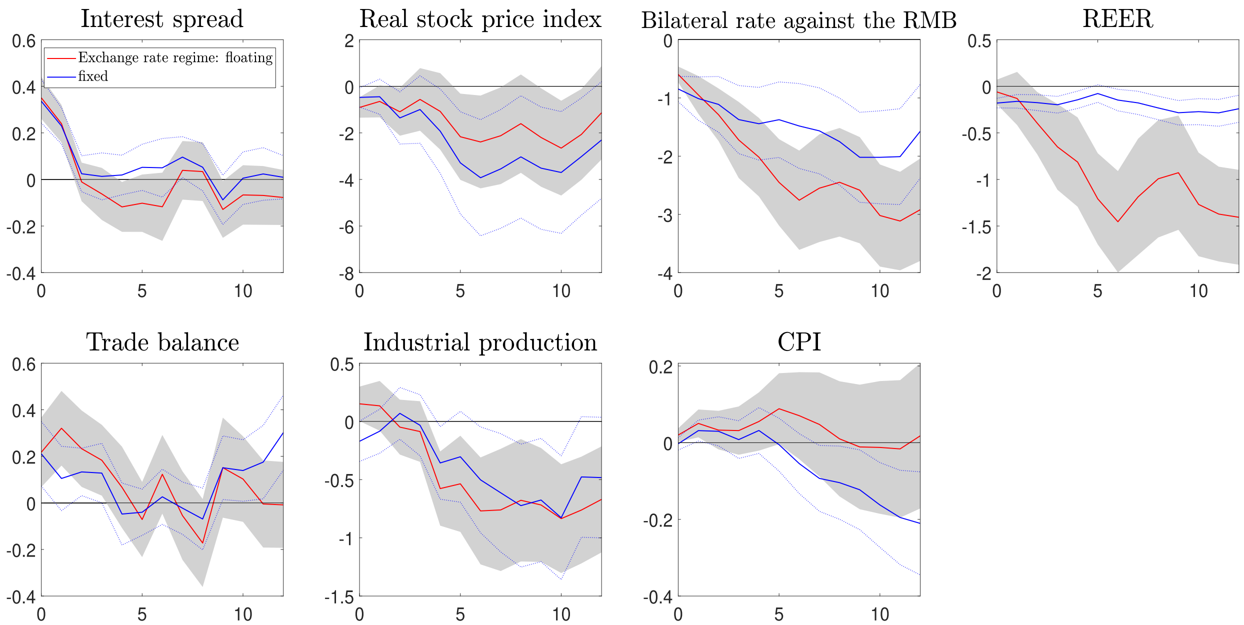


**Fig. C.3.** IRFs of countries with different levels of currency regime. Note: See Fig. 4.

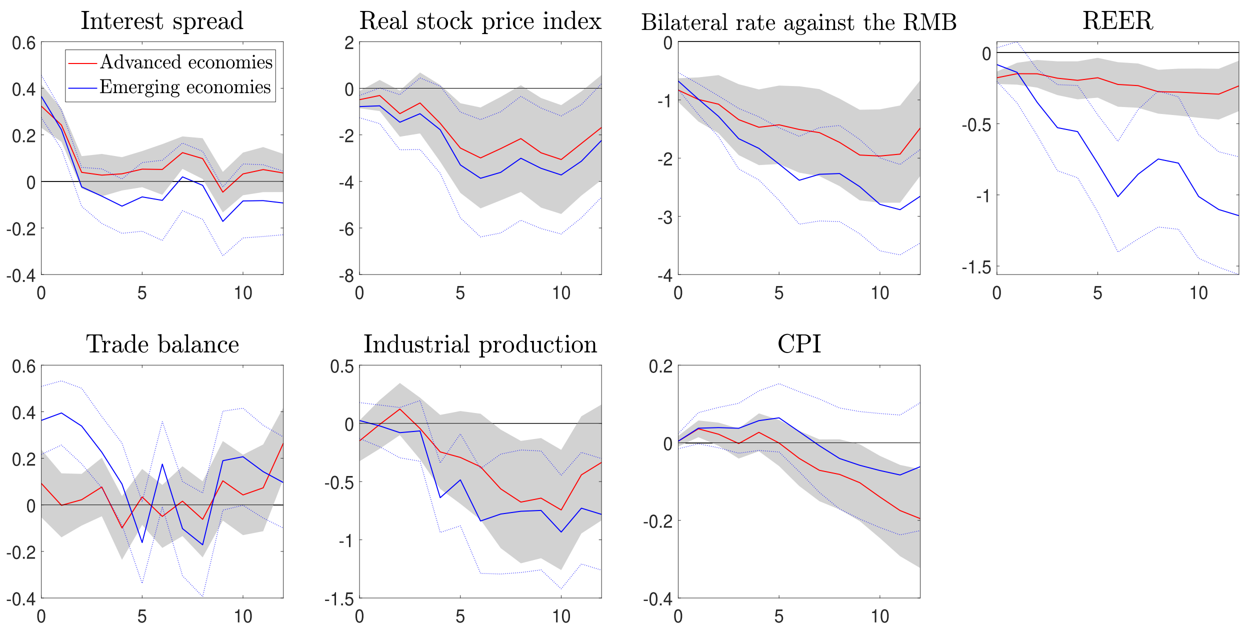


**Fig. C.4.** IRFs of countries with different levels of income level. Note: See Fig. 4.

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