Estimating the International Spillover Effects of China's Fiscal Policy: A Global VAR Analysis

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Abstract

We examine the international spillover effects of China's fiscal policy. Global vector autoregressive (GVAR) model is used for this purpose. First, we demonstrate that China's government spending stimulates private consumption domestically and internationally. Second, we show that an improvement in the general government primary balance by the Chinese government has positive and statistically significant spillover effects on the GDP of several regions. These results imply that while government spending in China is an effective short-term stimulus measure to prop up private consumption when a global economic downturn occurs, fiscal rectitude in China in normal times can be justified in the long run from an international perspective.

JEL classification: C32, E62, F42, H30
Keywords: China's economy; international spillover effects; government spending; fiscal consolidation; global vector autoregression

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1. Introduction

Since the early 2000s, China's economy has experienced remarkable growth. In terms of nominal GDP, China is now second only to the US. China has played a crucial role in the global economy by cultivating interdependent economic linkages with various countries, from advanced to emerging economies.[1] In fact, Miranda-Agrippino and Rey (2022) mention that China's demand is a crucial factor in global trade and commodity cycles. The interwovenness of China with the global economy means that China's fiscal policy may resonate beyond its shores; that is, it may not only benefit its economy but also propagate to various countries around the world.[2] Therefore, it is worthwhile to investigate the spillover effect of China's fiscal policy on the global economy.

In this study, we examine whether China's fiscal policy has international spillover effects on various countries around the globe. To this end, we use the global vector autoregressive (GVAR) model proposed by Pesaran et al. (2004). The GVAR model is suitable for addressing international spillover effects because of its ability to capture interconnectedness among multiple economies through trade and financial linkages. Unlike traditional VAR models, which focus on one country, the GVAR estimation can integrate foreign and global variables as weakly exogenous inputs, allowing a simultaneous examination of domestic and international dynamics. Furthermore, the

[1] For instance, Green (2023) points out that China is still the largest trading partner for various countries and currency unions.

[2] International spillover effects can be justified from a theoretical perspective. Many macroeconomic textbooks, like Heijdra and van der Ploeg (2002), explain this phenomenon. Furthermore, a recent work by Ilori et al. (2022) demonstrates the positive international spillover effects of fiscal policy shocks using a dynamic stochastic general equilibrium model.

inclusion of trade-weighted matrices ensures that we accurately reflect regional interdependencies, which is critical for understanding the fiscal policy transmission to the various countries in our sample.

Our findings can be summarized as follows. First, we robustly show that China's government spending has a positive effect on private consumption of China and the US. Second, we demonstrate that the improvement in China's general government balance has negative and statistically significant effects on private consumption, both domestically and internationally. Finally, we find positive spillover effects on the GDP between China and several other regions with respect to fiscal consolidation. These empirical results suggest that while government spending in China would be an effective short-term stimulus measure to reinvigorate private consumption of China and some other countries, fiscal consolidation in China helps enhance economic growth of China and many other countries in the long run.

Our study is related to two bodies of literature. First, our research is related to recent empirical studies that examine the international spillover effects of fiscal policy. For example, Favero et al. (2011) highlight the heterogeneous nature of fiscal policy multipliers. Hebous and Zimmermann (2013) estimate the spillover effects of a fiscal shock in one country on the outputs of other countries within the EU using the GVAR method. Konstantakis and Michaelides (2014) examine the transmission of debt crises using the GVAR approach. Furthermore, Chudik et al. (2020) identify global and national output and fiscal policy shocks using public debt and GDP data. However, these studies focus primarily on advanced economies and neglect the global

implications of fiscal policies in emerging and middle-income countries. We differentiate ourselves by focusing on China, the most influential emerging country in the world.

Second, we complement studies on China's fiscal policy effectiveness by assuming an open economy framework. Several earlier studies examine this issue, including Zheng and Guo (2013), Yuan and Chen (2015), Mao and Sheng (2017), Chen and Liu Chen and Liu (2018), Garcia-Barragan and Liu (2021), and Zhang (2024), among others. Among them, while Yuan and Chen (2015) compare the effects of China's fiscal policy with those of other BRICS countries (Brazil, Russia, India, and South Africa), they leave other countries out of their analysis. Zhang (2024) addresses the spillover effects between China and other countries. However, whereas Zhang (2024) examines the effects of government spending by focusing on the bilateral relationship between China and each G-7 country, Zhang (2024) does not address how China's fiscal policy propagates to a wide range of countries including emerging, middle-income, and advanced economies. We do this.[3]

The remainder of this paper proceeds as follows. Section 2 describes the empirical framework and data. Sections 3 and 4 present the empirical results and robustness checks, respectively. Finally, section 5 concludes the paper.

[3] Several studies, such as that by Wang and Wen (2019), examine the effects of China's fiscal policy on its domestic macroeconomic variables. However, they do not use an open economy setting. Chen and Groenewold (2018) examine the fiscal policy effects using the GVAR in China: however, they examine the effects on its domestic regional economy. While a recent study by Chen et al. (2023) analyzes the international spillover effects of China's monetary policy with fiscal policy variables included as a control variable, they do not examine the fiscal policy effectiveness.

2. Empirical framework and data

2.1. Empirical framework

The GVAR enables us to address international spillover effects on vast macroeconomic factors using large-scale panel data. It has three advantages. First, it allows us to measure the effects of domestic and foreign country-specific shocks. Second, it helps analyze the long-run relationships and dynamics. Third, it enables us to test many hypotheses from a macroeconomic perspective using international spillovers.

The model is constructed using a region-specific VECM, whereby every economy or region has local macroeconomic factors and is associated with other economies by incorporating conforming foreign-specific variables, which can interrelate simultaneously. Hence, applying the GVAR framework involves two primary steps. In the first step, we apply a single-country-specific VECMX with foreign factors that are considered weakly exogenous. In the second step, individual country models are stacked in the GVAR model and simultaneously employ trade weights.

The first step in constructing the GVAR model is to estimate each country-specific VECMs, individually augmented by weakly exogenous country-specific foreign and global variables, signified by VARX*, containing a constant and deterministic time trend. Following the detailed description of the model in some previous studies, we explain the overall specification of a country-specific framework (VARX*) as follows.

Suppose $N+1$ countries in the global economy indexed by $i = 0,\ 1,\ 2, \ldots, N$, where country 0 is the reference country and $\mathrm{t} = 1,\ \ldots,\ T$ denotes time.[4] For each country, we build an augmented VARX*(p_i, q_i) model, where p_i is the lag order of the domestic variables (x_{it}) and q_i is the lag order of the foreign variables (x_{it}^*). We determine the lag lengths p_i and q_i for the VARX*(p_i, q_i) model based on the Akaike Information Criterion (AIC).[5] To present the GVAR, we use the VARX*$(1, 1)$ model representation, which can be written as

$$x_{it} = a_{i0} + a_{i1}t + \Phi_{i1}x_{it-1} + \Lambda_{i0}x_{it}^* + \Lambda_{i1}x_{it-1}^* + \psi_{i0}d_t + \psi_{i1}d_{t-1} + u_{it}, \qquad (1)$$

where x_{it} denotes a $k_i \times 1$ vector of domestic variables for country i in period t.[6] x_{it}^* denotes a $k_i^* \times 1$vector of foreign variables for country i in period t. d_t is a $k_i \times 1$ vector of global variables in period t. x_{it} is endogenous, x_{it}^* is weakly exogenous, and d_t is exogenous. Φ_i and Λ_i are $k_i \times k_i$ and $k_i \times k_i^*$ coefficient matrices associated with the domestic and foreign variables, respectively. Moreover, a_{i0} is a $k_i \times 1$ vector of fixed intercepts, a_{i1} is a $k_i \times 1$ vector of deterministic time trends, and u_{it} is a $k_i \times 1$ vector of the error terms, which we assume to be serially uncorrelated.

We obtain x_{it}^* as follows.

[4] We use the US as the reference country because it is the largest economy in our sample and exerts the greatest influence.
[5] Please also see Table 2.
[6] Our notation follows that of Pesaran et al. (2004), Dees et al. (2007), and Bettendorf (2017).

$$x_{it}^{*} = \sum_{j=0}^{N} \omega_{ij}\, x_{jt}, \tag{2}$$

where ω_{ij} is a weighting factor that captures the importance of region j for region i, with $\sum_{j=0}^{N} \omega_{ij} = 1$ and $\omega_{ii} = 0$. Following previous studies, such as Dees et al. (2007), we use trade shares to calculate ω_{ij}. The weights are computed as a three-year average from 2014 to 2016 because huge exogenous shocks to the global economy, such as the global financial crisis, did not occur within this period, which makes the weight relatively stable compared to other periods.[7]

In the second step, we combine the individual VARX models using a matrix to solve the global model. Now, we define z_{it} as a $(k_i + k_i^{*}) \times 1$ vector of the domestic and foreign variables as $z_{it} = (x_{it}, x_{it}^{*})'$. Thus, we can rewrite Eq. (1) as

$$A_{i0} z_{it} = a_{i0} + a_{i1} t + A_{i1} z_{it-1} + \psi_{i0} d_t + \psi_{i1} d_{t-1} + u_{it}, \tag{3}$$

where $A_{i0} = (I_{k_i}, -\Lambda_{i0})$ and $A_{i1} = (\Phi_{i1}, -\Lambda_{i1})$.

Using the trade weight matrix, we can rewrite the country-specific variables as

$$z_{it} = W_i x_t. \tag{4}$$

Using Eq. (4), we can reformulate Eq. (3) as

[7] For the details on how to calculate the weights based on average trade shares over a period of certain years among the countries under study, please see Dees et al. (2007) and Cashin et al. (2014), among others. In fact, many studies use this strategy rather than time varying weights.

$$A_{i0}W_i x_t = a_{i0} + a_{i1}t + A_{i1}W_i x_t \ + \psi_{i0}d_t + \psi_{i1}d_{t-1} + u_{it}. \quad (5)$$

When stacking all the country models, we obtain Equation (6).

$$G_0 x_t = a_0 + a_1 t + G_1 x_{t-1} + \psi_0 d_t + \psi_1 d_{t-1} + u_t, \quad (6)$$

where $a_0 = \begin{pmatrix} a_{\mathbf{00}} \\ a_{\mathbf{10}} \\ \vdots \\ a_{N0} \end{pmatrix}$, $a_1 = \begin{pmatrix} a_{\mathbf{01}} \\ a_{\mathbf{11}} \\ \vdots \\ a_{N1} \end{pmatrix}$, $u_t = \begin{pmatrix} u_{\mathbf{0}t} \\ u_{\mathbf{1}t} \\ \vdots \\ u_{Nt} \end{pmatrix}$

and $G_0 = \begin{pmatrix} A_{00}W_0 \\ A_{10}W_1 \\ \vdots \\ A_{N0}W_N \end{pmatrix}$, $\quad G_1 = \begin{pmatrix} A_{01}W_0 \\ A_{11}W_1 \\ \vdots \\ A_{N1}W_N \end{pmatrix}$.

Finally, we define $X_t = (x_t,\ d_t)'$ and rewrite Eq. (6) as:

$$H_0 X_t = a_0 + a_1 t + H_1 X_{t-1} + \varepsilon_t, \quad (7)$$

where $\mathrm{H}_0 = (G_{0,} \quad -\psi_0)$ and $\mathrm{H}_1 = (G_1, \quad -\psi_1)$.

We use the generalized impulse response function (GIRF) proposed by Pesaran and Shin (1998), following many GVAR studies. The GIRF generates shock response curves that do not depend on variables of different orders. We follow Dees et al. (2007)

in generating bootstrap medians and confidence bands by bootstrapping through 1,000 repetitions of the simulation to provide robust inference.

2.2. Data

We use quarterly frequency data for 33 economies, including developed and developing economies from 1990 Q1 to 2019 Q4. Because we cover more than 90% of the world's GDP, our GVAR model is highly representative of the global economy and captures the multilateral nature of global interconnectedness. Nine regions were created for the empirical application: the US, China, Japan, the Rest of Asia, North America, South America, Europe, Oceania, and Africa. Table 1 lists the countries included in the model. Our sample period excludes the post-COVID 19 period because the transmission mechanism of macroeconomic policy by the Chinese government may have changed since 2020, as Zhang (2024) points out.

The six core domestic variables ($x_{i,t}$) in our GVAR model are the natural logarithm of real GDP (y_{it}), ratio of general government spending to GDP (gx_{it}), real interest rate (r_{it}), real effective exchange rate ($reer_{it}$), ratio of net exports to GDP (nx_{it}), and ratio of private consumption to GDP (c_{it}).[8] Instead of gx_{it}, we use the ratio of the general government's primary balance to GDP (gb_{it}) as a robustness check. Additionally, as Favero and Giavazzi (2007) and Chung and Leeper (2007), studies that

[8] Since Chinese authorities moved to the managed floating exchange rate regime from the single pegged currency policy in 2005, that year would contain a structural change in the economy. However, You and Sarantis (2012) do not confirm the structural break in the cointegration relationship between real effective exchange rate and other macroeconomic variables in China around 2005. Following their results, we do not address this structural change in our estimation.

do not consider government budget constraints may be biased. We later consider this by adding the debt-to-GDP ratio (d_{it}) to the country-specific VAR model as a robustness check.

We construct country-specific foreign variables (x_{it}^{*}) using fixed trade weights corresponding to the domestic variables. For the global variable, following the standard literature, we include the natural logarithm of the nominal price of oil in US dollars ($poil_t$) to capture the volatility of the world commodity market. Each country-specific model has up to six domestic variables (x_{it}), five foreign variables (x_{it}^{*}), and one global variable. The oil price is considered a weak exogenous factor.

Data on real GDP, real interest rate, real effective exchange rate, and oil price are taken from Mohaddes and Raissi (2024).[9] For the trade matrices, we use data calculated by Mohaddes and Raissi (2024).

The data for the ratio of general government spending to GDP are the general government's final consumption expenditure (% of GDP), which are obtained from the OECD Economic Outlook for OECD countries and the World Development Indicators (WDI) for other countries.[10] The ratio of central government debt to GDP is also downloaded from the OECD Economic Outlook and the WDI.[11] The ratio of the general government's primary balance to GDP is from the IMF.

[9] Please also see https://www.mohaddes.org/gvar. As stated, since we exclude the effects of the COVID-19 pandemic, our sample period ends in 2019. We mention the possibility of extending the sample period in Section 5.

[10] Since we can obtain the data on government spending from both the OECD and the WDI, we use government spending data to capture the fiscal policy effectiveness. Thus, we cannot examine the effects of public investment.

[11] As we cannot obtain the general government data for some countries, we use data on the central government for the data on government debt.

The ratio of private consumption to GDP is from OECD National Accounts data files. If data for some countries are not available, we obtained them from the WDI. The ratio of net exports per GDP is obtained from the WDI.

3. Empirical results

3.1. Testing unit root and cointegrations

We first check the long-run relationship of each variable based on the augmented Dickey-Fuller test for all 33 countries.[12] Table 2 report the results of the co-integration tests. We use VARX*(2, 1) for almost all countries, following the AIC. We determine the number of long-run relations of each country-specific VARX* model using Johansen's maximal eigenvalues and trace statistics, which Pesaran et al. (2000) developed for models with weakly exogenous I (1) regressors. We choose the number of cointegrating relations based on trace test statistics using 68% critical values from MacKinnon (2010).

3.2. Testing weak exogeneity

We must check whether the foreign variables (x_{it}^{*}) are weakly exogenous. We follow Dees et al. (2007) to test this assumption, and report the results in Table 3. The results

[12] We report the detailed results on the unit-root test in Appendix 1.

suggest that foreign and global variables satisfy the assumption of weak exogeneity in almost all cases.

3.3. The spillover effects of government spending on the global economy

As mentioned earlier, we divide the 33 countries into 9 regions and examine the spillover effects of China's government spending shocks on c_{it} or y_{it} regarding the 9 regions.[13]

Figure 1 presents the estimation results of the GIRFs for China's government spending shock on c_{it}. As Figure 1 shows, China's private consumption responds positively by 5% in the first year, reaches its peak, and then stabilizes at close to 1.8%. However, Figure 2 shows that the increase in China's government spending had a temporary negative impact on GDP at first and then turned positive and stabilized, but the effect became statistically insignificant.

Figures 1 shows that, similar to many empirical studies using VAR, China's fiscal policy increases its domestic consumption.[14] Furthermore, it has positive spillover effects on other economies. First, we find a positive and statistically significant effect of the US on c_{it}. Second, our results show that the rest of the Asian countries increase c_{it} by 2%, although the effects become statistically insignificant.

[13] The detailed results for all the 33 countries are presented in Appendix 2.

[14] For example, Iwata (2013) offers a related discussion. As Iwata (2013) indicates, many empirical studies using VAR tend to also find a depreciation of the real exchange rate in accordance with the increase in government spending. While we also check the effects on the China's real exchange rate, we confirm the depreciation of the renminbi but it is statistically insignificant. Detailed results can be obtained upon request.

We attribute the spillover effect to the US to the linkage between the US and Chinese trade markets. China's expanding domestic demand will increase the demand for US commodities, driving the US economy and, thus, US consumption. This finding is supported by Bekiros (2014), who shows spillover volatility between the US and China through trade and financial markets.

Meanwhile, regions such as the rest of Asia, Europe, and Oceania are expected to benefit from China's fiscal policy because China provides government funds to some countries in these areas. For these countries, financial aid from the Chinese government may also benefit the economy, in addition to the spillover effects of China's fiscal policy. At first glance, the grant does not seem to revitalize the economies of these regions. However, the Chinese government became eager to support these regions after the 2010s and later in the sample period. Therefore, it is difficult to capture the exact effects of China's financial support in these regions.[15] With respect to the African region, we recall that we included only South Africa, as shown in Table 1. The Chinese government provides financial assistance to the South African government, and some assistance may be used for government spending. However, many studies estimating fiscal policy effectiveness in South Africa report that the fiscal multiplier of South Africa is less than one, and some estimate it to be negative.[16] One reason is that government spending may directly crowd out private consumption in South Africa. If

[15] For instance, although the Belt and Road Initiative was announced in 2013, most countries joined after 2017. In this regard, the effects of the Belt and Road Initiative should be examined through another framework by extending sample period.

[16] For instance, please see recent studies such as Merrino (2021), Du Rand et al. (2023), and Mbaleki (2024).

this is the case, the negative and statistically significant response to private consumption in South Africa may be explained by its economic structure.

4. Alternative frameworks

To further assess the robustness of the model, we replace the data on government spending per GDP (gx_{it}) with the general government primary balance per GDP (gb_{it}). Second, we add government debt-to-GDP ratio (d_{it}) to the original specifications.

4.1. Using the primary balance data instead of government spending data

First, we estimate the global impulse response functions by replacing gx_{it} with gb_{it}. Since government budget balance is the difference between government revenue and expenditure, the robustness of results on economic variables is demonstrated when opposite results are observed between gb_{it} and economic variables.

As Figures 3 and 4 show, China's general government primary balance has a long-term negative impact on c_{it} and a long-term positive impact on y_{it} of China. Furthermore, it also has negative and statistically significant spillover effects on c_{it} of the US and other countries, which supports the results shown in Figure 1.

Figure 4 also demonstrates that China's fiscal consolidation has a positive impact on its GDP and other countries' output, although the magnitude is very small.[17] This is consistent with the theoretical argument of Erceg and Lindé (2012), who demonstrate the positive spillover effects of fiscal consolidation in an open-economy macroeconomic model. Furthermore, the Chinese economy may reach a point at which the debt-to-GDP ratio lowers economic growth and exceeds a certain threshold, as suggested by Reinhart and Rogoff (2010).[18] In recent years, the debt outstanding of local governments in China has exceeded that of the central government. In particular, local government financing vehicles (LGFVs), which is an entity that finances local public infrastructures, have issued a lot of bonds and local governments have helped the reimbursement of the bonds: this is called as "local governments' hidden debt."[19] Because of the rise in the debt outstanding of the local public sector as well as the possibility of future increases in the debt burden of local governments, the general government debt-to-GDP ratio in China may surpass the threshold; therefore, the Chinese economy would be in a situation where fiscal consolidation promotes economic growth.[20] The Chinese central government has urged the local public sector to reduce its debt.[21] Our results also suggest that the request for fiscal rectitude toward

[17] We also try to clarify the transmission mechanism of the spillover effects of China's GDP on GDP and net export of other countries following Beetsma et al. (2006). Please see Appendix 3 for the details.
[18] Another possibility is that the rise in fiscal surplus decreases interest rate in the loanable market, which stimulates private demand and GDP. Although we check the effects of the general government primary balance per GDP on long-term interest rate, we cannot necessarily yield negative and statistically significant responses. Detailed results are obtained upon request.
[19] For more details, please see Bai et al. (2016). Please also see https://asia.nikkei.com/Spotlight/Caixin/China-s-economy-hostage-to-local-governments-hidden-debts.
[20] Due to the limitation of the data, we cannot divide the data into central and local governments with respect to general government primary balance. Therefore, note that we have nothing but to interpret based upon the results and related facts.
[21] For instance, please see https://baijiahao.baidu.com/s?id=1772583790785985565&wfr=spider&for=pc.

local governments by the Chinese central government may not only enhance its economic growth, but also have positive spillover effects on the rest of the world.

4.2. Extending the baseline GVAR with government debt

As Favero and Giavazzi (2007) and Chung and Leeper (2007) argue, the results that do not consider government budget constraints are biased. Hebous and Zimmermann (2013) address this point by adding the government debt-to-GDP ratio (d_{it}) as an endogenous variable to control for the dynamics of government budget constraints. There are seven core variables: $x_{it} = (y_{it}, gx_{it}, c_{it}, r_{it}, reer_{it}, nx_{it}, d_{it})$.

Figures 5 and 6 show that China's government spending has a long-term positive impact on domestic consumption and no statistically significant impact on GDP in the long run. These results are consistent with those shown in Figures 1 and 2.

Meanwhile, China's government spending has a positive and statistically significant long-run spillover effect on both c_{it} and y_{it} in the United States; the spillover effects on the US economy become more salient with the addition of d_{it}.

5. Conclusion and discussion

In this study, we have investigated the international spillover effects of China's fiscal policies using the GVAR method. The empirical results show that Chinese government spending increases private domestic consumption. The positive spillover effect between

Chinese government spending and private consumption in the US is robust. When it comes to the effects of the general government's primary balance, we demonstrate that while fiscal austerity in China depresses private consumption in both China and some other countries, it also has positive international spillover effects on output.

At first glance, the effects of the general government's primary balance on private consumption and GDP seem contradictory. However, as discussed in Section 4.2, the Chinese economy may be in a situation where the debt-to-GDP ratio exceeds the threshold such that fiscal expansion decreases economic growth because of the accumulation of government debt outstanding, particularly by the local public sector. In this regard, one interpretation is that, whereas fiscal consolidation decreases private consumption in the short run, the decrease in government bonds may have positive effects on GDP in both China and the rest of the world in the medium and long terms.

Following these arguments, our first policy implication is that fiscal austerity, especially in the local public sector, should be prioritized in China in the long run. Furthermore, we suggest that the proactive debt management policy adopted by the Chinese central government to address the local government debt problem would also be meaningful for other emerging countries facing similar fiscal challenges. Second, government spending would be useful as a stimulus measure for China and other countries when a global economic downturn (like the 2007-2008 financial crisis) occurs.[22]

[22] The idea that the government should delay fiscal consolidation in a recession but pursue it in a boom is consistent with the theoretical argument by Glazer (2013).

Our research can be extended as follows: First, while focusing on the empirical investigations, it is necessary to construct a theoretical model to support our findings. Second, as some studies have examined the international transmission of monetary policy in China, it would also be an option to examine the international spillover effects of China's monetary and fiscal policy mix. Finally, if longer data were available, it would be necessary to include post-pandemic data to address the structural changes caused by the COVID-19 pandemic.

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Appendix 1. Detailed results on unit root tests for all the countries

Table A.1. reports the unit root test results for all countries. From the table, most of the variables are not stationary in a level specification. However, we confirm that all the variables follow I (1) process after taking the first difference. Therefore, we take the first difference for all the variables except $reer_{it}$ and nx_{it} in our estimation.

Appendix 2. Detailed results on IRFs for other countries

Figures A.1 and A.2 report the results of the IRFs for other countries reported in the main text.

Appendix 3. The spillover effects of China's fiscal consolidation on GDP and net export of all countries

As shown in Section 4.3., since the improvement in China's primary balance has positive impact on GDP of some other countries, we try to dig deeper the transmission mechanism of China's fiscal policy. To do this, we follow Beetsma, et al. (2006), who identify that fiscal policy stimulates domestic economic activities of one country and thus its import rises. Here, since the increase in the import means the rise of exports for other countries, the economic activities of other countries are also invigorated.

Therefore, we examine the effects of China's GDP on the response of the logarithm of GDP (y_{it}) and net exports (nx_{it}) of other regions.

Figures A3 and A4 show the responses of y_{it} and nx_{it} of other regions, respectively. We confirm the positive spillover effects on y_{it} and nx_{it} of the US in period 0, although the effects soon become statistically insignificant. According to Figure A3, there are also positive spillover effects on y_{it} for Japan, rest of Asia, North America, Europe, and Oceania. These are consistent with Arora and Vamvakidis (2011) and Ahuja and Nabar (2012), who confirmed that there exist international spillovers from China's economic growth and that distance matters less over time with globalization. Figure A4 shows that a positive GDP shock in China has a positive and statistically significant spillover effect on nx_{it} in Japan and the US initially, but no positive and statistically significant effect on other regions. Ahuja and Nabar (2012) confirmed the results of the cross-country impact of China's growing influence on the growth of its trading partners. Japan is typically the case, as its exports of luxury goods (e.g., high-end passenger cars) to China have grown.

Table 1
Countries and regions in the GVAR Model

US	**North America**	**Europe**	**Oceania**
	Canada	Austria	Australia
China	Mexico	Belgium	New Zealand
		Finland	
Japan	**South America**	France	**Africa**
	Argentina	Germany	South Africa
Rest of Asia	Brazil	Italy	
India	Chile	Netherlands	
Indonesia	Peru	Norway	
Korea		Spain	
Malaysia		Sweden	
Philippines		Switzerland	
Singapore		Turkey	
Thailand		United Kingdom	
Serbia			

Table 2
Cointegration test results

Country	p	q	r
Argentina	2	1	4
Australia	1	1	4
Austria	1	1	5
Belgium	1	1	5
Brazil	2	1	4
Canada	1	1	4
China	2	1	3
Chile	1	1	4
Finland	1	1	5
France	1	1	4
Germany	2	1	4
India	1	1	4
Indonesia	2	1	4
Italy	1	1	5
Japan	1	1	5
Korea	1	1	6
Malaysia	1	1	4
Mexico	2	1	5
Netherlands	1	1	5
Norway	2	1	5
New Zealand	1	1	5
Peru	2	1	4
Philippines	2	1	3
South Africa	1	1	4
Saudi Arabia	2	1	4
Singapore	2	1	3
Spain	1	1	4
Sweden	1	1	5
Switzerland	2	1	4
Thailand	2	1	3
Turkey	2	1	2
United Kingdom	1	1	5
USA	1	1	3

Note: Lag orders are estimated using the AIC. The r-value of the cointegration relationships was obtained using the Johansen trace test.

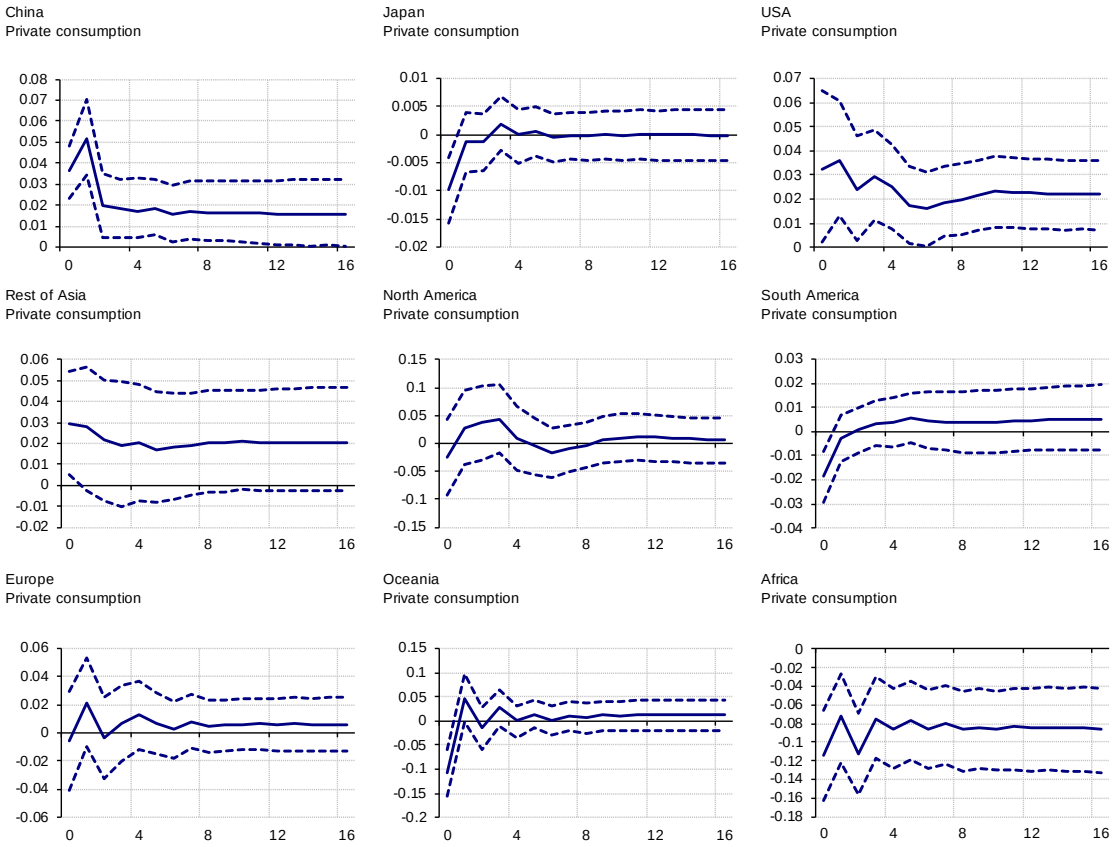
Table 3

Exogeneity tests for the foreign and global variables

Country	Critical value	ys	gxs	cs	reers	nxs	rs	poil
Argentina	2.48	0.43	0.52	0.42		0.32	4.35	0.11
Australia	2.46	0.98	0.54	2.96		1.32	3.51	3.60
Austria	2.31	1.40	1.28	0.29		0.77	1.15	0.65
Belgium	2.31	0.87	1.93	2.25		0.29	0.92	0.18
Brazil	2.47	0.88	2.01	1.17		0.87	1.70	0.44
Canada	2.47	0.49	1.90	0.10		0.40	0.89	1.83
China	2.70	0.43	0.61	0.19		0.85	5.64	0.85
Chile	2.47	2.81	0.75	3.57		0.66	1.36	2.58
Finland	2.31	0.99	0.92	1.30		0.54	4.20	1.66
France	2.47	0.55	0.92	0.32		0.99	1.55	0.54
Germany	2.47	0.96	0.72	1.17		0.39	0.65	0.43
India	2.47	0.19	0.46	0.38		0.50	0.53	0.64
Indonesia	2.48	1.30	0.42	1.38		0.10	1.17	0.20
Italy	2.32	0.73	0.80	1.07		0.32	1.73	1.83
Japan	2.31	1.29	2.09	1.07		0.63	0.93	1.67
Korea	2.20	1.03	1.91	0.80		0.40	1.98	0.56
Malaysia	2.47	4.57	0.83	4.88		0.05	2.11	1.14
Mexico	2.31	0.45	0.14	1.57		0.76	0.98	0.47
Netherlands	2.31	1.40	1.94	0.33		1.09	1.44	0.62
Norway	2.31	0.68	2.71	1.89		0.95	1.76	0.63
New Zealand	2.31	1.72	0.78	2.98		1.32	0.76	1.42
Peru	2.47	1.49	1.85	2.66		2.15	3.20	2.12
Philippines	2.70	4.92	0.97	1.05		0.85	0.53	0.61
South Africa	2.47	0.58	0.16	1.70		1.84	1.91	0.43
Saudi Arabia	2.47	0.84	1.21	0.23		0.91	0.42	0.83
Singapore	2.70	3.74	1.02	1.85		1.06	1.71	1.61
Spain	2.47	0.46	1.49	0.68		0.51	1.18	0.32
Sweden	2.31	0.96	1.18	1.25		3.02	1.71	0.50
Switzerland	2.47	0.38	0.97	1.02		0.33	0.62	0.63
Thailand	2.70	1.60	3.39	3.59		0.99	0.29	1.13
Turkey	3.09	1.96	0.91	0.31		3.59	2.24	1.54
United Kingdom	2.31	2.88	1.32	2.13		2.76	2.83	0.55
USA	2.70	2.65	2.93	0.69	1.19	1.89		2.21

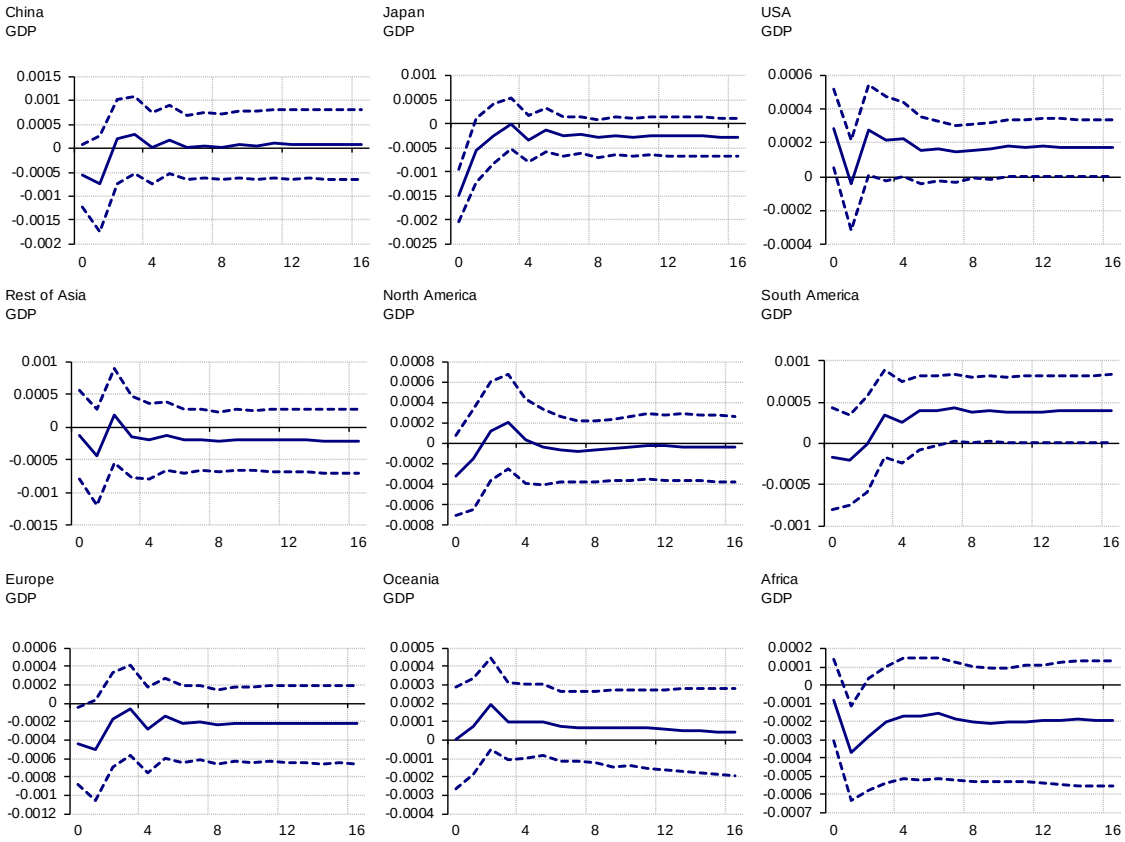
Notes: Six foreign variables and one global variable are represented as follows: the natural logarithm of real GDP (ys), ratio of general government spending to GDP (gxs), ratio of private consumption to GDP (cs), real effective exchange rate ($reers$), ratio of net exports to GDP (nxs), real interest rate (rs), and natural logarithm of the nominal price of oil in US dollars ($poil$). We follow Dees et al. (2007) to test exogeneity and use the US as the reference country.

Fig. 1. Estimated impulse response functions of private consumption per GDP (c_{it}) with respect to China's government spending shocks.



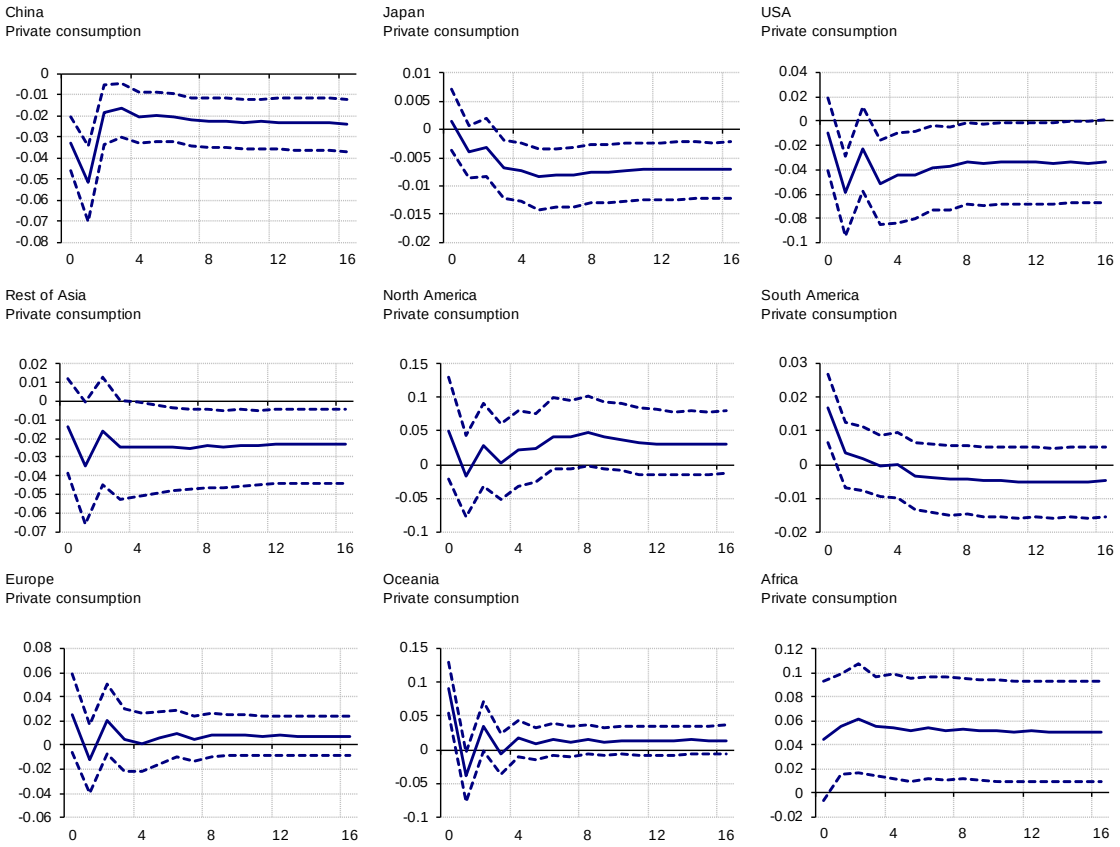
Note: The solid lines of the impulse response functions correspond to the medians and the dashed lines to the one-standard-error bands (1,000 replications).

Fig. 2. Estimated impulse response functions of the logarithm of GDP (y_{it}) with respect to China's government spending shocks.



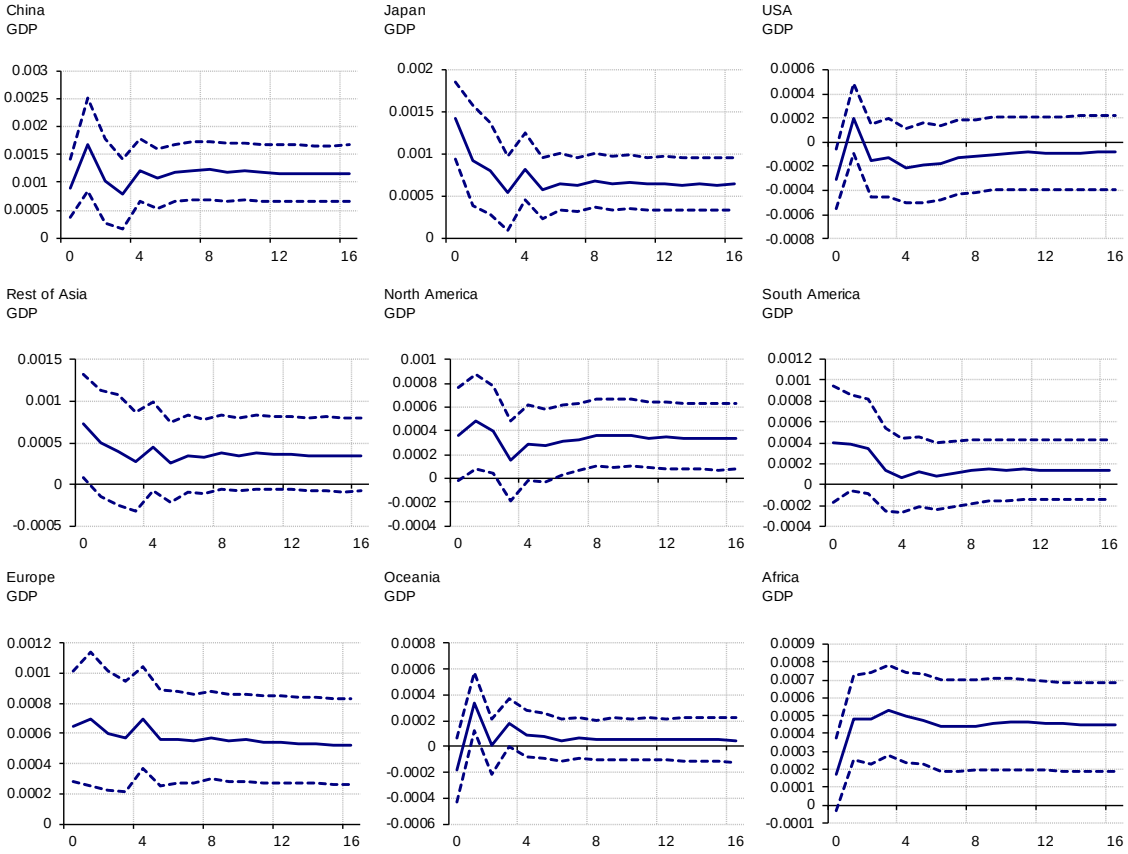
Note: The solid lines of the impulse response functions correspond to the medians and the dashed lines to the one-standard-error bands (1,000 replications).

Fig. 3. Estimated impulse response functions of private consumption per GDP (c_{it}) with respect to China's general government primary balance shocks.



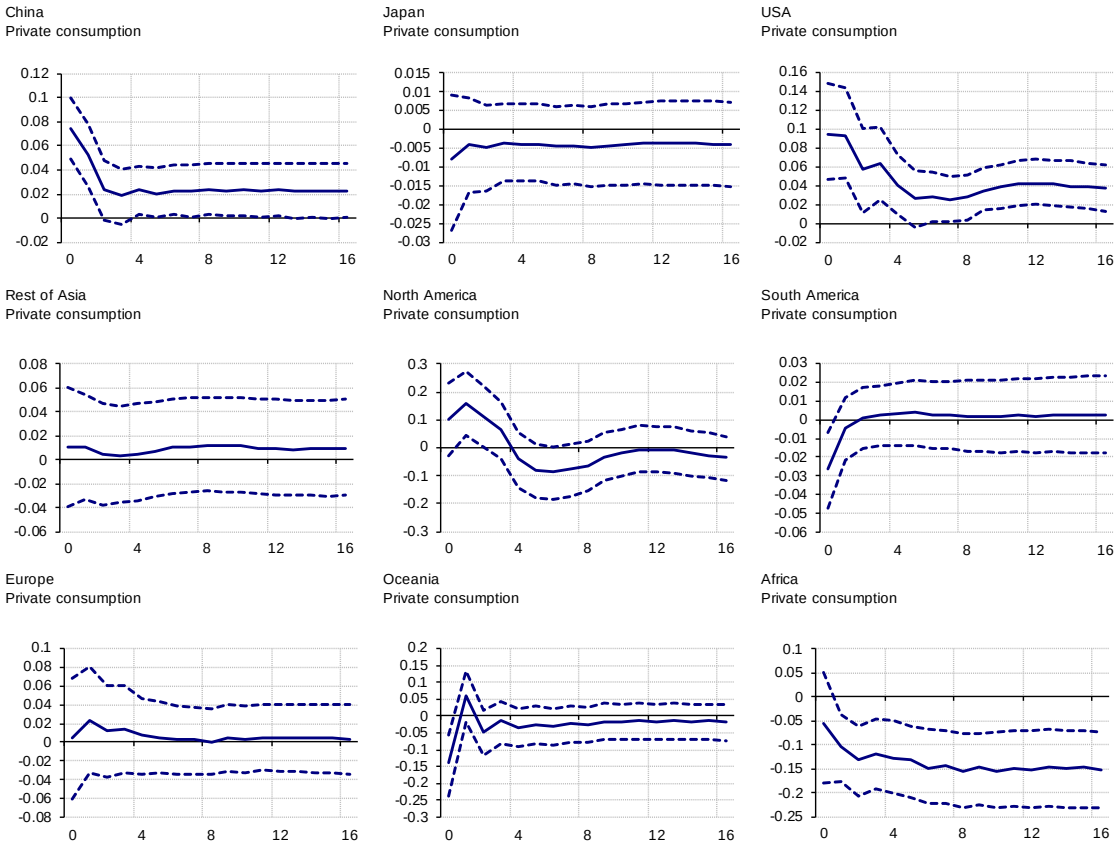
Note: The solid lines of the impulse response functions correspond to the medians and the dashed lines to the one-standard-error bands (1,000 replications).

Fig. 4. Estimated impulse response functions of the logarithm of GDP (y_{it}) with respect to China's general government primary balance shocks.



Note: The solid lines of the impulse response functions correspond to the medians and the dashed lines to the one-standard-error bands (1,000 replications).

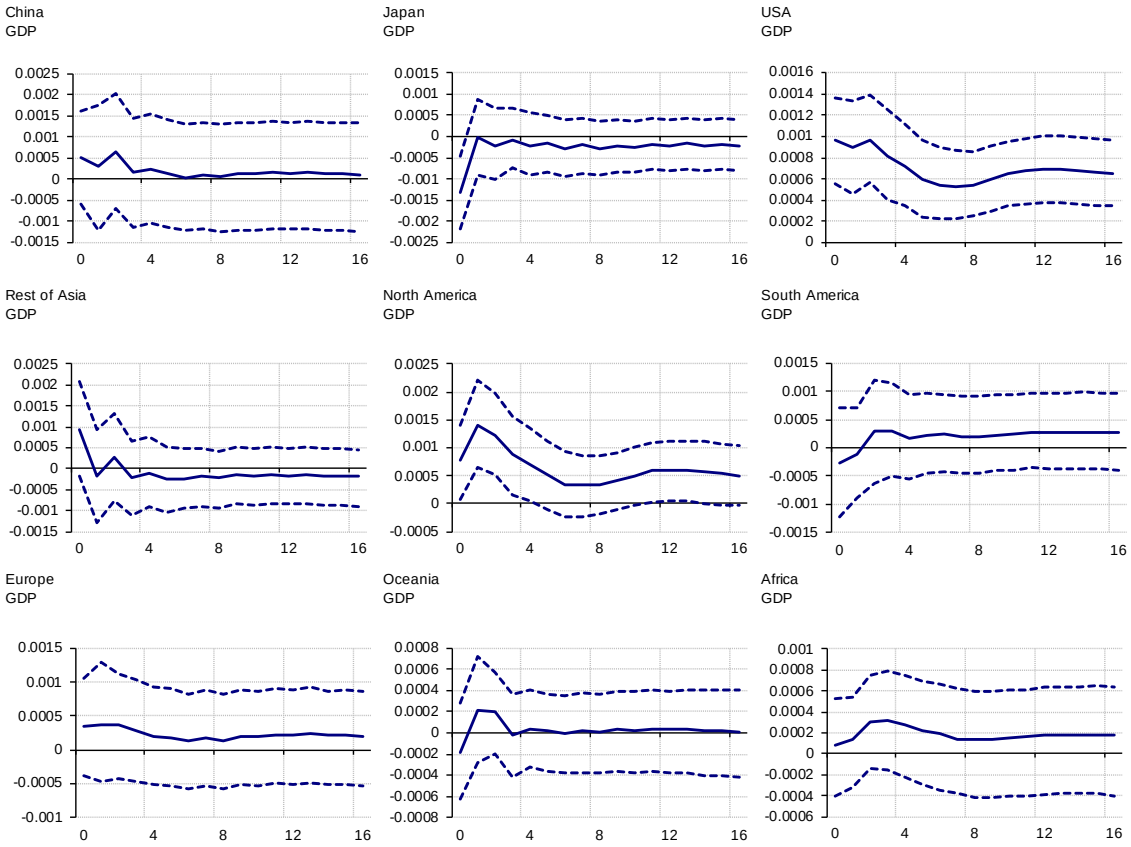
Fig. 5. Estimated impulse response functions of private consumption per GDP (c_{it}) with respect to China's government spending shocks (the case with debt-to-GDP ratio).



Note: The solid lines of the impulse response functions correspond to the medians, and the dashed lines correspond to one standard error band (200 replications[23]).

[23] We did this because bootstrap resampling by more than 200 replications did not converge.

Fig. 6. Estimated impulse response functions of the logarithm of GDP (y_{it}) with respect to China's government spending shocks (the case with debt-to-GDP ratio).



Note: The solid lines of the impulse response functions correspond to the medians and the dashed lines to the one-standard-error bands (200 replications).

Table A1

Unit root tests for the domestic variables at the 5% significance level

Domestic Variables	Statistic	Critical Value	Argentina	Australia	Austria	Belgium	Brazil	Canada	China	Chile	Finland	France	Germany
y	ADF	-3.45	-1.87	-0.84	-2.01	-1.74	-1.65	-1.45	-0.82	-3.27	-2.05	-1.55	-4.41
	WS	-3.24	-2.03	-1.26	-1.85	-2.03	-1.50	-1.69	-1.34	-1.16	-2.07	-1.82	-4.38
gx	ADF	-3.45	-2.43	-1.40	-2.74	-1.50	-2.27	-1.67	-3.56	-1.30	-2.19	-2.44	-2.01
	WS	-3.24	-1.28	-1.58	-2.25	-1.80	-2.42	-1.78	-3.74	-1.68	-2.22	-1.72	-2.25
c	ADF	-3.45	-2.24	-3.00	-3.31	-3.10	-3.52	-3.44	-2.96	-2.74	-2.42	-2.60	-2.90
	WS	-3.24	-2.21	-2.97	-2.95	-3.33	-3.70	-2.45	-3.15	-2.99	-2.57	-2.78	-1.97
reer	ADF	-3.45	-2.33	-2.06	-2.22	-2.19	-2.04	-1.63	-2.74	-2.01	-2.81	-2.15	-2.20
	WS	-3.24	-0.95	-2.18	-2.45	-2.43	-2.08	-1.75	-2.24	-1.95	-2.45	-2.40	-2.38
nx	ADF	-3.45	-3.28	-4.01	-5.19	-4.66	-3.51	-3.92	-4.66	-6.41	-3.40	-3.24	-4.25
	WS	-3.24	-3.42	-3.77	-5.33	-4.39	-2.83	-4.05	-4.88	-6.64	-3.63	-3.39	-3.42
r	ADF	-3.45	-3.26	-4.13	-5.91	-5.90	-5.95	-8.07	-3.15	-4.38	-3.15	-6.26	-5.87
	WS	-3.24	-3.19	-4.26	-6.07	-6.11	-3.60	-8.22	-3.02	-4.44	-3.15	-6.42	-5.88
Foreign Variables													
ys	ADF	-3.45	-0.95	-1.05	-3.15	-2.01	-1.21	-1.61	-2.53	-0.64	-2.55	-2.16	-1.66
	WS	-3.24	-1.40	-1.23	-3.06	-2.11	-1.36	-1.55	-2.32	-1.09	-2.75	-2.25	-1.90
gxs	ADF	-3.45	-2.66	-2.36	-2.49	-1.98	-2.23	-3.08	-2.09	-2.33	-2.16	-2.08	-1.86
	WS	-3.24	-2.84	-2.57	-2.72	-2.25	-2.41	-3.23	-2.04	-2.54	-2.43	-2.28	-2.14
cs	ADF	-3.45	-4.77	-2.54	-3.53	-2.88	-2.81	-2.47	-3.42	-2.85	-3.18	-2.95	-2.33
	WS	-3.24	-4.96	-2.77	-3.38	-3.08	-3.04	-2.21	-3.55	-3.05	-3.25	-3.08	-2.58
reers	ADF	-3.45	-1.72	-1.90	-1.76	-1.75	-1.92	-1.45	-1.94	-1.70	-1.79	-1.75	-1.72
	WS	-3.24	-1.87	-2.15	-2.06	-2.05	-2.04	-1.78	-2.19	-1.97	-2.08	-2.04	-2.00
nxs	ADF	-3.45	-3.91	-4.58	-4.05	-3.52	-3.67	-2.97	-4.46	-4.69	-3.97	-3.50	-3.86
	WS	-3.24	-3.15	-4.69	-3.53	-3.54	-3.87	-2.90	-4.31	-4.69	-3.82	-3.28	-3.94
rs	ADF	-3.45	-5.20	-3.94	-6.12	-6.44	-4.33	-4.45	-6.99	-5.09	-5.03	-5.68	-5.72
	WS	-3.24	-3.49	-4.07	-6.29	-6.43	-4.49	-4.09	-6.17	-4.33	-4.81	-5.86	-5.81

Table A1 (continued)

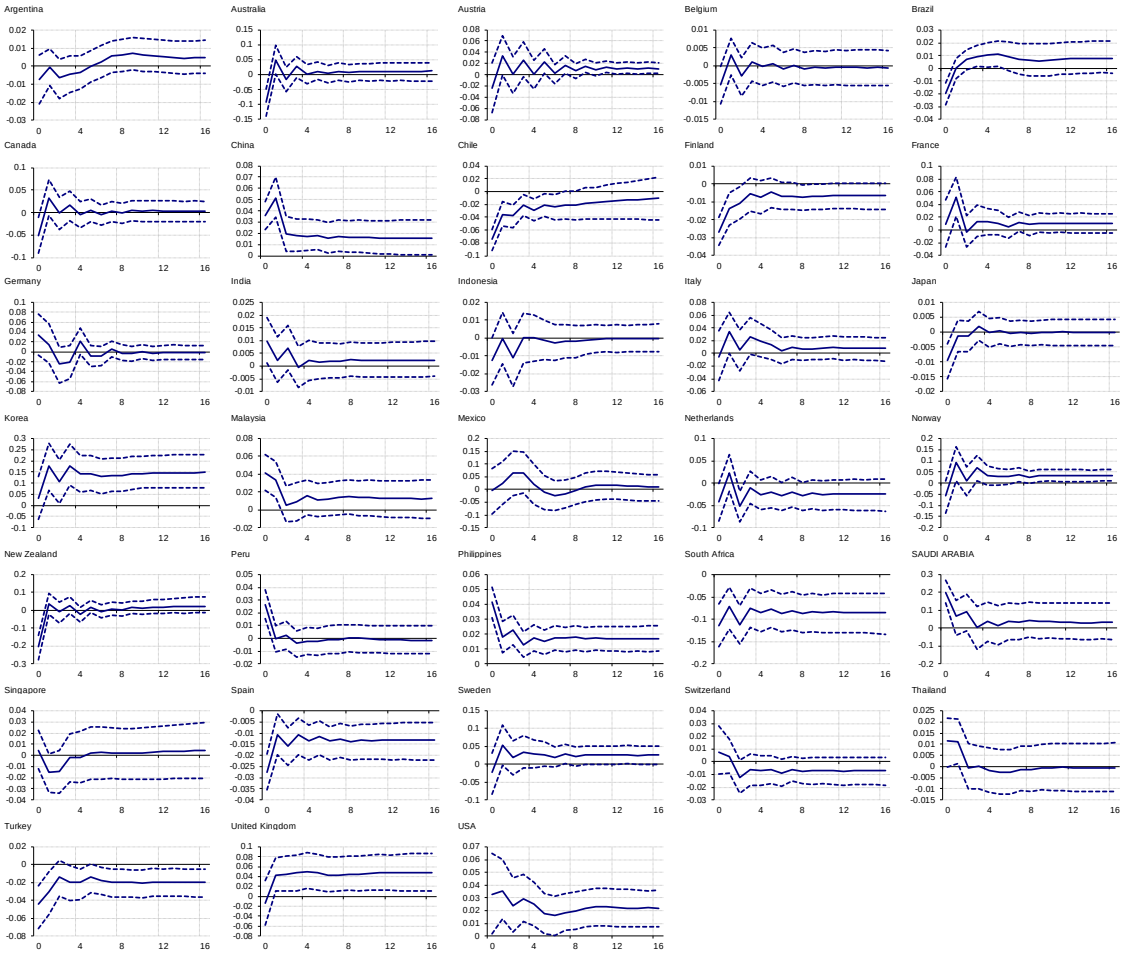
Domestic Variables	Statistic	Critical Value	India	Indonesia	Italy	Japan	Korea	Malaysia	Mexico	Netherlands	Norway	New Zealand	Peru
y	ADF	-3.45	-3.57	-1.71	-1.69	-3.77	-2.24	-3.30	-3.15	-1.60	-1.86	-2.00	-1.43
	WS	-3.24	-0.67	-1.99	-1.42	-3.72	-0.49	-1.61	-3.20	-1.29	-0.10	-2.22	-1.19
gx	ADF	-3.45	-1.89	-2.01	-1.80	-0.74	-2.20	-1.80	-1.08	-1.51	-1.56	-1.97	-1.71
	WS	-3.24	-2.18	-0.81	-1.68	-1.03	-0.37	-0.78	-1.46	-1.68	-1.88	-1.77	-1.54
c	ADF	-3.45	-6.25	-2.77	-2.78	-3.81	-9.62	-2.52	-2.94	-2.57	-3.82	-2.39	-3.21
	WS	-3.24	-6.48	-2.99	-2.74	-4.03	-9.81	-2.12	-3.01	-2.77	-3.07	-2.29	-1.77
reer	ADF	-3.45	-3.44	-2.47	-2.22	-2.83	-3.15	-2.33	-2.67	-2.20	-1.95	-2.37	-2.11
	WS	-3.24	-1.60	-2.65	-2.24	-2.48	-3.33	-2.55	-2.48	-2.42	-2.22	-2.54	-1.99
nx	ADF	-3.45	-3.31	-3.22	-3.52	-4.78	-4.75	-1.87	-4.19	-5.04	-4.78	-5.28	-2.97
	WS	-3.24	-3.52	-3.36	-3.71	-4.63	-4.30	-0.60	-3.71	-5.24	-4.37	-5.50	-3.08
r	ADF	-3.45	-5.28	-6.91	-2.60	-6.49	-4.24	-6.81	-3.21	-5.22	-8.57	-6.03	-8.27
	WS	-3.24	-5.38	-7.08	-2.84	-6.63	-4.18	-6.88	-3.45	-5.34	-8.74	-6.19	-0.92
Foreign Variables													
ys	ADF	-3.45	-1.49	-1.64	-2.22	-0.90	-0.78	-1.62	-1.54	-2.09	-1.84	-0.74	-0.74
	WS	-3.24	-1.69	-1.57	-2.40	-1.10	-1.15	-1.59	-1.46	-2.20	-2.06	-0.98	-1.13
gxs	ADF	-3.45	-2.18	-2.22	-2.20	-2.30	-2.24	-2.45	-2.35	-2.36	-1.96	-2.44	-2.39
	WS	-3.24	-1.93	-2.37	-2.46	-2.25	-2.36	-2.66	-2.42	-2.61	-2.20	-2.61	-2.63
cs	ADF	-3.45	-3.38	-2.21	-3.16	-3.29	-2.72	-2.66	-2.77	-3.22	-2.68	-2.93	-2.84
	WS	-3.24	-3.57	-2.42	-3.34	-3.45	-2.89	-2.87	-2.43	-3.35	-2.88	-3.03	-2.97
reers	ADF	-3.45	-1.74	-1.78	-1.71	-1.88	-1.69	-1.80	-1.77	-1.74	-1.76	-1.83	-1.73
	WS	-3.24	-2.02	-2.07	-2.01	-2.03	-1.95	-2.09	-2.01	-2.03	-2.05	-2.07	-1.99
nxs	ADF	-3.45	-5.67	-4.44	-4.28	-4.56	-5.24	-4.19	-3.17	-4.23	-3.93	-4.25	-4.56
	WS	-3.24	-5.81	-4.37	-3.96	-4.77	-5.44	-4.33	-3.15	-4.01	-3.90	-4.44	-4.68
rs	ADF	-3.45	-5.07	-4.30	-5.37	-4.22	-3.98	-4.24	-6.61	-5.81	-5.33	-4.54	-4.09
	WS	-3.24	-5.11	-4.46	-5.47	-4.39	-4.14	-4.41	-6.67	-5.88	-5.15	-4.69	-4.15

Table A1 (continued)

Domestic Variables	Statistic	Critical Value	Philippines	South Africa	Saudi Arabia	Singapore	Spain	Sweden	Switzerland	Thailand	Turkey	United Kingdom	USA
y	ADF	-3.45	-2.52	-1.60	-1.36	-1.47	-1.85	-4.01	-3.58	-2.86	-2.84	-1.41	-1.89
	WS	-3.24	0.69	-0.77	-1.46	-0.85	-2.10	-3.21	-1.66	-1.75	-2.90	-1.70	-1.79
gx	ADF	-3.45	-1.08	-1.02	-1.90	-1.43	-1.68	-2.21	-2.61	-1.08	-2.20	-1.56	-3.30
	WS	-3.24	-1.35	-1.20	-1.45	-1.76	-1.98	-2.31	-2.17	-1.14	-2.35	-1.71	-3.42
c	ADF	-3.45	-3.53	-2.56	-3.33	-2.27	-2.17	-3.15	-2.67	-2.85	-3.73	-2.97	-2.81
	WS	-3.24	-3.69	-2.77	-3.15	-2.47	-2.45	-3.16	-2.45	-2.67	-3.94	-3.03	-2.34
reer	ADF	-3.45	-1.90	-2.32	-1.26	-1.60	-2.01	-2.51	-2.19	-2.16	-0.54	-1.62	
	WS	-3.24	-2.18	-2.54	-1.50	-1.73	-2.24	-2.73	-2.45	-2.41	-1.07	-1.93	
nx	ADF	-3.45	-1.74	-4.02	-3.84	-0.66	-2.84	-4.04	-3.77	-2.41	-6.77	-5.13	-2.75
	WS	-3.24	-1.16	-3.94	-4.06	-1.21	-3.01	-4.05	-3.89	-1.90	-5.26	-5.00	-2.48
r	ADF	-3.45	-6.40	-3.47	-5.48	-3.89	-4.34	-3.80	-4.39	-5.08	-5.59	-6.97	-5.15
	WS	-3.24	-6.38	-3.24	-5.59	-4.00	-4.29	-2.19	-3.22	-5.11	-5.66	-4.90	-4.56
Foreign Variables													
ys	ADF	-3.45	-2.04	-1.42	-1.55	-2.50	-2.11	-1.52	-2.09	-1.82	-1.71	-1.96	-1.46
	WS	-3.24	-1.72	-1.69	-1.75	-2.23	-2.24	-1.66	-2.21	-1.94	-1.89	-2.10	-1.74
gxs	ADF	-3.45	-2.10	-2.29	-2.32	-1.85	-2.20	-2.16	-2.31	-2.10	-2.23	-2.18	-2.03
	WS	-3.24	-2.24	-2.41	-2.52	-1.50	-2.46	-2.38	-2.52	-2.15	-2.36	-2.42	-2.21
cs	ADF	-3.45	-2.78	-2.76	-3.20	-3.20	-3.06	-2.83	-3.03	-3.13	-2.92	-3.09	-2.89
	WS	-3.24	-3.00	-2.99	-3.40	-3.42	-3.22	-3.02	-3.22	-3.34	-3.10	-3.28	-2.95
reers	ADF	-3.45	-1.93	-1.64	-1.67	-2.05	-1.69	-1.76	-1.70	-1.82	-1.75	-1.71	-1.66
	WS	-3.24	-2.19	-1.88	-1.91	-2.29	-1.99	-2.04	-1.99	-2.10	-2.00	-1.99	-1.96
nxs	ADF	-3.45	-4.59	-5.19	-4.27	-4.14	-3.96	-4.79	-3.66	-4.66	-3.69	-4.15	-3.76
	WS	-3.24	-4.58	-5.28	-4.25	-4.13	-3.78	-4.87	-3.72	-4.73	-3.77	-4.22	-3.85
rs	ADF	-3.45	-4.83	-4.16	-5.24	-5.16	-6.31	-6.60	-6.19	-4.71	-5.36	-5.99	-3.68
	WS	-3.24	-4.98	-4.35	-5.30	-5.32	-6.17	-6.74	-6.27	-4.88	-5.47	-6.14	-3.86

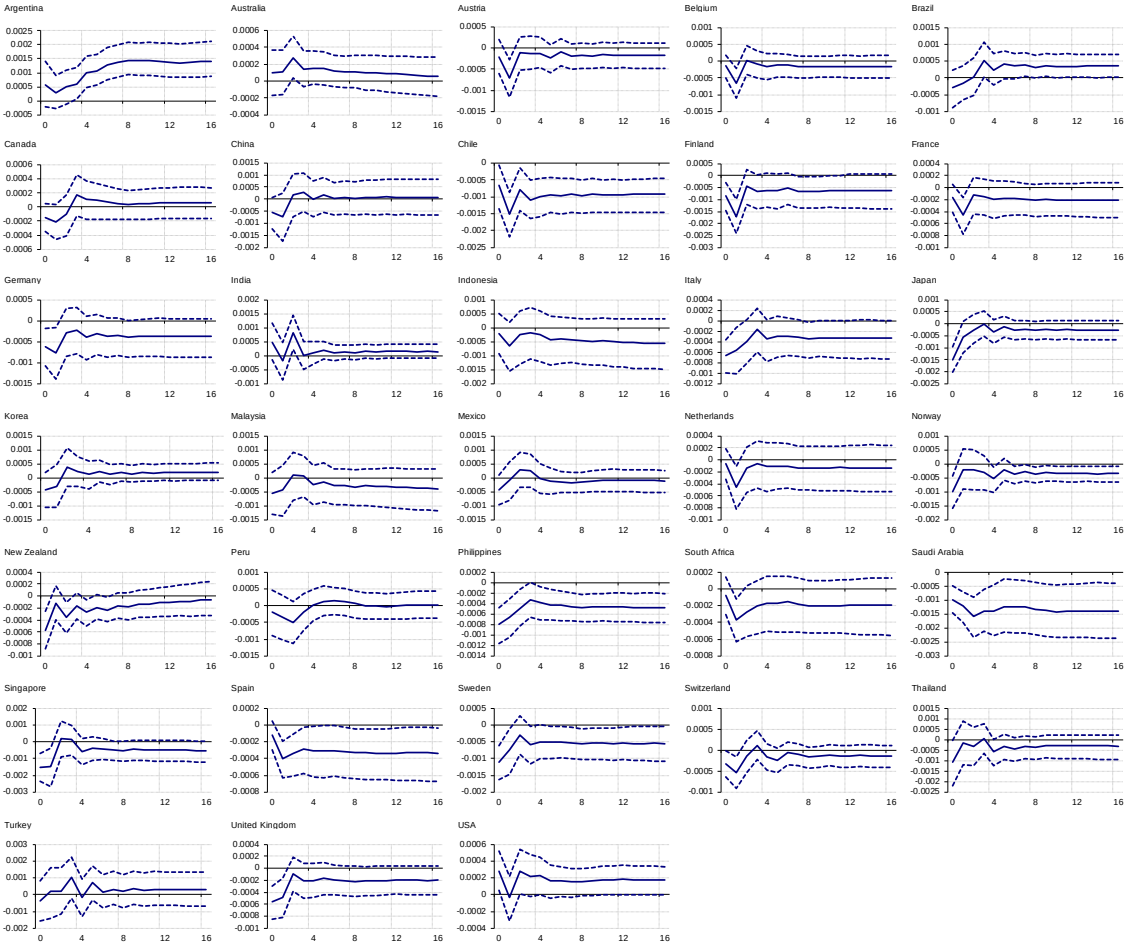
Notes: The six domestic variables are the natural logarithm of real GDP (y), ratio of general government spending to GDP (gx), ratio of private consumption to GDP (c), ratio of net exports to GDP (nx), real effective exchange rate ($reer$), and real interest rate (r). The six foreign variables and one global variable are the natural logarithm of real GDP (ys), ratio of general government spending to GDP (gxs), ratio of private consumption to GDP (cs), real effective exchange rate ($reers$), ratio of net exports to GDP (nxs), and real interest rate (rs). The augmented Dickey-Fuller (ADF) test is used to examine the presence of unit roots to ensure stationarity of the data. Weighted statistics (WS) are calculated to represent aggregated measures adjusted by weights to account for cross-sectional dependencies across countries or regions in the GVAR framework

Fig. A1. Estimated impulse response functions of private consumption per GDP (c_{it}) with respect to China's government spending shocks for all countries.



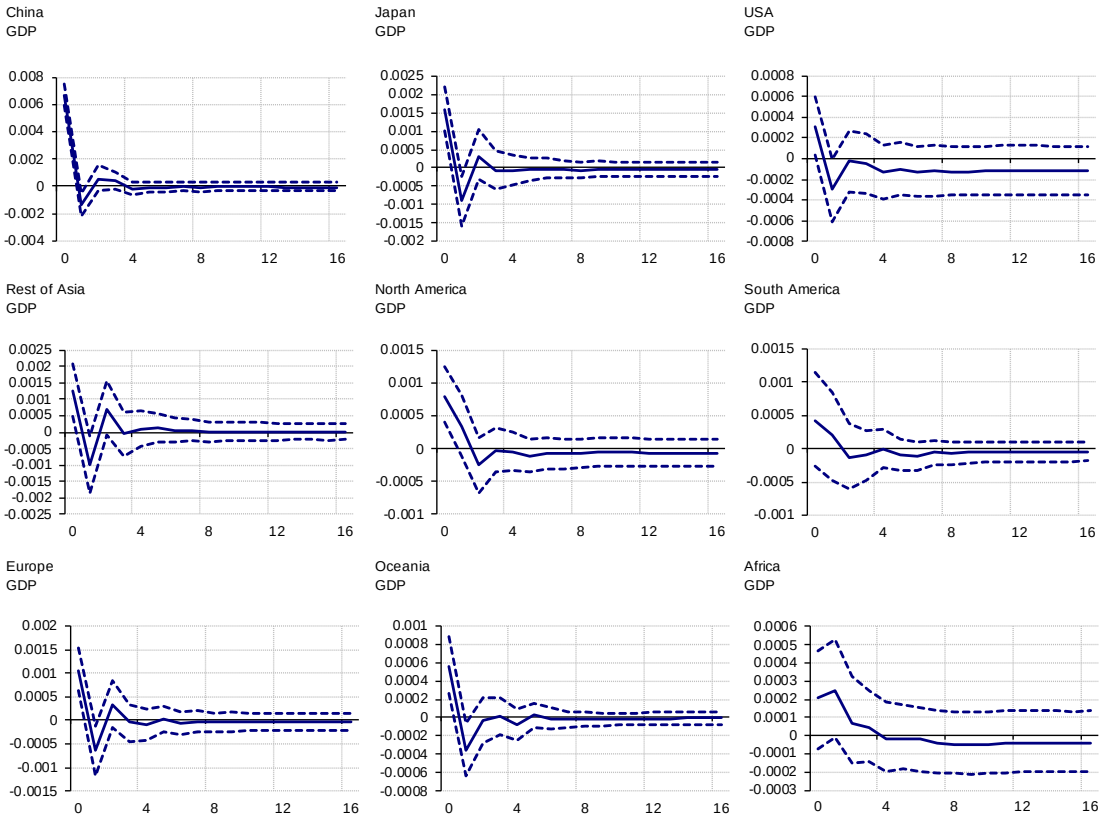
Note: The solid lines of the impulse response functions correspond to the medians and the dashed lines to the one standard error bands (1000 replications).

Fig. A2. Estimated impulse response functions of the logarithm of GDP (y_{it}) with respect to China's government spending shocks for all countries.



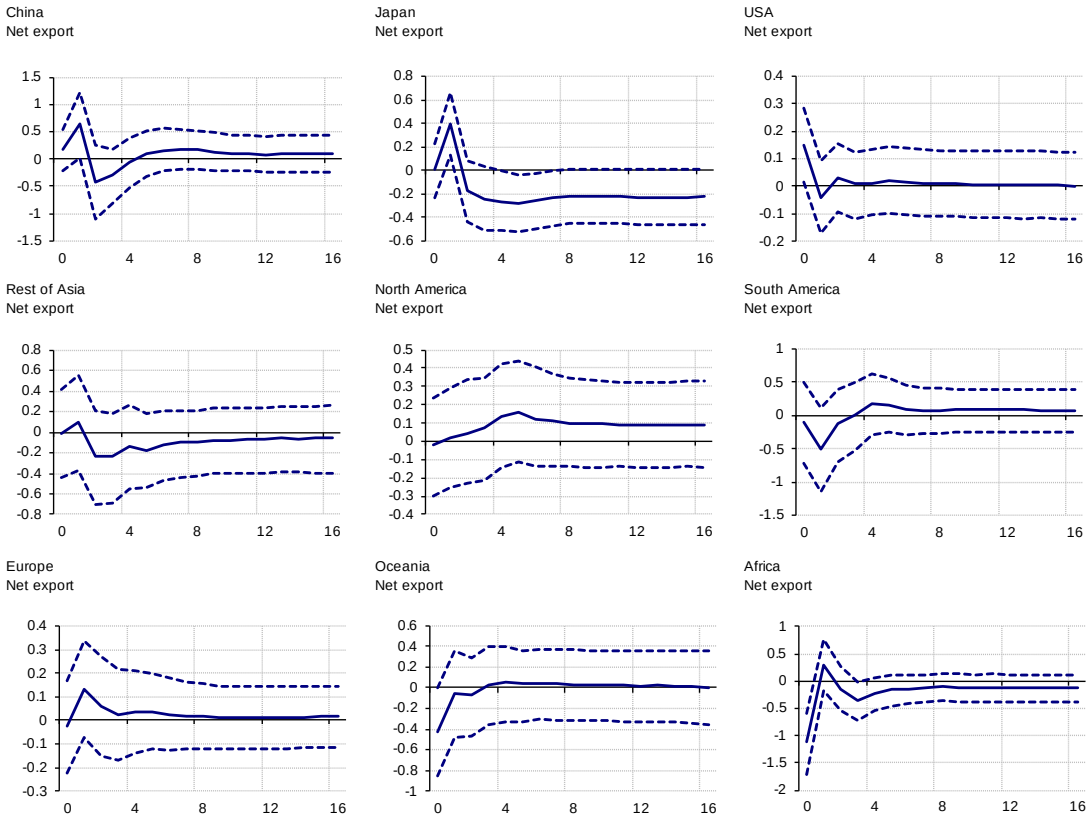
Note: The solid lines of the impulse response functions correspond to the medians and the dashed lines to the one-standard error bands (1000 replications).

Fig. A3. Estimated impulse response functions of the logarithm of GDP (y_{it}) with respect to China's GDP shocks.



Note: The solid lines of the impulse response functions correspond to the medians and the dashed lines to the one-standard error bands (1000 replications).

Fig. A4. Estimated impulse response functions of net export per GDP (nx_{it}) with respect to China's GDP shocks.



Note: The solid lines of the impulse response functions correspond to the medians and the dashed lines to the one-standard error bands (1000 replications).

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