Swing in the Fed's balance sheet policy and spillover effects on emerging Asian countries

Yves, Togba Boboy and Yoon, Seong-Min

Department of Economics, Pusan National University

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Togba Boboy Yves[a] and Seong-Min Yoon[a,†]

[a] Department of Economics, Pusan National University, Busan, Republic of Korea

Abstract

This paper investigates the effects of the Fed's balance sheet policy at the zero lower bound on the macroeconomic and financial variables of emerging Asian countries. Based on a heterogeneous structural panel VAR model using monthly data from eight emerging Asian countries, we find evidence of cross-border spillover effects on long-term bond yields, GDP, prices, stock market index, local currency, and real credit. However, the quantile responses show that there is substantial heterogeneity among countries' responses to Fed shocks. Accordingly, these effects vary across countries and horizons depending on their macroeconomic fundamentals, financial openness, and intensity of macroprudential regulations.

Keywords: Quantitative easing; Unconventional monetary policy; International transmission mechanism, Structural panel VAR model; Quantile response.

JEL classification: C31, E44, E58, F41

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† Corresponding author. Professor, Department of Economics, Pusan National University, 2, Busandaehak-ro 63beon-gil, Geumjeong-Gu, Busan 46241, Republic of Korea. Tel.: +82 515102557; Fax: +82 515813143. E-mail: smyoon@pusan.ac.kr.

1. INTRODUCTION

The recent recessions in the United States and Europe in 2008 were characterized by very low inflation rates (below the target rates), high unemployment rates, low GDP growth, and zero nominal interest rates. In response to the economic contraction in the United States, unconventional monetary policy (UMP) has been utilized. This intervention has increased the size, and changed the composition, of the Fed's balance sheet significantly. In this regard, research suggests that the Fed's program has been effective, with palpable effects on financial conditions (e.g. Krishnamurthy and Vissing-Jorgensen, 2011; Gagnon et al., 2011; Bhattarai and Neely, 2016).

Research has also addressed international spillover effects from U.S. unconventional monetary policy to advanced and emerging economies (EME) using event studies (Neely, 2015; Bowman et al., 2015), GVARs (Chen et al., 2016; Dedola et al., 2017; Anaya et al., 2017), Qual VARs (Tillmann, 2016) or PVARs (Bhattarai et al., 2015). Some studies have also analyzed the role of country characteristics and/or different transmissions channels (Bowman et al., 2015; Dedola et al., 2017; Anaya et al., 2017; Mishra et al., 2014b; Ammer et al., 2010). However, conclusions in the literature regarding country-specific responses and the role of country policies and characteristics are far from established. For example, Bowman et al. (2015) find that financial openness, GDP growth, stock market capitalization, and trade openness to the United States are affected by fluctuations in U.S. financial variables. However, Anaya et al. (2017) make a case that the exchange rate arrangement, the quality of institutions, and the degree of financial openness does not play important roles in explaining heterogeneous among the responses from emerging countries.

However, studies that have considered the role of country characteristics examined the linkages to either U.S. financial variables or the average impulse responses among EME countries or country groups, and therefore, ignored country-specific responses. Additionally, concerned about the Fed program, some Asian country has looked for other ways to deal with the impact of the Fed balance sheet policy abroad. The use of capital controls, currency interventions, and other macroprudential policies are one (Cerutti et al., 2015; Fernández et al., 2016). These policies

affecting country characteristics, may also explain heterogeneous responses among countries. In this regard, the question still persists about a detailed empirical analysis of the role of country characteristics for the size of spillover effects based on a panel model which facilitates the estimation of country-specific responses and compare responses across countries according to country policies and characteristics.

To address this challenge, this paper takes an empirical look at the Fed's balance sheet policy, toward further investigating whether the co-movement in the Fed's balance sheet has differential impacts on the macro and financial variables of emerging Asian countries and the role of country characteristics. While a number of papers have analyzed the role of country characteristics, we instead focus on the role of domestic capital controls and other macroprudential regulations.

The empirical model used here is most similar to Pedroni (2013). The advantage of the SPVAR model by Pedroni (2013) compared to the frequently applied model of Canova and Ciccarelli (2009) seems to reside in the possibility of identifying country-specific responses while exploring cross-section responses in the presence of short time-series in order to reduce estimation uncertainty. However, our methodology differs from the general specifications in Pedroni (2013) which seems suited for analysis of domestic or regional shocks (Mishra et al., 2014a). The most notable difference is that the source of common shock affecting panel countries is not indirectly inferred by using cross-sectional averages of the country-specific time series, rather it is treated as identifiable on the basis of its impacts on other countries. The assumption of a small open economy enables for accommodating the interdependencies among countries is induced by linkages to the U.S. economy.[3] With this idea in mind, our empirical strategy is implemented in two steps. In the first step, we use two identification schemes to isolate Fed's balance sheet shocks in structural vector autoregressive setups by means of total assets or term spread as a policy instrument. In the second step, we feed the PSVAR with these identified shocks and then examine within a panel regression setup the role of country characteristics and policies.

Our three main findings address the concerns expressed above. First, we find that the time series of both identified shocks are mostly expansionary and seem to capture important asset

[3] See Hao et al. (2017) for a similar reasoning.

purchase policy measures of the Fed during the sample period. Our results also suggest that a balance sheet shock leads to an increase in real GDP and prices. This shock also decreases financial uncertainty; therefore, increases investor risk appetite. This finding is qualitatively consistent with Baumeister and Benati (2013). We argue that the view that emerges from the results of both identifications schemes are strikingly different. Second, our estimates from SPVAR confirm the existence of strong heterogeneity in country responses of all variables to a positive Fed shock. This allows our findings to be only partially consistent with previous works. Finally, we find that macroeconomic fundamentals, financial openness, capital controls and intensity of macroprudential regulations explain the heterogeneous responses of emerging Asian macro-financial variables to Fed balance sheet shocks. In particular, we also find that the significance of these estimates varies across the responsiveness of real credit, long-term government bond yields, stock market indices, exchange rate prices and real GDP to Fed shocks.

This research is broadly complementary to the growing literature examining the impact of U.S. monetary policy spillovers to advanced and emerging countries, using the VAR framework (Chen et al., 2016; Tillmann, 2016; Bhattarai et al., 2015; Dedola et al., 2017; Anaya et al., 2017). More specifically, Bhattarai et al. (2015) also estimate the effects of the Fed program in two steps and identify the source of its shock using short-run restrictions. Unlike these studies, this analysis compares two sets of identification schemes in which the Fed program are identified using total assets and term spread as a policy instrument, respectively. In doing so, our methodology is quite similar to the combination of zero and sign restrictions used in Gambacorta et al. (2014) and Weale and Wieladek (2016). Second, this research also provides support to the long-run monetary neutrality property to distinguish the Fed balance sheet shock from other shocks, assuming that country variables are left unchanged in the long-run in response to a Fed shock. Blinder (2010) and Chen et al. (2016) explore the role of the term spread as a possible transmission route of U.S. unconventional monetary policy. This study is partially complementary to these studies in that results from an identified spread shock are only qualitatively similar for some cases in identifications scheme I.

Some related papers that analyze the role of country characteristics include Bowman et al. (2015), Georgiadis (2016), Anaya et al. (2017) and Dedola et al. (2017). This research deviates

from these studies in that within a panel-data setup, the role of country characteristics is regressed to individual country responses within the initial months of the first QE round. A vast number of papers examine the impacts on emerging economies' financial variables, but relatively few tackle the empirical macro issues considered here. For example, Anaya et al. (2017) look at the dynamic responses of these variables to a U.S. UMP shock with a focus on capital flows as a transmission channel and reach the opposite conclusions.

The remainder of this paper is organized as follows: Section 2 describes the sample data. Section 3 explains the methodology used to estimate the Fed balance sheet shocks and structural panel VAR models. Section 4 presents the results and the robustness checks. Lastly, Section 5 concludes.

2. DATA

We use monthly data from the United States and eight emerging Asian countries,[4] including Hong Kong, India, Indonesia, South Korea, Malaysia, Philippines, Singapore, and Thailand.[5] The sample period spans 76 months, from September 2008 to December 2014.[6] We collected data from the IMF's International Financial Statistics, Bank for International Settlements (BIS), Morgan Stanley Capital International (MSCI) (see Appendix A for a list of the indicators). Data for the U.S. is taken from the FRED; however, monthly real GDP data for the U.S. is taken from Macroeconomic Advisers. We consider one regime during which the federal rate became binding at the zero lower bound (ZLB) and the Federal Open Market Committee (FOMC) conducted monetary policy primarily by changing the size and composition of the Fed's balance sheet.[7]

[4] We chose the countries following the classification of emerging economies by the Morgan Stanley (MSCI Asia Emerging markets).

[5] Table A1 in Appendix contains details of the sources for both the U.S. and emerging Asian economies.

[6] To address the discrepancy in our data we transformed some variables, which originally did not have monthly frequency. We use a linear interpolation to increase the frequency to monthly.

[7] See Gilchrist et al. (2015) for more details on the FOMC unconventional monetary policy.

Table 1 provides summary statistics for the average values of indicators of country characteristics. We consider the following characteristics, split into three categories: macroeconomic fundamentals (real GDP growth, inflation, and real credit growth), financial openness (financial integration, capital openness, currency exposure, and market capitalization), and macroprudential policies (capital regulation, LTV regulations, local and foreign reserve requirements, and capital controls). The average value of financial openness related indicators such as capital openness, foreign currency exposure, and financial integration are very small for all countries compared to Hong Kong and Singapore. From Table 1, we compute the median value of each characteristic over the entire sample and then classify each country, depending on whether the value of their indicators falls above or below the computed median value.

Table 2 displays country classifications by indicator and does not show consistent trends across countries. For instance, there is not accurate evidence of the relationship between financial openness and intensity of macroprudential policy regulation across countries. Further, the intensity of capital controls (overall restrictions included capital inflows and outflows) are relatively larger in a country with a higher rate of inflation and real GDP growth such India, Indonesia and Malaysia. However, this pattern does not provide consistent proof to gauge whether a large intensity of capital controls (inflows) affects the responses of countries to Fed balance sheet shocks. To further investigate this concern, we regress the point impulse response over a horizon of the 5 months on the first value of 5 months of country characteristics. The use of the first month is by construction, as this is the long-run restriction of our panel SVAR.

Table 1. Average sample values of country characteristics

Country	Financial integration	Capital openness	Currency exposure	Capital regulation	LTV regulations	Local reserve requirements	Capital controls	Capital controls (inflows)	Capital controls (outflows)
Hong Kong	22.35	1.00	9.49	0.79	0.51	0.00	0.02	0.03	0.02
India	0.72	0.20	0.05	0.16	1.55	-0.12	0.95	0.91	1.00
Indonesia	0.82	0.50	-0.03	0.32	2.06	2.08	0.66	0.70	0.63
Korea	1.45	0.60	0.32	0.67	5.20	1.00	0.11	0.13	0.08
Malaysia	2.50	0.30	0.75	0.32	1.18	-1.11	0.81	0.70	0.92
Philippines	1.03	0.32	0.08	1.16	-0.96	2.84	0.88	0.75	1.00
Singapore	15.97	1.00	5.04	0.79	3.45	1.00	0.13	0.10	0.15
Thailand	1.78	0.20	0.53	0.32	0.05	0.00	0.76	0.67	1.00

Country	Market capitalization	Real credit growth	Inflation	Real GDP growth
Hong Kong	996.0	0.43	3.6	2.7
India	73.6	0.79	9.5	7.0
Indonesia	37.9	1.81	6.0	5.7
Korea	84.9	0.47	2.7	3.2
Malaysia	133.8	0.59	4.5	5.2
Philippines	66.9	3.12	2.55	4.6
Singapore	232.8	0.45	3.3	4.9
Thailand	73.8	0.77	2.7	2.9

Table 2. Country classifications

Financial integration		Capital openness		Foreign currency exposure		Capital regulation		LTV regulations		Local reserve requirements	
More	Less	More	Less	More	Less	More	Less	More	Less	More	Less
Hong Kong	India	Hong Kong	India	Hong Kong	India	Hong Kong	Indonesia	India	Hong Kong	Indonesia	Hong Kong
Singapore	Indonesia	Indonesia	Malaysia	Malaysia	Indonesia	India	Malaysia	Indonesia	Malaysia	Korea	India
Malaysia	Korea	Korea	Philippines	Singapore	Korea	Korea	Thailand	Korea	Philippines	Philippines	Malaysia
Thailand	Philippines	Singapore	Thailand	Thailand	Philippines	Philippines		Singapore	Thailand	Singapore	Thailand
						Singapore					

Market capitalization		Real credit growth		Inflation		Real GDP growth		Capital controls		Capital controls (inflows)		Capital controls (outflows)	
More	Less	More	Less	More	Less	More	Less	More	Less	More	Less	More	Less
Hong Kong	Indonesia	India	Hong Kong	India	Hong Kong	India	Hong Kong	Indonesia	Hong Kong	Indonesia	Hong Kong	Indonesia	Hong Kong
India	Philippines	Indonesia	Korea	Indonesia	Korea	Indonesia	Korea	Malaysia	India	India	Korea	India	Korea
Korea	Thailand	Thailand	Malaysia	Malaysia	Philippines	Malaysia	Thailand	Philippines	Korea	Malaysia	Singapore	Malaysia	Singapore
Malaysia			Philippines		Singapore	Singapore	Philippines	Thailand	Singapore	Philippines		Philippines	
Singapore			Singapore		Thailand					Thailand		Thailand	

3. EMPIRICAL METHODOLOGY

Our empirical strategy is implemented in two steps. First, we estimate a U.S. structural vector autoregressive (SVAR) model in which Fed balance sheet shocks (Fed shocks) are identified using two identification schemes. Second, we feed the identified shocks in the PSVAR. Finally, we setup a panel fixed-effect model in order to analyze the role of country-specific policies and characteristics.

3.1. Identifying Fed balance sheet shocks

We use the structural vector autoregressive estimated on monthly data[8] as follows:

$$y_t' A_0 = \sum_{k=1}^{p} y'_{t-1} A_k + c + \varepsilon'_t, \quad \text{for } 1 \leq t \leq T, \tag{1}$$

where y_t is an $n \times 1$ vector of endogenous variables including the log total asset; the log of CPI; the log of real GDP and the log of the level of implied stock market volatility (VIX) at time t. c is a $1 \times n$ vector of parameters. ε'_t is an $n \times 1$ vector of exogenous structural shocks, A_k is an $n \times n$ matrix of parameters for $0 \leq k \leq p$ with A_0 invertible. p is the lag length, and T is the sample size. The SVAR specified in equation (1) can be written as:

$$y_t' A_0 = x_t' A_+ + \varepsilon'_t, \quad \text{for } 1 \leq t \leq T, \tag{2}$$

where $A'_+ = \left[A'_1 \ldots A'_p \; c'\right]$ and $x_t' = \left[y'_{t-1}, \ldots, y'_{t-p}, 1\right]$ for $1 \leq t \leq T$. Their dimensions are $m \times m$ and $m \times 1$ with $m = np + 1$, respectively. The reduced-form VAR associated with the structural model specified in equation (2) is:

$$y_t' = x_t' B + u'_t, \quad \text{for } 1 \leq t \leq T \tag{3}$$

where $B = A_+ A_0^{-1}$, $u'_t = \varepsilon'_t A_0^{-1}$ and $E[u_t u'_t] = \Sigma = (A_0 A'_0)^{-1}$. B and Σ are reduced-form parameters, while A_0 and A_+ are the structural parameters. Likewise, u'_t are the reduced-form

[8] The baseline VAR is estimated on monthly data using four lags because of the short time-series and a constant using the importance sampler approach by Arias, et al. (2018). We also check whether our results are robust for alternative setting of the lags (2 and 6) and then find sharply similar results.

innovations and ε_t are the structural shocks. Following the importance sampler approach by Arias et al. (2018), we let $\Theta = (A_0, A_+)$ collect the value of the structural parameters. Formally, given Θ of the structural parameters and the data, the structural Fed balance sheet shocks at the time t are estimated as:

$$\varepsilon_t^{FED}(\Theta) = y'_t A_0 - x'_t A_+ \quad \text{for } 1 \leq t \leq T. \tag{4}$$

As one would expect, the structural parameters are not identified and to achieve identification, we impose a combination of sign and zero restrictions. To incorporate these restrictions, we employ the approach proposed by Arias et al. (2018).[9] Motivated by Gambacorta et al. (2014) and Weale and Wieladek (2016), we use two different sets of a combination of sign and zero restrictions to identify the Fed balance sheet shock as summarized in Table 3. These two sets of restrictions we use will be referred to as Identifications I and II.

It is well known that the objective of unconventional monetary policy through the asset purchase policies, and of monetary policy generally, is to set financial conditions consistent with full employment and stable prices. Thus, following Gambacorta et al. (2014), we make an assumption of a zero contemporaneous reaction of price and output to Fed balance sheet shocks referred to as total asset shocks. However, to distinguish balance sheet shocks from real economy disturbance as such aggregates supply and demand shocks, our identification I did not restrict the response of total assets to these shocks so that these have an immediate effect on the Fed balance sheet. Additionally, since the onset of financial crisis, because the aim of the unconventional monetary policy was to undo the economic distortions arising from financial turmoil and disruption, our balance sheet shocks would also lead to a decline in the level of implied stock market volatility (VIX). More importantly, to disentangle the Fed balance sheet shock from other disturbances, it is essential to assume that total assets also rise in response to financial disruptions. Considering this, the endogenous response of the central bank balance sheet to financial and economic uncertainty responses has a non-negligible advantage (Gertler and Karadi, 2015). That is, the Fed shock can be identified as a decline in financial uncertainty and risk, to which monetary policy authorities react with a rise in its balance sheets (Weale and Wieladek, 2016).

[9] We refer to Arias et al. (2018) for details.

Table 3. Identification of Fed balance sheet shocks

	Total assets	Log price	Log GDP	Log VIX	Term spread
Balance sheet shock	> 0	0	0	$0 \leq$	
Spread shock		0	0	$0 \leq$	$<$

There have been many studies of the international effectiveness of QE, and most consider the term spread as the unconventional monetary policy instrument (Blinder, 2010; Chen et al., 2016). In line with these studies, our Identification II explores the role of term spread as a possible transmission route of the Fed balance sheet policy. We assume that both the term spread and financial uncertainty fall in response to the Fed balance sheet policy. Moreover, the responses of price and output are similar to the identification scheme I. To estimate our models, we follow Arias et al. (2018) and use a uniform-normal-inverse-Wishart distribution over the orthogonal reduced-form parameterization, characterized by four parameters: UNIW$(\nu, \Phi, \Psi, \Omega)$. We chose the same prior density parameterization as in Arias et al. (2018) such that: $\nu = n,\ \Phi = \mathrm{I}_n,\ \Psi = 0_n,\ \Omega^{-1} = I_n$.

3.2. Panel SVAR model

As mentioned above, the PSVAR in our analysis differs from the general specification of Pedroni (2013) in that we consider a mix of panel time series data and a pure time series data. The starting point of our analysis is the reduced-form panel VAR expressed as:

$$B_i(L)\ \Delta z_{it} = \epsilon_{it}, \tag{5}$$

where B_i is the coefficient matrix; $\epsilon_{i,t}$ denotes the composite error term. The vector of endogenous variables $z_{it} = (\ z_{1,it}, z_{2,t})'$ is a mix of panel times series and pure time series. In other words, $z_{1,it}$ is a panel variable and $z_{2,t}$ is not a panel variable, but rather a time series variable. This means that for $z_{2,t}$, the cross sectional average is trivially equal to itself. This in return implies that it is logically impossible to use it to identify both an idiosyncratic and common shock. Equivalently,

using the setup from Pedroni (2013), this accommodates the fact that the loading value for common stock in this case is $\lambda_i = 1$ for all i, meaning that there is no idiosyncratic component to a Fed shock.

We assume that $z_{1,it}$ contains panel variables according to each channel such as the log of GDP, log of CPI, 10-year bond yield, log of stock market indices, log of credit to non-financial sector, and log of real effective exchange rate and $z_{2,t}$ include only the time series of the Fed shock. Note that $z_{1,it}$ is demeaned to eliminate country-specific fixed effects. The effect of structural shocks (structural impulse responses and the variance decompositions of interest), ϵ_{it}, on the observed variables is obtained from the structural MA representation in differences $\Delta z_{it} = B_i^{-1}(L)\epsilon_{it} = A_i(L)\epsilon_{it}$ where $\epsilon_{it} = (\epsilon_t, \epsilon_{it})'$ are structurally identified shocks corresponding to a fed balance sheet shock, ϵ_t and country-specific shocks ϵ_{it}. The effect of a structural shock, ϵ_t on countries variables is the cumulative sum of its effects on these variables. The long-run cumulative effects are summarized by the matrix$\mathrm{A}_i(\mathrm{L}) = \sum_{s=0}^{Q_i} A_{i,s} L^s$. Here, the identifying restrictions are imposed in terms of the steady-state restrictions on A_i, which can be represented succinctly as $A(1)_{i,j} = 0$, where $\mathrm{A}_i(1) = \lim_{Q_i \to \infty} \sum_{s=0}^{Q_i} A_{i,s} L^s$ is the steady-state responses of the log levels z_{it} to the structural shocks ϵ_{it}. In our baseline model, the long-run restriction is imposed on variables which are assumed to be $I(1)$, because otherwise no structural shock can have a nonzero long-run effect on a stationary variable.

More importantly, $A(1)_{i,j} = 0$ is implemented according to macro and financial blocks, respectively.[10] As noted above, we assume that the steady-state values for both macro and financial variables are invariants to the Fed's shocks. In other words, the Fed balance sheet shock has a transitory effect on the equilibrium of panel variables, but no long-run effect. In particular, $A(1)_{1,3} = A(1)_{2,3} = 0$ indicate that Fed shocks has no long-run effects on Asian macro variables such as real GDP and CPI. Yet, $A(1)_{1,5} = A(1)_{2,5} = A(1)_{3,5} = A(1)_{4,5} = 0$ indicates that the steady-state values for credit to private sectors, real exchange rate, long-run government bond and stock price are invariants to the Fed's shocks. As mentioned above, common stock is not inferred

[10] To avoid the identification problem, we consider one block at time. Thus we identify the parameters in the matrix $A(1)_{i,j}$ as $A(1)_{1,3} = A(1)_{2,3} = 0$ and $A(1)_{1,5} = A(1)_{2,5} = A(1)_{3,5} = A(1)_{4,5} = 0$ in the first and second block, respectevely.

by using cross-sectional averages of the country-specific time series, rather it is identified in our first step via their impact on U.S. time series data.

Here the long-run identification scheme proposed by Blanchard and Quah (1989) is chosen because it appears to place less reliance on country-specific information (Mishra et al., 2014a). We believe that if so, the assumption about both macro and financial responses and the speed of information flows could likely be heterogeneous among emerging Asian countries. Moreover, one may argue that the Fed policy's spillover effects may be long lasting compared to our restriction schemes. We agree that Fed shocks may well have such long-run spillover effects. However, we also believe that these effects are temporary because of the temporary flow effects on liquidity premia and other factors such as domestic policies.

Lastly, we also generate the confidence bands (25th and 75th percentiles) around the spatial individual country quantile in order to examine whether some subset of emerging Asian countries responds heterogeneously to Fed shocks.[11]

4. EMPIRICAL RESULTS

In this section, our results are presented in three steps. First, we discuss the results of the estimated Fed balance sheet shocks, and then present the responses from the estimated U.S. structural VAR model. Second, we present the impulse response functions and variance decompositions from the estimated baseline structural PVAR models. We also discuss the implied share of the distributional responses and variances attributable to a Fed balance sheet shock. Finally, we discuss the results of estimated panel fixed-effect regressions, exploring the role of country policies and characteristics.

4.1. Fed balance sheet shocks

Figure 1 documents the posterior medians of the structural Fed balance sheet shocks, reflecting the standard deviations of the innovations. Note that our Identifications I and II are quite

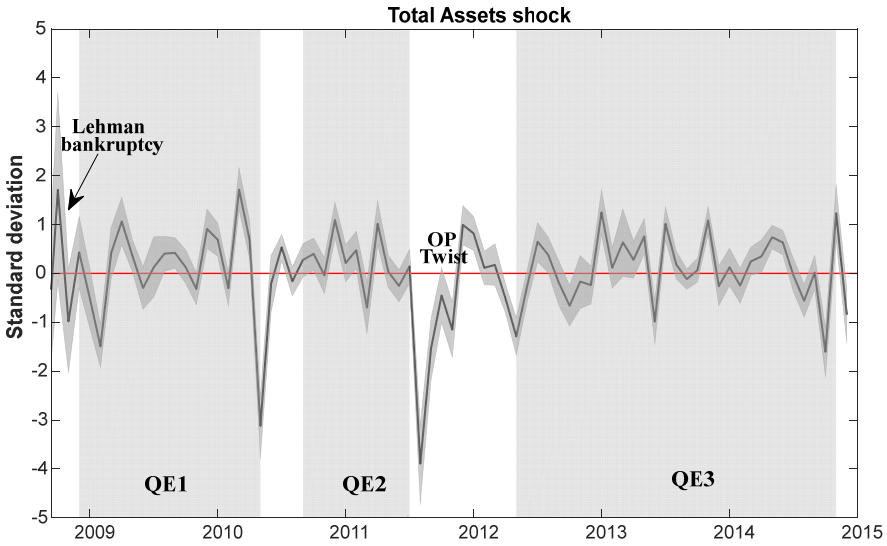
[11] We refer the readers to Pedroni (2013) for further details.

similar in spirit to the combination of zero and sign restrictions used in Boeckx et al. (2017) in order to identify unconventional monetary policy shocks. Their study defines the sum of the shocks as zero over the whole sample period. In doing so, a rise in the shock series implies an expansionary balance sheet shock, whereas a decline reflects a tightening of the balance sheet relative to the average endogenous response to other economic distortions arising from price and wage stickiness, credit market frictions, monopolistic competition and the like.

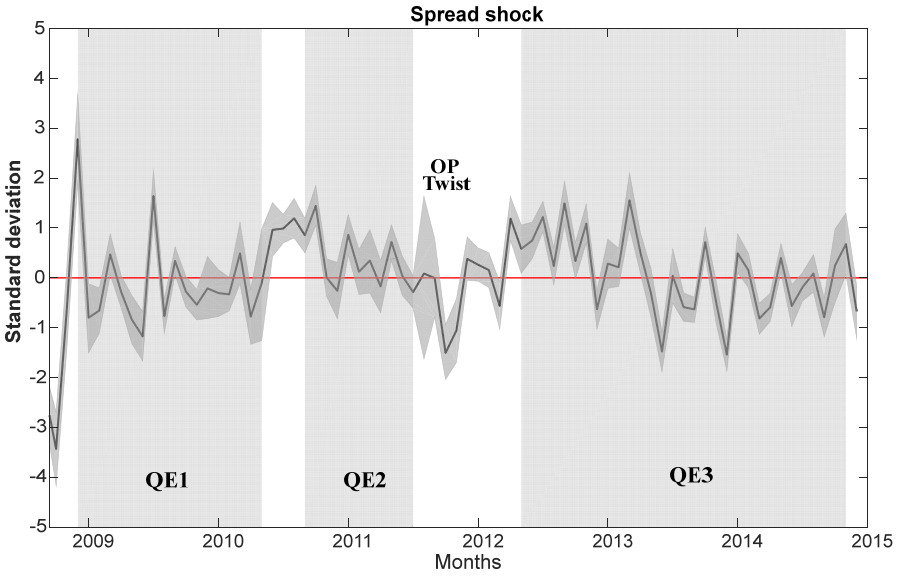
For all rounds and operations (QE1, QE2, OP Twist and QE3), their starts are identified as expansionary balance sheet shocks, implying that our identification strategies II and I are plausible. Under each round, the expansionary balance sheet shock interpreted as an unexpected component Fed decisions regarding asset purchases depend critically on which assets are purchased and its objectives. For instance, asset purchase programs on November 25, 2008, and March 2010 in QE1 are captured by our identified shocks; that is, the expansionary shocks which aimed at supporting directly the housing market. Expansionary shocks in QE2, in which the Fed purchased only Treasuries, aimed to ensure that inflation is at levels consistent with its mandate. Further, the Operation Twist, mainly the Maturity Extension Program (MEP) and Reinvestment Policy were introduced in order to twist yield curve in response to the onset of recession and spike in the financial stress index. Our identified shocks capture the start of these operations. Moreover, expansionary shocks in the third round reflected the extension of Operation Twist and policy introduced in response to labor market contraction. As most monetary policy decisions are announced before they are implemented, over the sample period, one would expect some expansionary shocks to occur after the date of the announcements (Fratzscher et al., 2013). However, regarding the spread shock, we identify the unexpected change in term spread innovations differ from the total asset shock in some ways and resemble them in others. The most notable difference is the timing and size of shocks.

Figure 1. Dynamic of the identification of Fed balance sheet shocks

(a) Identification I



(b) Identification II



Notes: The figures 1(a) and 1(b) show the estimated Fed balance sheet shocks, reflecting the unexpected change of the total assets and term spread, respectively. The shadow area (in dark grey) shows 68% posterior credibility set. The shadow areas (in light grey) show the round of assets purchases program, QE1, QE2 and QE3 respectively.

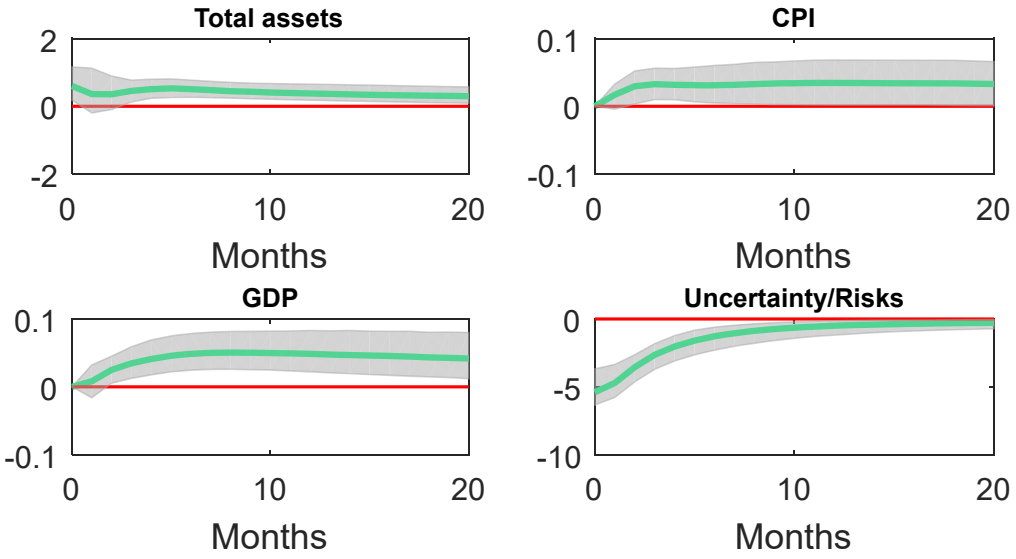
4.2. The domestic effects of Fed balance sheet shocks

Figure 2 shows the point-wise median as well as the 68 percent equal-tailed point-wise probability bands for the impulse response functions for GDP, CPI, VIX and monetary instrument. It indeed displays the responses of one standard deviation Fed's balance sheet shocks, corresponding to Identification I and II. Under Identification I, total assets rise on impact, and VIX decrease on impact; GDP and CPI do no change on impact. This is by construction as they are the restrictions. Qualitatively, the results show that both CPI and GDP rise in response to an asset purchases shock. More importantly, results are consistent with the view that unconventional monetary policy under asset purchase programs lead to a decline in financial uncertainty. These effects are statistically significant.

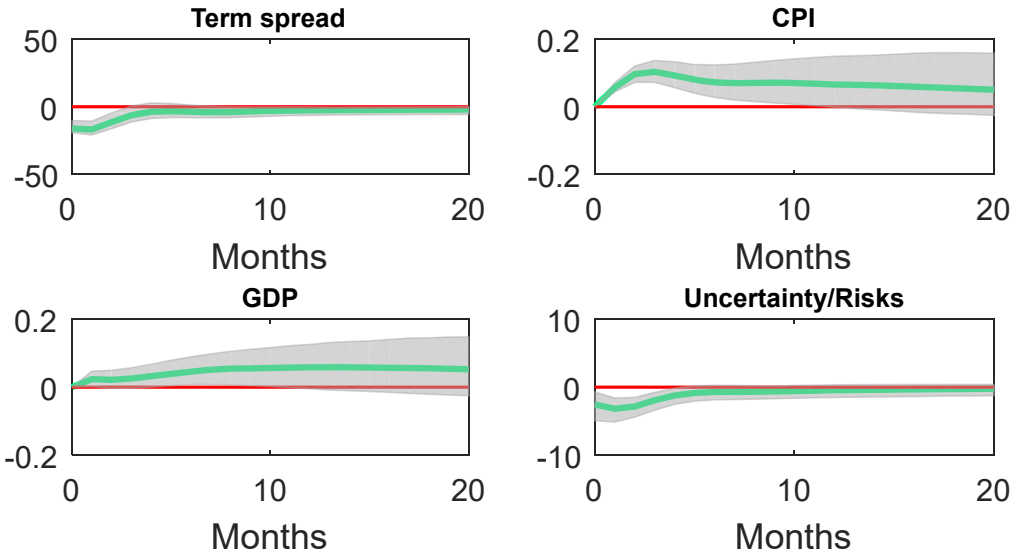
Consistent with previous works, we consider VIX as a measure of financial uncertainty and risk appetite (Bekaert et al., 2013) in that its decline reflects a change in the risk-taking channel of monetary policy. Our results are consistent with previous findings (Baumeister and Benati, 2013; Weale and Wieladek, 2016). However, the magnitude of our responses are small and differ strikingly from previous studies, meaning that the underlying quantitative differences can arise as a result of the identification schemes or data in which the model was estimated. However, under identification II, the term spread and VIX decline on impact and GDP and CPI do no change on impact. Similar to previous findings, CPI and GDP rise in response to the spread of shocks trough the decline in term spread and financial uncertainty. These results are consistent with the idea that the long-term Treasury bond yields played a demonstrable role in the transmission of the Fed's asset purchase program to the real economy. Our findings support previous works that use the spread shock to distinguish unconventional monetary policy from other disturbances. We further analyze the international role of a shock to term spread below.

Figure 2. Dynamic effects of Fed Balance sheet shocks in the U.S. economy

(a) Identification I



(b) Identification II



Notes: Responses to a one standard deviation Fed's balance sheet shock (Total assets and term spread shocks). The solid curves represent the point-wise posterior medians, and the shaded areas represent the 68 percent equal-tailed point-wise probability bands. 10. 000 independent draws were used to generate the responses.

We conduct a robustness check by considering an alternative specification for the choice of lag, the set of variables included in the VAR, and the change in the sample period. First, the alternative setting of the lag (2 and 6) yield results very similar to those initially reported. Second, we use IP instead of GDP, use BBB-AAA corporate bond spread instead of VIX, and use of CPE instead of CPI. The results suggest that these changes make only a slight difference on our results. Third, we use a sample ending in September 2013, prior to the tapering announcement, which shows that results are not driven by the pattern of that period. We report results of robustness checks in the Appendix.

4.3. Spillover effects of Fed balance sheet shocks

We first examine the unit root test and the cross-sectional dependence (CD) across countries.[12] Our results suggest that there is a cross-sectional dependency of time-series data among emerging Asian countries. Further, all variables are non-stationary at level and become stationary at first difference.[13] This allows the use of the long-run identifying restricted panel VAR because this restriction requires that the individual data follow a unit root process (Blanchard and Quah, 1989; Pedroni, 2013).

4.4. Impulse responses and variance decomposition

In this subsection, we report the medians as well as the 25th and 75th percentiles as the error bands for the impulse response functions (IRFs) and dynamic variance decompositions (VD) of the endogenous variables of the panel SVAR. As one would expect, under Identification I and II, the results from 25th and 75th percent quantile responses and its share of the total forecast variances attest to the existence of substantial heterogeneity across countries to a positive Fed shock. We present the results in Appendix A.

[12] We use the Stata routine XTCD for the CD test, and MULTIPURT for the panel unit root tests for multiple variables and lags.

[13] The results of the unit root test and cross-sectional dependence are available upon request.

4.5. Robustness analysis

We conduct a robustness check by considering an alternative specification for the set of variables included in the panel SVAR model. For both blocks, we add the new variable VIX. The motivation behind this approach is that its response to a Fed balance sheet shock should help evaluate whether monetary shock is correctly identified. The results reported in Appendix B are qualitatively similar to those of the baseline specification. In particular, as one would expect, VIX declines following Fed shocks.

4.6. The cross-country distribution of the effects of Fed balance sheet shocks

Figures 3 and 4 report the values for each variable and country, the distributional characteristics of values over the 5-month horizon of median responses to a Fed Balance sheet shock and their respective variance decomposition. We consider only the response and variance decomposition of our baseline identification scheme, referred to as Identification I. As displayed in Figure 3, there is substantial heterogeneity across countries in terms of the magnitude and sign of the estimated effect of Fed shocks.

With respect to the response of prices to a Fed balance sheet shock, the effects are small and vary considerably across countries, with the largest effect evident for Singapore. Prices fall slightly in Korea, Singapore, and Thailand. However, they tend to rise moderately in India and Malaysia. Excluding Singapore and Hong Kong, a Fed balance sheet shock seems to have large and negative effects on real GDP, with the largest decline present in Thailand. However, the difference in the shape of the distributional characteristics of each country's responses shows a heterogeneous pattern across horizons.

Among financial variables, the peak median response of the real exchange rate is positive but small; that is, most countries experience an appreciation of exchange rate. The largest appreciation occurred in Indonesia. However, other countries such as Korea, Singapore, and Thailand experience negative effects. With respect to the response of the stock market index, the estimated effects also vary substantially across countries and horizons. Only countries including India, Philippines, and Singapore experience an increase in stock markets. Except for Hong Kong,

the sign of the peak response of long-run interest rate is similar across countries. Thus, the long-run interest rate rises in most countries; the largest increase takes place in Indonesia. Moreover, the real credit declines moderately in most countries; however, countries like Indonesia and Singapore experience a small increase in real credit.

With respect to the cross-country distribution of the variance decomposition of financial and macro variables, Figure 4 displays substantial heterogeneity across countries in terms of the magnitude and horizons of the estimated effects of Fed balance sheet shocks. To understand what drives the heterogeneity in emerging Asian macro and financial variables' responses, we propose below a panel-data setup with country-specific variables.

4.7. Country characteristics and the effects of Fed balance sheet shocks

What could account for this discrepancy across countries? In order to understand that, we propose a panel fixed-effect setup with country-specific variables. In other words, the point impulse response over a horizon of the 5 months is regressed on the first value of 5 months of country characteristics during QE1. We compute the fixed-effects regression of the form:

$$Z_{it} = \alpha_i + \gamma_t + \beta X_{it} + \epsilon_{it}, \quad (6)$$

where Z_{it} denotes the point impulse response of country i at month t. X_{it} represents country-specific variables for the same country-month pair, and ϵ_{it} represents an error term. The variable α_i denotes country-specific fixed effects, controlling for time-invariant country characteristics. γ_t denotes time fixed-effects, controlling for aggregate factors that may have affected Z at particular points in time. Note that Z_{it} represent the point impulse response of endogenous variables of the panel SVAR. Thus, the model specified in equation (6) is estimated for each point impulse response relative to each variable. To save space, we only report the results of the first round (QE1). Tables 4-9 summarize the results. Standard errors clustered by country and corrected for autocorrelation and heteroscedasticity are reported in parenthesis.[14] The results are robust

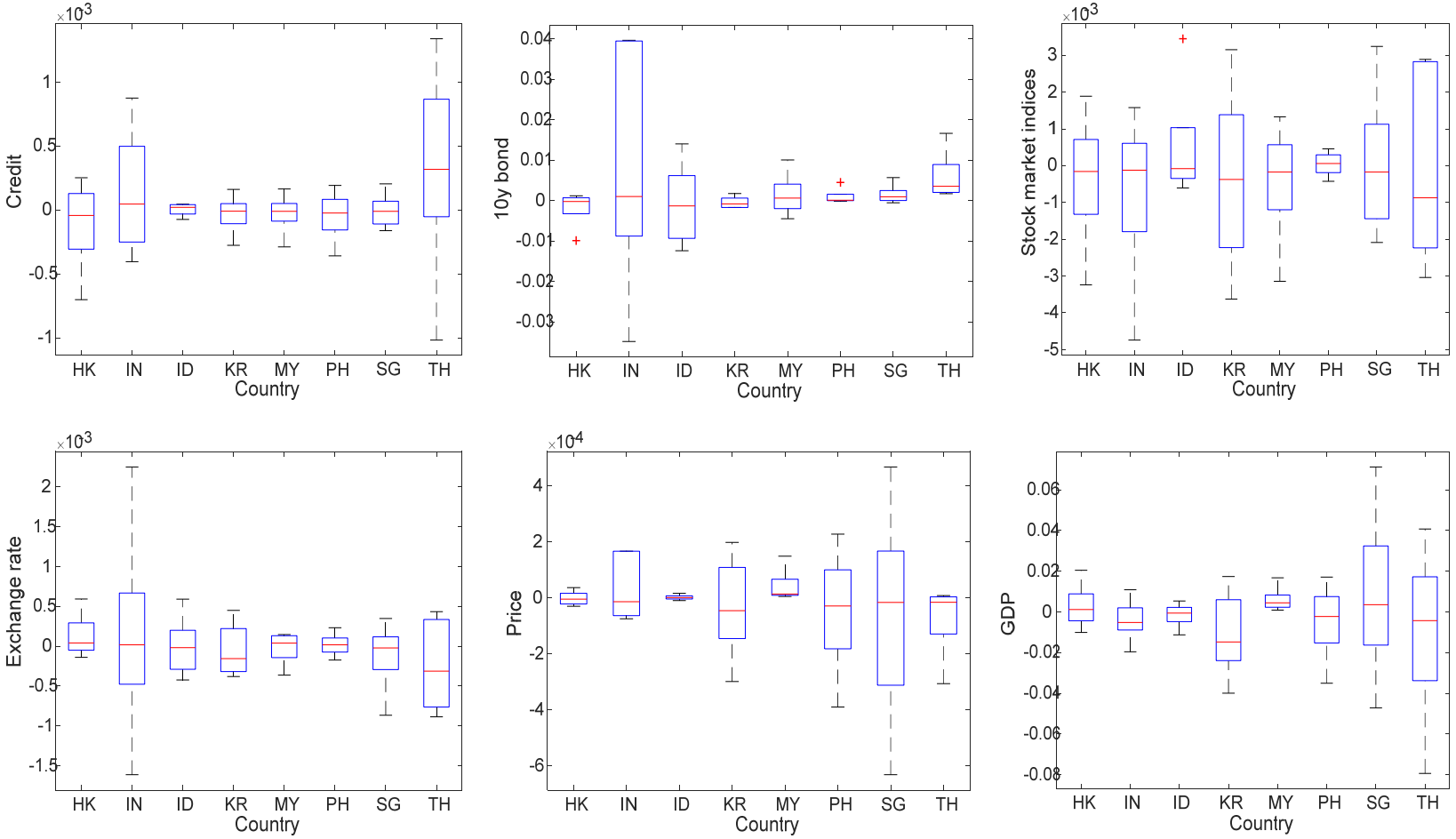
[14] Note that we do not report the results of the variable of capital requirements because of the problem of multicollinearity. Instead, we add two aggregates measures, which are sum of the cumulative of the 9 instruments by country and time proposed by Cerutti et al. (2016). The nine instruments include capital requirements, capital buffer

across different specifications in Tables 4-9, and the estimated magnitudes of the coefficients are quite stable.

Table 4 summarizes the results of the model specified in equation (6) for the response of real credit to a Fed balance sheet shock. Results show that macroeconomic fundamentals (real GDP growth and inflation), financial openness (financial integration, capital openness, currency exposure, market capitalization), and macroprudential policies (LTV regulations, local and foreign reserve requirements and capital controls) seem to drive the responsiveness of real credit to a Fed shock. For instance, the responsiveness of real credit is negatively associated with the intensity of capital inflow controls. In other words, countries with higher intensity of capital controls tends to experience less credit cycle following an unexpected change in the Fed balance sheet. In particular, our results also suggest that financial openness play an important role in explaining the heterogeneous responses across countries.

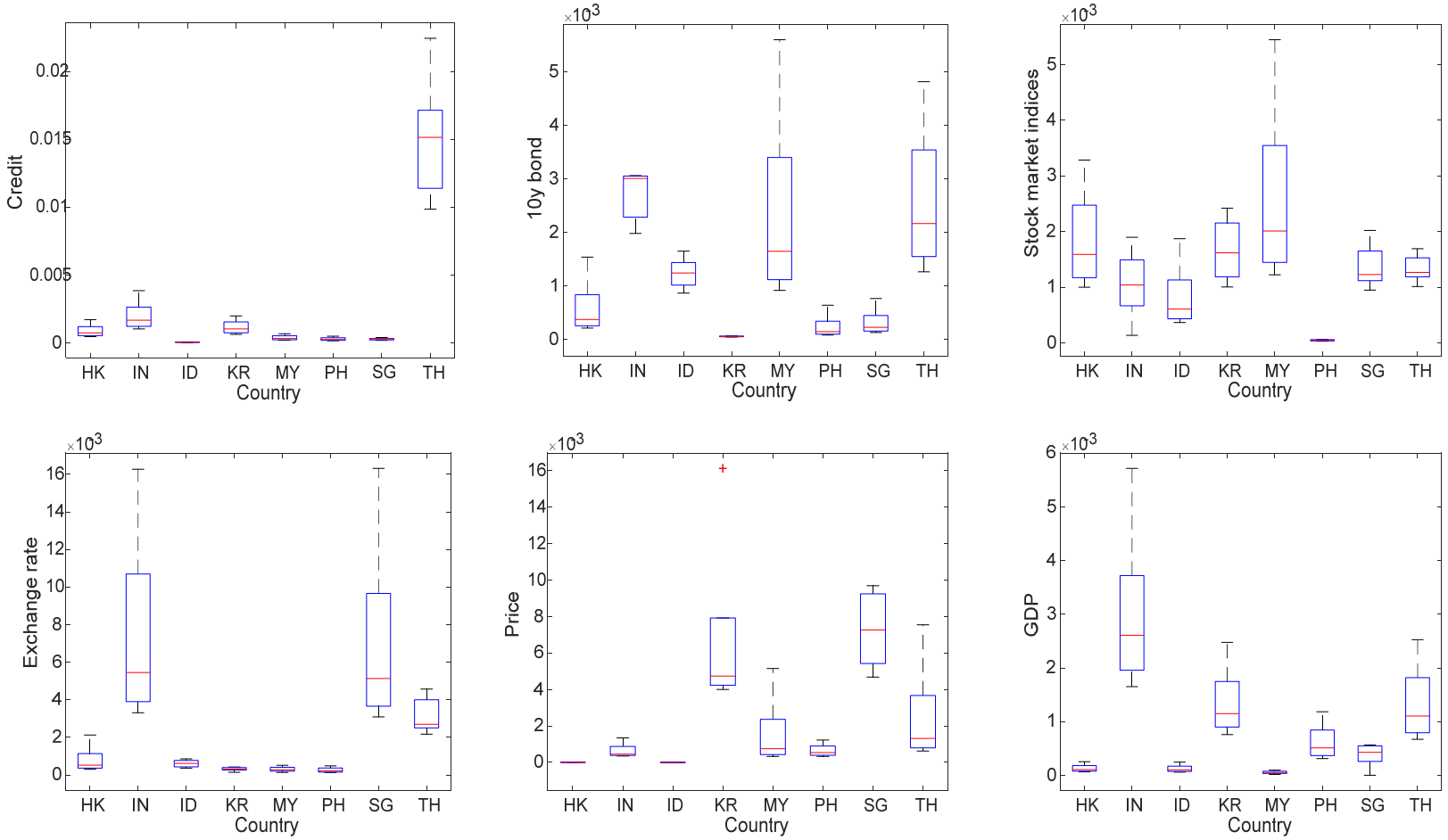
(real estate credit), capital buffer (consumer credit), capital buffer (other sector), concentration limit, interbank exposure limit, loan-to-value ratio capital, foreign and local reserve requirements. See Table A1 for more exposition.

Figure 3. Cross-country distribution of IRFs



Note: Boxplot of country-specific distribution of impulse response functions over a horizon of 5 months.

Figure 4. Cross-country distribution of VDs



Note: Boxplot of country-specific distribution of variance decomposition over a horizon of 5 months.

Table 4. Determinants of responses of real credit to a Fed balance sheet shock

	1	2	3	4	5	6	7
LTV regulations	-0.0003***	-0.0003***	-0.0003***	-0.0003***	-0.0004***	-0.0004***	
	(0.0000)	(0.0000)	(0.00002)	(0.0000)	(0.0000)	(0.0000)	
CUM_PRUC	0.0006***	0.0007***	0.0007***	0.0007***	0.0006***	0.0006***	
	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	
CUM_PRUC2	-0.0005***	-0.0006***	-0.0006***	-0.0007***	-0.0004***	-0.0005***	
	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0001)	(0.0001)	
Foreign res. requirements	0.0012***	0.0012***	0.0012***	0.0012***	0.0011***	0.0011***	
	(0.0004)	(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	
Local res. requirements	-0.0004***	-0.0004***	-0.0004***	-0.0004***	-0.0005***	-0.0005***	
	(0.0000)	(0.00002)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	
Foreign currency exposure	0.00004***			0.00002**	0.0001**	0.0001**	
	(0.0000)			(0.0000)	(0.0000)	(0.0000)	
Financial integration		0.00003***					
		(0.00001)					
Market cap. to GDP			-0.00001**				
			(0.0000)				
Financial open.	0.0012***	0.0012***	0.0012***	0.0012***	0.0012***	0.0009***	
	(0.00017)	(0.00018)	(0.0001)	(0.0002)	(0.0002)	(0.0001)	
Capital controls (overall)	-0.0025***	-0.0026***				-0.0021***	
	(0.00015)	(0.00015)				(0.0003)	
Capital controls (inflows)			-0.0024***				
			(0.0002)				
Capital controls (outflows)				-0.0026***			
				(0.0001)			
Inflation						0.00001***	
						(0.0000)	
GDP growth						0.00002***	
						(0.0000)	
Credit growth							0.0027
							(0.5150
Observations	40	40	40	40	40	40	40
Adj. R-squared	0.0097	0.0101	0.0043	0.0038	0.0168	0.0101	0.0020
Country & time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table presents the estimated parameter values from fixed effects panel regressions. The dependent variable is the point estimate response of real credit over 5 horizons. Standard errors clustered by country level, are shown in parentheses. *** is significant at the 1% level, ** at the 5% level, and * at the 10% level.

Table 5. Determinants of responses of long-run government bond to a Fed balance sheet shock

	1	2	3	4	5	6	7
LTV regulations	0.0021**	0.0022*	0.0022**	0.0017	0.0027***	0.0038***	
	(0.0008)	(0.0009)	(0.0009)	(0.0013)	(0.0004)	(0.0010)	
CUM_PRUC	-0.0279***	-0.0278***	-0.0278***	-0.0282***	-0.0274***	-0.0261***	
	(0.0067)	(0.0067)	(0.0066)	(0.0072)	(0.0061)	(0.0070)	
CUM_PRUC2	0.0247**	0.0246**	0.0247**	0.0256**	0.0237***	0.0214**	
	(0.0075)	(0.0076)	(0.0075)	(0.0085)	(0.0065)	(0.0079)	
Foreign res. requirements	0.0333***	0.0333***	0.0333***	0.0329***	0.0338***	0.0345***	
	(0.0038)	(0.0038)	(0.0037)	(0.0043)	(0.0033)	(0.0040)	
Local res. requirements	0.0109***	0.0109***	0.0109***	0.0103***	0.0115	0.0123***	
	(0.0021)	(0.0020)	(0.0021)	(0.0016)	(0.0025)	(0.0021)	
Foreign currency exposure	0.0002			0.0004	0.000006	-0.00008	
	(0.0005)			(0.0006)	(0.0006)	(0.0002)	
Financial integration		0.0002					
		(0.0004)					
Market cap. to GDP			-0.000008				
			(0.0000)				
Financial open.	0.0251***	0.0250***	0.0251***	0.0251***	0.0249***	0.0191***	
	(0.0013)	(0.0013)	(0.0013)	(0.0014)	(0.0012)	(0.0026)	
Capital controls (overall)	0.0235	0.0234	0.0222			0.0338	
	(0.0194)	(0.0195)	(0.0206)			(0.0191)	
Capital controls (inflows)				0.0220			
				(0.0194)			
Capital controls (outflows)					0.0248		
					(0.0192)		
Inflation						0.0006***	-0.0019**
						(0.0001)	(0.0008)
GDP growth						-0.0007***	0.1212**
						(0.0001)	(0.0462)
Credit growth							0.0015*
							(0.0007)
Observations	40	40	40	40	40	40	40
Adj. R-squared	0.0083	0.0087	0.0063	0.0108	0.0056	0.0009	0.0009
Country & time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table presents the estimated parameter values from fixed effects panel regressions. The dependent variable is the point estimate response of long-run government bond over 5 horizons. Standard errors clustered by country level, are shown in parentheses. *** is significant at the 1% level, ** at the 5% level, and * at the 10% level.

Table 6. Determinants of responses of stock market to a Fed balance sheet shock

	1	2	3	4	5	6	7
LTV regulations	-0.0073***	-0.0073***	-0.0072***	-0.0071***	-0.0075***	-0.0083***	
	(0.0006)	(0.0006)	(0.0005)	(0.0008)	(0.0004)	(0.0004)	
CUM_PRUC	0.0026	0.0026	0.0025	0.0029	0.0023	0.0022	
	(0.0039)	(0.0039)	(0.0039)	(0.0042)	(0.0036)	(0.0038)	
CUM_PRUC2	0.0013	0.0013	0.0013	0.0008	0.0018	0.0024	
	(0.0044)	(0.0045)	(0.0044)	(0.0050)	(0.0038)	(0.0042)	
Foreign res. requirements	-0.0025	-0.0025	-0.0025	-0.0023	-0.0028	-0.0027	
	(0.0022)	(0.0022)	(0.0022)	(0.0025)	(0.0019)	(0.0022)	
Local res. requirements	-0.0053***	-0.0053***	-0.0053***	-0.0051***	-0.0055***	-0.0062***	
	(0.0012)	(0.0012)	(0.0013)	(0.0010)	(0.0015)	(0.0013)	
Foreign currency exposure	0.00007			0.000006	0.0001	0.0007	
	(0.0001)			(0.0001)	(0.0002)	(0.0004)	
Financial integration		0.0000					
		(0.0001)					
Market cap. to GDP			-0.000002				
			(0.0000)				
Financial open.	0.0161***	0.0160***	0.0160***	0.0160***	0.0161***	0.0132***	
	(0.0027)	(0.0026)	(0.0026)	(0.0026)	(0.0026)	(0.0032)	
Capital controls (overall)	-0.0081	-0.0080	-0.0086			-0.0041	
	(0.0112)	(0.0113)	(0.0118)			(0.0085)	
Capital controls (inflows)				-0.0086			
				(0.0113)			
Capital controls (outflows)					-0.0076		
					(0.0110)		
Inflation						0.00008	
						(0.0001)	
GDP growth						0.0002***	
						(0.0000)	
Credit growth							-0.0145
							(0.0128)
Observations	40	40	40	40	40	40	40
Adj. R-squared	0.0084	0.0104	0.0120	0.0096	0.0110	0.0099	0.0085
Country & time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table presents the estimated parameter values from fixed effects panel regressions. The dependent variable is the point estimate response of stock market index over 5 horizons. Standard errors clustered by country level, are shown in parentheses. *** is significant at the 1% level, ** at the 5% level, and * at the 10% level.

Table 7. Determinants of responses of exchange rate to a Fed balance sheet shock

	1	2	3	4	5	6	7
LTV regulations	0.0002***	0.0002***	0.0002***	0.0001***	0.0002	-0.0002	
	(0.0000)	(0.00005)	(0.00004)	(0.00005)	(0.0001)	(0.0002)	
CUM_PRUC	-0.0006***	-0.0006***	-0.0006***	-0.0007***	-0.0006***	-0.0010***	
	(0.0000)	(0.0001)	(0.0001)	(0.00007)	(0.0001)	(0.0002)	
CUM_PRUC2	0.0002	0.0002***	0.0002	0.00025*	0.0002	0.0009**	
	(0.0001)	(0.0001)	(0.0001)	(0.00012)	(0.0001)	(0.0003)	
Foreign res. requirements	0.0029***	0.0028***	0.0028***	0.0027***	0.0028***	0.0025***	
	(0.00006)	(0.0001)	(0.0001)	(0.00006)	(0.0001)	(0.0001)	
Local res. requirements	0.0006***	0.0007***	0.0007***	0.0006***	0.0007***	0.0003*	
	(0.0000)	(0.0001)	(0.00006)	(0.0001)	(0.0001)	(0.0002)	
Foreign currency exposure	-0.00004			-0.00004	-0.00004	0.0001	
	(0.0000)			(0.0001)	(0.0001)	(0.0001)	
Financial integration		-0.00002					
		(0.0000)					
Market cap. to GDP			0.000001				
			(0.0000)				
Financial open.	-0.0015***	-0.0015***	-0.0015***	-0.0015***	-0.0015***	-0.0005***	
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0010)	
Capital controls (overall)	0.0004	0.0004	0.0006			-0.0015	
	(0.0002)	(0.0003)	(0.0004)			(0.0012)	
Capital controls (inflows)				0.0006***			
				(0.000)			
Capital controls (outflows)					0.0002		
					(0.0004)		
Inflation						-0.0001*	-0.0001*
						(0.0000)	(0.0000)
GDP growth						0.0002*	0.00005
						(0.0000)	(0.00003)
Credit growth							-0.0025
							(0.0024)
Observations	40	40	40	40	40	40	40
Adj. R-squared	0.0666	0.0666	0.0085	0.0754	0.0622	0.0475	0.0004
Country & time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table presents the estimated parameter values from fixed effects panel regressions. The dependent variable is the point estimate response of exchange rate over 5 horizons. Standard errors clustered by country level, are shown in parentheses. *** is significant at the 1% level, ** at the 5% level, and * at the 10% level.

Table 8. Determinants of responses of CPI to a Fed balance sheet shock

	1	2	3	4	5	6	7
LTV regulations	-0.0003***	-0.0003***	-0.0003***	-0.0003**	-0.0003***	-0.0004***	
	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0000)	(0.0000)	
CUM_PRUC	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	
	(0.0005)	(0.0005)	(0.0005)	(0.0006)	(0.0005)	(0.0006)	
CUM_PRUC2	-0.0003	-0.0002	-0.0002	-0.0003	-0.0002	-0.0002	
	(0.0006)	(0.0006)	(0.0006)	(0.0007)	(0.0005)	(0.0007)	
Foreign res. requirements	0.0002	0.0003	0.0003	0.0002	0.0002	0.0003	
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	
Local res. requirements	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	
	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0002)	(0.0002)	
Foreign currency exposure	0.00001			0.00004	0.00002	0.00002	
	(0.0000)			(0.0000)	(0.0000)	(0.00003)	
Financial integration	-0.0010	0.000005					
	(0.0015)	(0.0000)					
Market cap. to GDP			-0.00004				
			(0.0000)				
Financial open.	0.0007***	0.0007***	0.0007***	0.0007***	0.0007***	0.0006*	
	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0003)	
Capital controls (overall)	0.0007	-0.0010	-0.0011			-0.0010	
	(0.0002)	(0.0015)	(0.0016)			(0.0014)	
Capital controls (inflows)				-0.0010			
				(0.0016)			
Capital controls (outflows)					-0.0010		
					(0.0015)		
Inflation						0.00006	-0.00001
						(0.0000)	(0.0000)
GDP growth						0.00007	0.00001
						(0.0000)	(0.0000)
Credit growth							-0.0016
							(0.0014)
Observations	40	40	40	40	40	40	40
Adj. R-squared	0.0005	0.0005	0.0005	0.0002	0.0011	0.0010	0.0026
Country & time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table presents the estimated parameter values from fixed effects panel regressions. The dependent variable is the point estimate response of CPI over 5 horizons. Standard errors clustered by country level, are shown in parentheses. *** is significant at the 1% level, ** at the 5% level, and * at the 10% level.

Table 9. Determinants of responses of real GDP to a Fed balance sheet shock

	1	2	3	4	5	6	7
LTV regulations	-0.0356***	-0.0361***	-0.0357***	-0.0315***	-0.0393***	-0.0311***	
	(0.0045)	(0.0051)	(0.0046)	(0.0069)	(0.0023)	(0.0056)	
CUM_PRUC	0.0272	0.0271	0.0272	0.0324	0.0226	0.0352	
	(0.0342)	(0.0343)	(0.0342)	(0.0367)	(0.0317)	(0.0372)	
CUM_PRUC2	-0.0268	-0.0264	-0.0266	-0.0361	-0.0184	-0.0406	
	(0.0386)	(0.0391)	(0.0387)	(0.0436)	(0.0336)	(0.0423)	
Foreign res. requirements	0.0001	-0.0001	-0.00002	0.0049	-0.0043	0.0059	
	(0.0193)	(0.0195)	(0.0193)	(0.0218)	(0.0168)	(0.0211)	
Local res. requirements	-0.0206*	-0.0209*	-0.0208*	-0.0169*	-0.0236	-0.0158	
	(0.0106)	(0.0105)	(0.0106)	(0.0081)	(0.0130)	(0.0115)	
Foreign currency exposure	-0.0022			-0.0033	-0.0013	-0.0010	
	(0.0041)			(0.0036)	(0.0048)	(0.0019)	
Financial integration		-0.0014					
		(-0.1385)					
Market cap. to GDP			0.0001				
			(0.0001)				
Financial open.	0.1103***	0.1110***	0.1101***	0.1100***	0.1106***	0.0659***	
	(0.0018)	(0.0018)	(0.0020)	(0.0019)	(0.0018)	(0.0137)	
Capital controls (overall)	-0.1380	-0.1385	-0.1254			-0.0649	
	(0.1001)	(0.1006)	(0.1076)			(0.1007)	
Capital controls (inflows)				-0.1501			
				(0.0996)			
Capital controls (outflows)					-0.1242		
					(0.1022)		
Inflation						0.0035***	
						(0.0008)	
GDP growth						-0.0029**	
						(0.0011)	
Credit growth							-0.1862
							(0.1964)
Observations	40	40	40	40	40	40	40
Adj. R-squared	0.0377	0.0371	0.0335	0.0301	0.0428	0.0018	0.0005
Country & time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table presents the estimated parameter values from fixed effects panel regressions. The dependent variable is the point estimate response of real GDP over 5 horizons. Standard errors clustered by country level, are shown in parentheses. *** is significant at the 1% level, ** at the 5% level, and * at the 10% level.

This implies that countries with higher financial openness (Chinn-Ito measure) are more affected by the Fed balance sheet policy.

Table 5 summarizes the results for long-run government bond yields. It is shown that except the ratio of stock market capitalization to GDP, capital controls and the ratio of total assets and liabilities to GDP, the set of categories includes macroeconomic fundamentals (real GDP growth, inflation, and real credit growth), financial openness (capital openness and foreign currency exposure), and macroprudential policies (LTV regulations, local and foreign reserve requirements) are significant in explaining the responsiveness of local long-run government bond yields to a Fed balance sheet shock. Table 6 summarizes the results for the response of stock markets to a Fed balance sheet shock. We find that LTV regulations, local reserve requirements and financial openness (Chinn-Ito measure) are the only set of country-specific variables that robustly explain the responses of stock market indexes to a Fed balance sheet shock. For instance, countries with higher intensity of either LTV regulation (e.g. India, Indonesia, Korea and Singapore) or local reserve requirements (e.g. Indonesia, Korea, Philippines and Singapore) are less affected by the change in the Fed balance sheet policy.

Table 7 summarizes the results for exchange rate effects. We find that LTV regulations, local and foreign reserve requirements, controls on capital inflows, domestic macroeconomic conditions (inflation and real GDP growth) and financial openness (Chinn-Ito measure) play important role in explaining the heterogeneous responses of exchange rate to a Fed balance sheet shock. The results for financial openness (Chinn-Ito measure) suggest that countries with higher financial openness are less affected by changes in Fed balance sheet policy. One would, of course, expect a positive sign. We argue that these results may accommodate the fact that countries (e.g. Indonesia, Korea and Singapore) with higher financial openness (Chinn-Ito measure) are classified among those with higher intensity of LTV regulations and local reserve requirements.

Finally, Tables 8 and 9 summarize the results for CPI and real GDP, respectively. We find that results from column 1 to 7 show that macroprudential instruments that aim at limiting loans to residential borrowers play an important role in explaining the responsiveness of prices and real GDP to a Fed balance sheet shock. Moreover, the results also show that countries with higher financial openness (Chinn-Ito measure) are more affected by the change in the Fed balance policy.

As one would expect, macroeconomic conditions (inflation and real GDP growth) are only significant in explaining heterogeneous responses of real GDP (not CPI) to a Fed balance sheet shock.

To summarize, this study provides some evidence that country characteristics and policies can affect the extent to which a country responds to Fed balance sheet shocks. In particular, as one would expect, stronger intensity of macroprudential regulations, control on capital inflows and possibly fewer financial openness, can partially mitigate any cross-border effects of the changes in Fed balance sheet policies.

5. CONCLUSION

We examined whether co-movements in the Fed's balance sheet had spillover effects on the selected macro and financial variables of emerging Asian countries. We identified this shock by means of a combination of zero and sign restrictions under two identification schemes with either total assets or term spread as a policy instrument. We found that a balance sheet shock led to an increase in nominal GDP and in CPI. This shock also decreased VIX, meaning a decline in financial uncertainty and an increase in investor risk appetite. This pattern is qualitatively similar to what one may expect after a positive monetary shock. In addition, under Identification II, we found similar results in the responses of GDP, CPI, and VIX. Our findings also accommodate the fact that the U.S. long-run rate played an important role in the transmission of the Fed program. Second, our findings suggest that the Fed program appear to have spillover effects, but in a heterogeneous manner. Finally, we explored the question of this heterogeneity and found that macroeconomic fundamentals, financial openness, intensity of capital controls and intensity of macroprudential policies explained country heterogeneity in response to Fed balance sheet shocks. In particular, the significance of these estimates, however, vary across the responsiveness of endogenous variables of the panel SVAR.

ACKNOWLEDGMENTS

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REFERENCES

Ammer, J., C. Vega and J. Wongswan (2010), 'International Transmission of U.S. Monetary Policy Shocks: Evidence from Stock Prices', *Journal of Money, Credit and Banking*, **42**, s1, 179–198.

Anaya, P., M. Hachula and C. J. Offermanns (2017), 'Spillovers of U.S. Unconventional Monetary Policy to Emerging Markets: The Role of Capital Flows', *Journal of International Money and Finance*, **73**, Part B, 275–295.

Arias, J. E., J. F. Rubio-Ramírez and D. F. Waggoner (2018), 'Inference Based on Structural Vector Autoregressions Identified with Sign and Zero Restrictions: Theory and Applications', *Econometrica*, **86**, 2, 685–720.

Baumeister, C. and L. Benati (2013), 'Unconventional Monetary Policy and the Great Recession: Estimating the Macroeconomic Effects of a Spread Compression at the Zero Lower Bound', *International Journal of Central Banking*, **9**, 2, 165–212.

Bekaert, G., M. Hoerova and M. L. Duca (2013), 'Risk, Uncertainty and Monetary Policy', *Journal of Monetary Economics*, **60**, 7, 771–788.

Bénétrix, A. S., P. R. Lane and J. C. Shambaugh (2015), 'International Currency Exposures, Valuation Effects and the Global Financial Crisis', *Journal of International Economics*, **96**, s1, S98–S109.

Bhattarai, S., A. Chatterjee and W. Y. Park (2015), 'Effects of US Quantitative Easing on Emerging Market Economies', Globalization and Monetary Policy Institute Working Paper 255, Federal Reserve Bank of Dallas.

Bhattarai, S. and C. J. Neely (2016), 'A Survey of the Empirical Literature on US Unconventional Monetary Policy', Working Papers 2016-21, Federal Reserve Bank of St. Louis.

Blanchard, O. J. and D. Quah (1989), 'The Dynamic Effects of Aggregate Demand and Supply Disturbances', *American Economic Review*, **79**, 4, 655–673.

Blinder, A. S. (2010), 'Quantitative Easing: Entrance and Exit Strategies', *Review* (Federal Reserve Bank of St. Louis), **92**, 6, 465–479.

Boeckx, J., M. Dossche and G. Peersman (2017), 'Effectiveness and Transmission of the ECB's Balance Sheet Policies', *International Journal of Central Banking*, **13**, 1, 297–333.

Bowman, D., J. M. Londono and H. Sapriza (2015), 'U.S. Unconventional Monetary Policy and Transmission to Emerging Market Economies', *Journal of International Money and Finance*, **55**, 27–59.

Canova, F. and M. Ciccarelli (2009), 'Estimating Multicountry VAR Models', *International Economic Review*, **50**, 3, 929–959.

Cerutti, E., S. Claessens and L. Laeven (2015). 'The Use and Effectiveness of Macroprudential Policies: New Evidence', IMF Working Paper No. 15/61, International Monetary Fund.

Chen, Q., A. Filardo, D. He and F. Zhu (2016), 'Financial Crisis, US Unconventional Monetary Policy and International Spillovers', *Journal of International Money and Finance*, **67**, 62–81.

Chen, Q., A. Filardo, D. He and F. Zhu (2016), 'Financial Crisis, US Unconventional Monetary Policy and International Spillovers', *Journal of International Money and Finance*, **67**, 62–81.

Dedola, L., G. Rivolta and L. Stracca (2017), 'If the Fed Sneezes, Who Catches a Cold?', *Journal of International Economics*, **108**, s1, S23–S41.

Fernández, A., M. W. Klein, A. Rebucci, M. Schindler and M. Uribe (2016), 'Capital Control Measures: A New Dataset', *IMF Economic Review*, **64**, 3, 548–574.

Fratzscher, M., M. Lo Duca and R. Straub (2016), 'On the International Spillovers of US Quantitative Easing', *Economic Journal*, **128**, 608, 330–377.

Gagnon, J., M. Raskin, J. Remache and B. Sack (2011), 'The Financial Market Effects of the Federal Reserve's Large-Scale Asset Purchases', *International Journal of Central Banking*, **7**, 1, 3–43.

Gambacorta, L., B. Hofmann and G. Peersman (2014), 'The Effectiveness of Unconventional Monetary Policy at the Zero Lower Bound: A Cross-Country Analysis', *Journal of Money, Credit and Banking*, **46**, 4, 615–642.

Georgiadis, G. (2016), 'Determinants of Global Spillovers from US Monetary Policy', *Journal of International Money and Finance*, **67**, 41–61.

Gertler, M. and P. Karadi (2015), 'Monetary Policy Surprises, Credit Costs, and Economic Activity', *American Economic Journal: Macroeconomics*, **7**, 1, 44–76.

Gilchrist, S., V. Z. Yue and E. Zakrajsek (2015), 'The Response of Sovereign Bond Yields to U.S. Monetary Policy', Paper presented at Banco Central de Chile, Santiago Chile, November 19th, 2015.

Hao, N., P. Pedroni, G. Colson and M. Wetzstein (2017), 'The Linkage between the U.S. Ethanol Market and Developing Countries' Maize Prices: A Panel SVAR Analysis', *Agricultural Economics*, **48**, 5, 629–638.

Krishnamurthy, A. and A. Vissing-Jorgensen (2011), 'The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy', *Brookings Papers on Economic Activity*, **43**, 2, 215–287.

Mishra, P., P. Montiel, P. Pedroni and A. Spilimbergo (2014a), 'Monetary Policy and Bank Lending Rates in Low-Income Countries: Heterogeneous Panel Estimates', *Journal of Development Economics*, **111**, 117–131.

Mishra, P., K. Moriyama, P. M. N'Diaye and L. Nguyen (2014b), 'Impact of Fed Tapering Announcements on Emerging Markets', IMF Working Paper No. 14/109, International Monetary Fund.

Neely, C. J. (2015), 'Unconventional Monetary Policy Had Large International Effects', *Journal of Banking & Finance*, **52**, 101–111.

Pedroni, P. (2013), 'Structural Panel VARs', *Econometrics*, **1**, 2, 180–206.

Tillmann, P. (2016), 'Unconventional Monetary Policy and the Spillovers to Emerging Markets', *Journal of International Money and Finance*, **66**, 136–156.

Weale, M. and T. Wieladek (2016), 'What are the Macroeconomic Effects of Asset Purchases?', *Journal of Monetary Economics*, **79**, 81–93.

APPENDIX A: FIGURES AND TABLES

TABLE A1. Data description and sources

Variable	Description and note	Source
Selected interest rates	Effective federal funds rate and 3-month treasury bill	Board of Governors of the Federal Reserve System.
US 10-year treasury yield	US sovereign bond yields	Board of Governors of the Federal Reserve System.
Selected assets	Selected Assets in millions of dollars	Board of Governors of the Federal Reserve System.
Securities held outright	Securities held outright in billions of dollars	Board of Governors of the Federal Reserve System.
Term spread	Difference between 10-year treasury yield minus 3-month treasury yield	Board of Governors of the Federal Reserve System.
US GDP	Monthly GDP	Macroeconomic Advisers
US CPI, CPE	Consumer Price Index	FRED
US total outflows	Others investment, equity, direct investment and debt security	IMF IFS and Bureau of Economic Analysis (BEA)
US stock market indices	Stock market in US dollar	MSCI
Output growth	Real GDP growth	IMF IFS and WDI
Inflation	Year-on-year change in consumer price index	IMF IFS and WDI
Degree of capital account openness	KAOPEN index measures the country's degree of capital account openness	Chinn-Ito index
Market capitalization	Market capitalization (%GDP)	Board of Governors of the Federal Reserve System.
EM Asia 10-year bond	Sovereign bond yields	MSCI
Credit growth (%GDP)	The private non-financial sector includes non-financial corporates, household, and non-profit institutions (see IMF SNA 2008).	BIS
Real effective exchange rate	Real effective exchange rate (period average; 2005=100)	BIS
EM Asia stock market indices	Stock market index for each EM Asia (non-adjusted MSCI Emerging Markets Index in US dollar).	MSCI

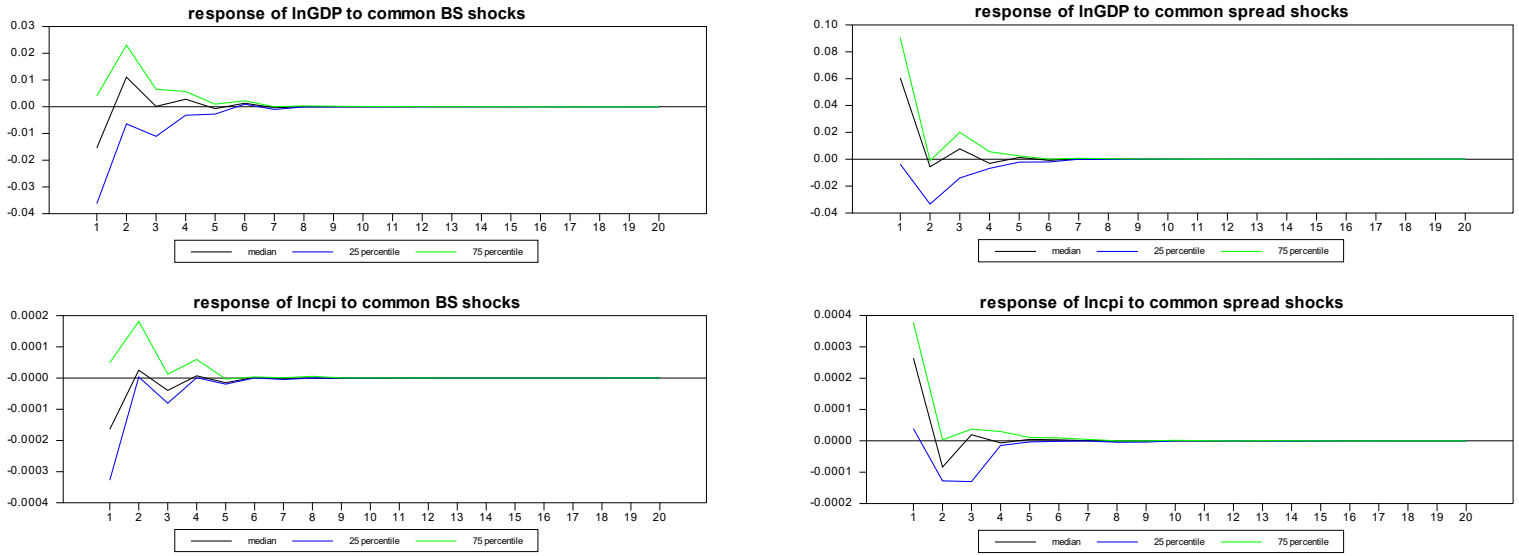
Note: BIS (Bank for International Settlements), IMF IFS (International Monetary Fund's International Financial Statistics), MSCI (Morgan Stanley Capital International), and WDI (World Development Indicators).

TABLE A1 *(continued).*

Variable	Description and note	Source
Capitals control	Overall restrictions index (all asset categories)	Fernández et al. (2016)
Control on capital inflows	Overall inflow restrictions index (all asset categories)	Fernández et al. (2016)
Control on capital outflows	Overall outflow restrictions index (all asset categories)	Fernández et al. (2016)
Capital Regulation, LTV (loan-to-value) Regulations, Local Reserve Requirements	Quarterly indices of the intensity of macroprudential policy regulation proxied by cumulated tightening minus cumulated loosening actions (2000-2014).	Cerutti et al. (2016)
Cum_PruC	Sum of the cumulative version of the 9 instruments by country and time	Cerutti et al. (2016)
Cum_PruC2	Sum of the cumulative version of the 9 instruments by country and time. In this case, all individual instruments are adjusted to have maximum and minimum changes of 1 and -1.	Cerutti et al. (2016)
Foreign Currency Exposure	Foreign currency exposure.	Bénétrix et al. (2015)
Financial integration	Financial integration proxied by the sum of total assets and liabilities as a share of GDP.	Bénétrix et al. (2015)

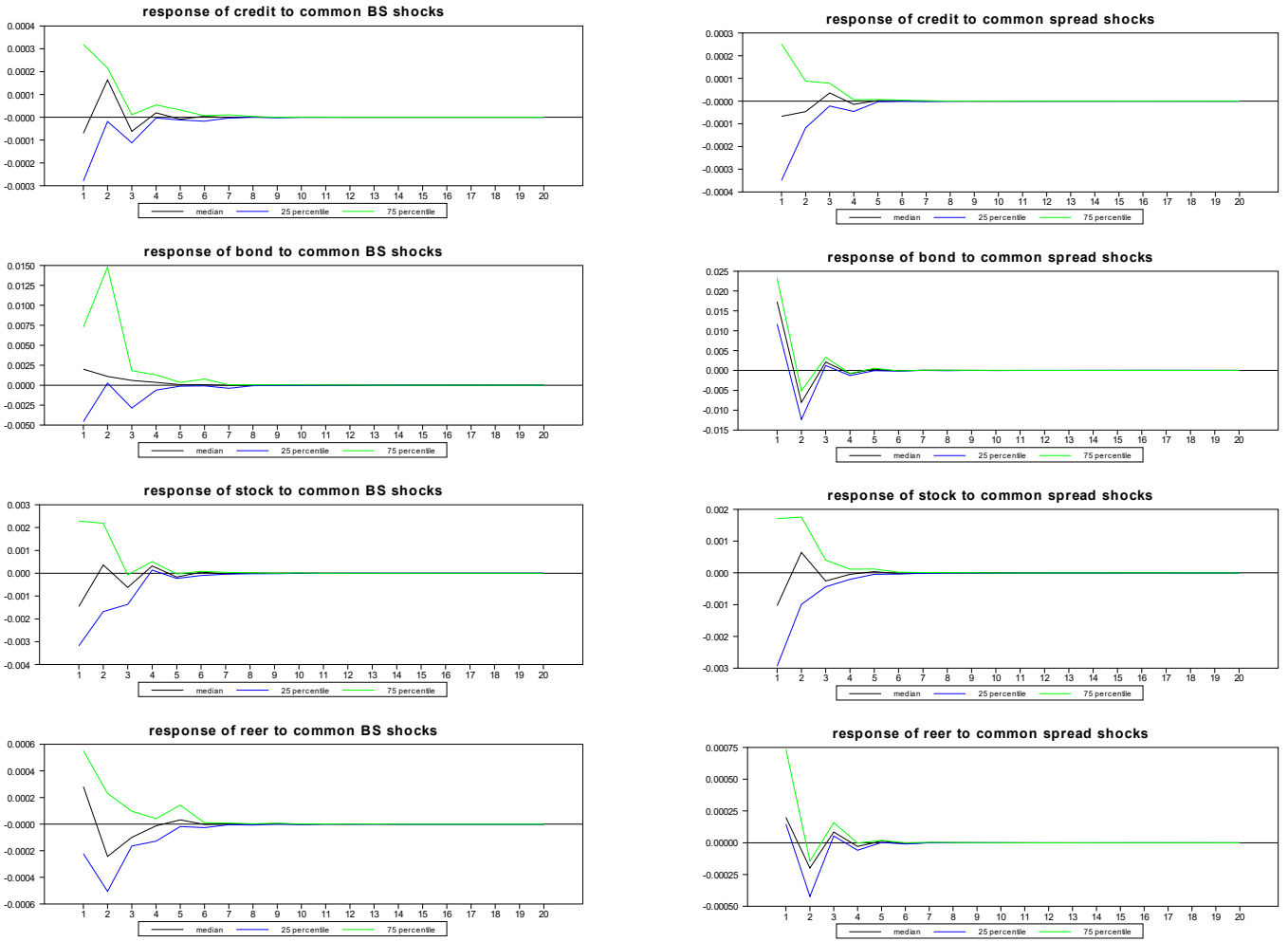
Note: We do not report the results of the variable of capital requirements because of its problem of multicollinearity. Instead, we add two aggregates measures, which are sum of the cumulative of the 9 instruments by country and time as proposed by Cerutti et al. (2016). The nine instruments include capital requirements, capital buffer (Real estate credit), capital buffer (Consumer credit), capital buffer (other sector), concentration limit, interbank exposure limit, loan-to-value ratio capital, foreign and local reserve requirements. See Cerutti et al. (2016) for more details.

Figure A1. IRFs **(**Macro block)



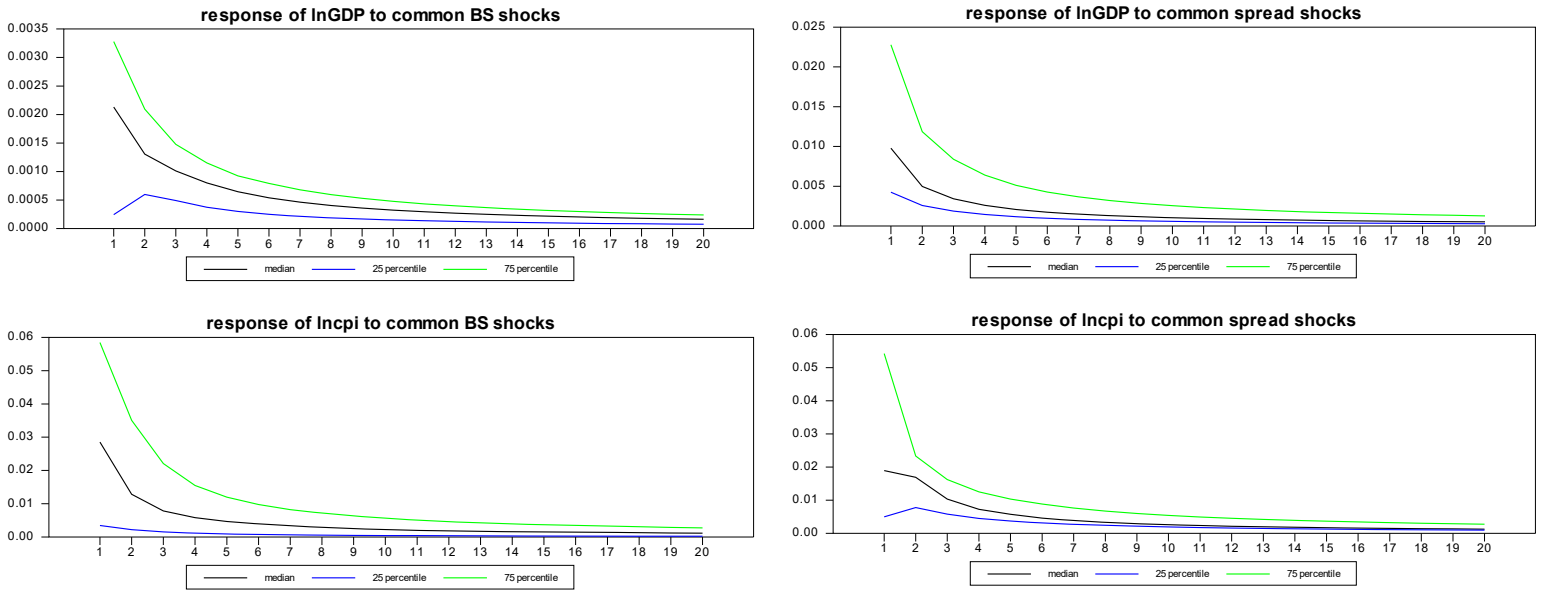
Notes: Estimates of the country-specific median impulse response functions for macro block, and the 25th and 75th percentiles as the error bands. The solid black, blue, and green lines report the median, 25th, and 75th percentile responses, respectively. The left axes are computed with a scale of 100 points. BS and spread represent the identified shocks under Identification I and II, respectively.

Figure A2. IRFs (Financial block)



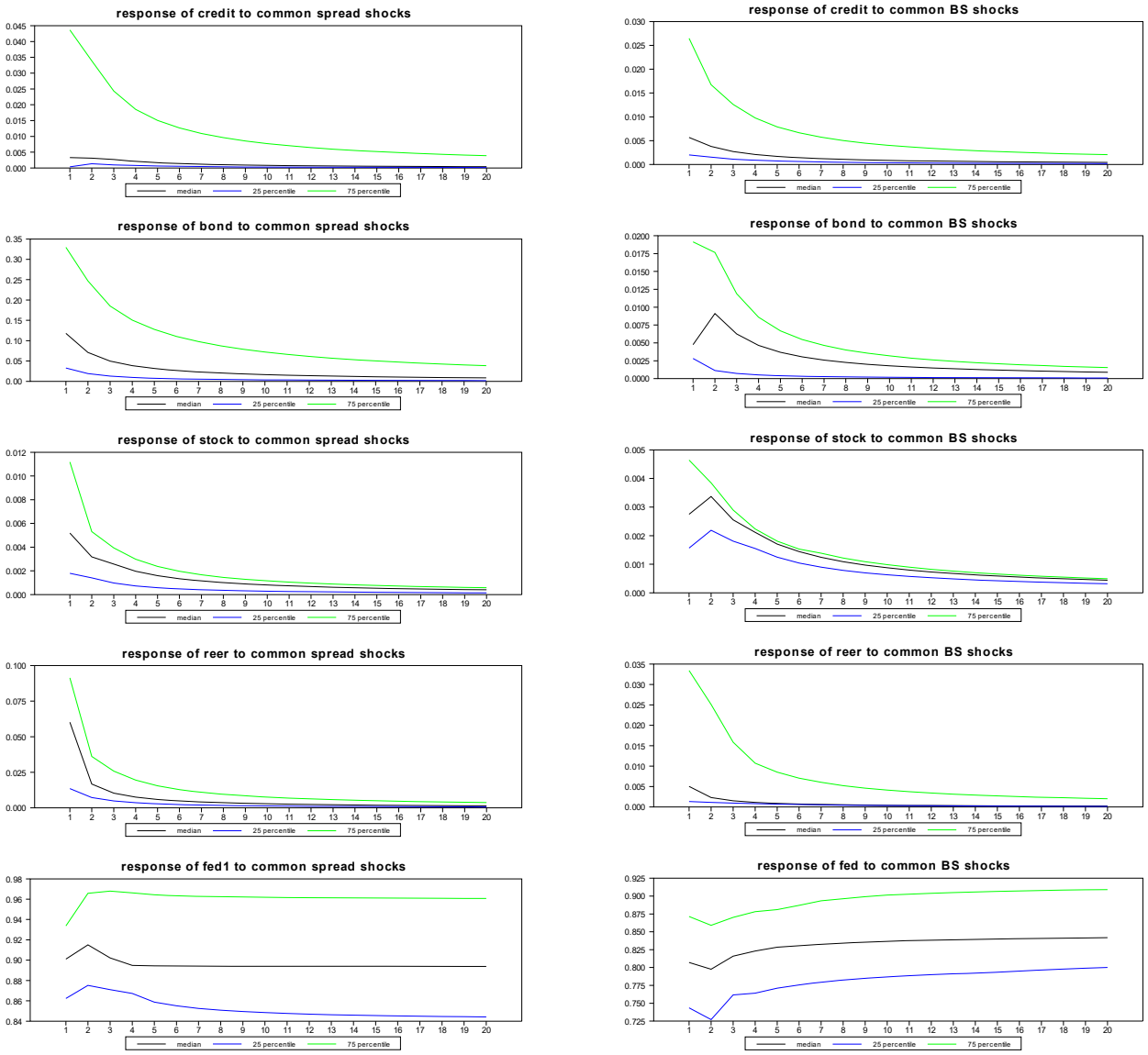
Notes: Estimates of the country-specific median impulse response functions for macro block, and the 25th and 75th percentiles as the error bands. The solid black, blue, and green lines report the median, 25th, and 75th percentile responses, respectively. The left axes are computed with a scale of 100 points. BS and spread represent the identified shocks under Identification I and II, respectively.

Figure A3. VDs (Macro block)



Notes: Estimates of the quantile variance decomposition for macro block, and the 25th and 75th quantiles as the error bands. The solid black, blue, and green lines report the median variance and the 25th and 75th quantile bands, respectively. BS and spread represent the identified shocks under Identification I and II, respectively.

Figure A4. VDs (Financial variables)



APPENDIX B. ROBUSTNESS ANALYSIS FOR PANEL SVAR

Figure B1. IRFs (Macro block with VIX)

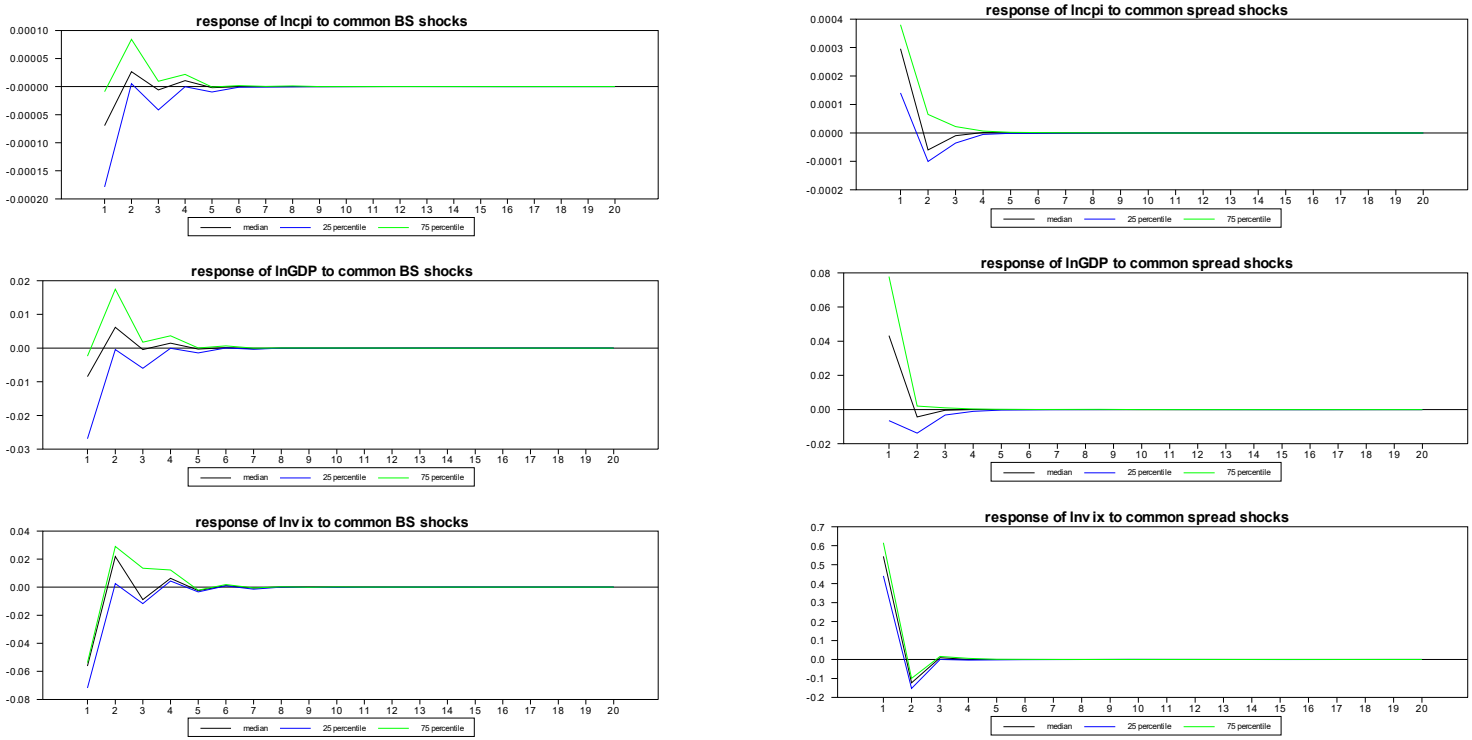
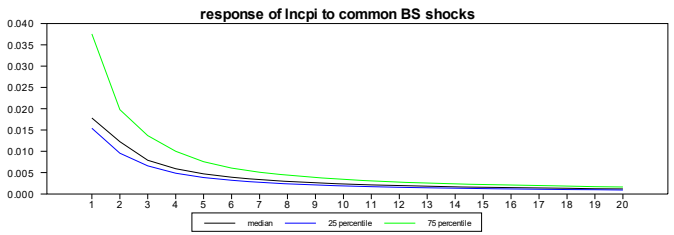
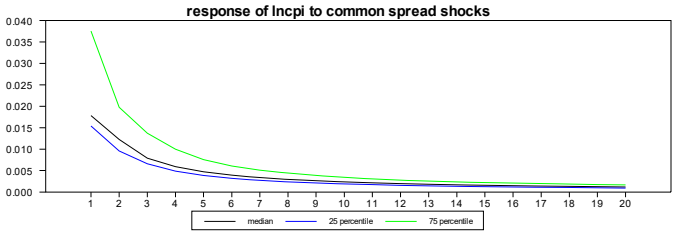
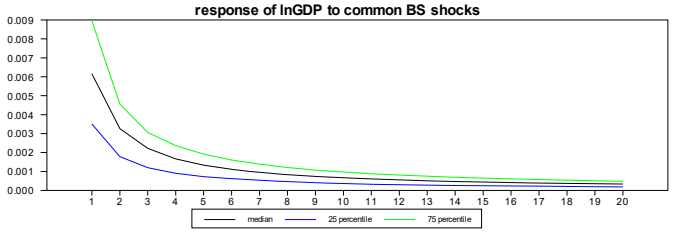
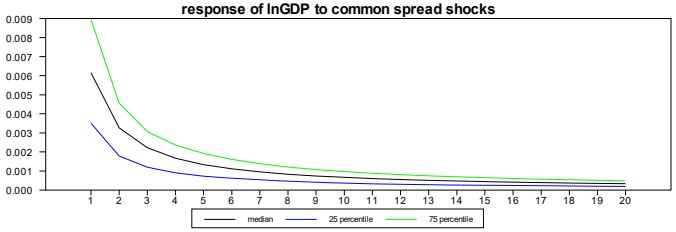


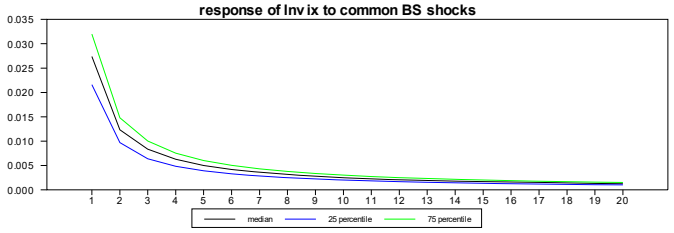
Figure B2. VDs (Macro block with VIX)











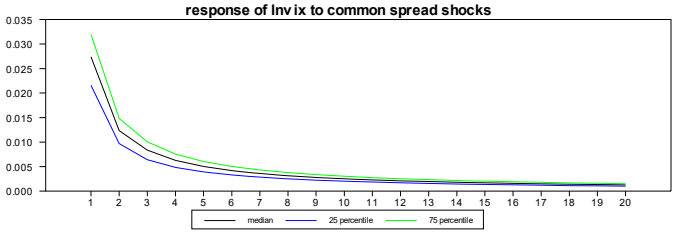
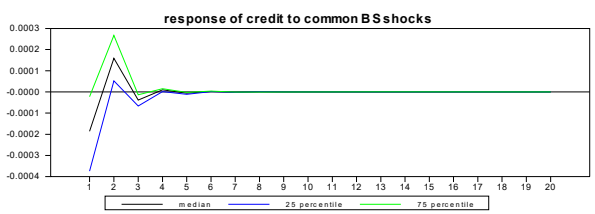
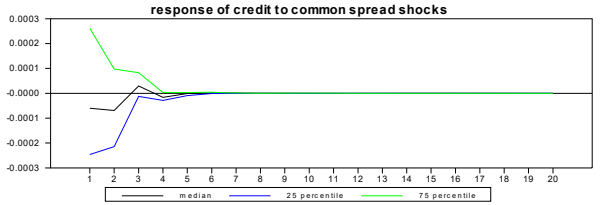
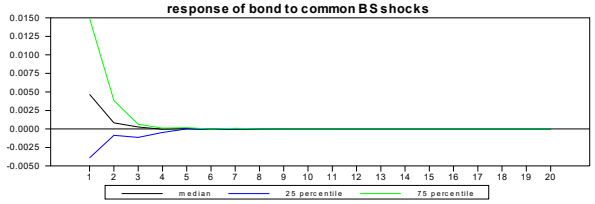
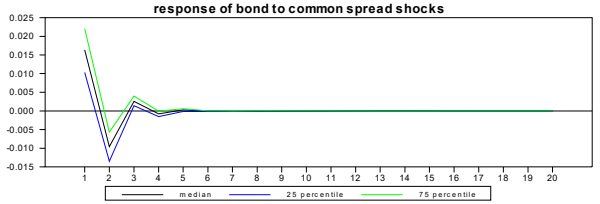


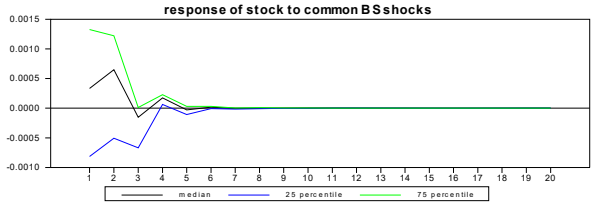
Figure B3. IRFs (Financial block with VIX)

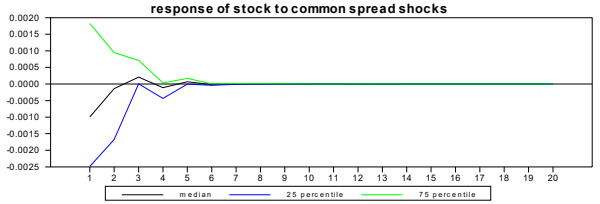


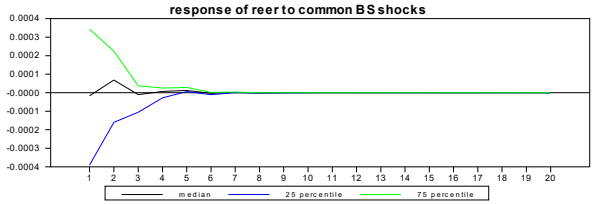


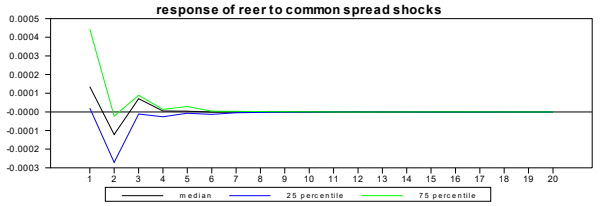


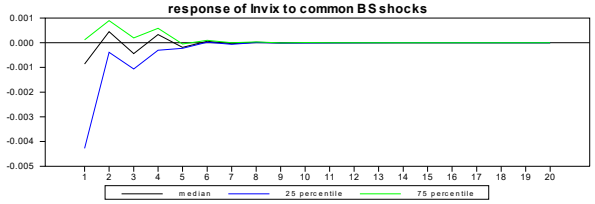












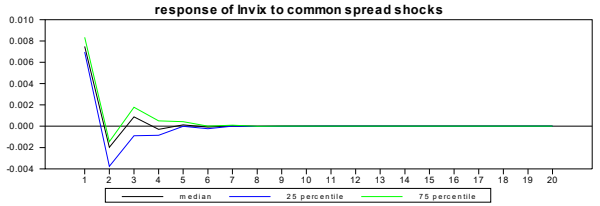
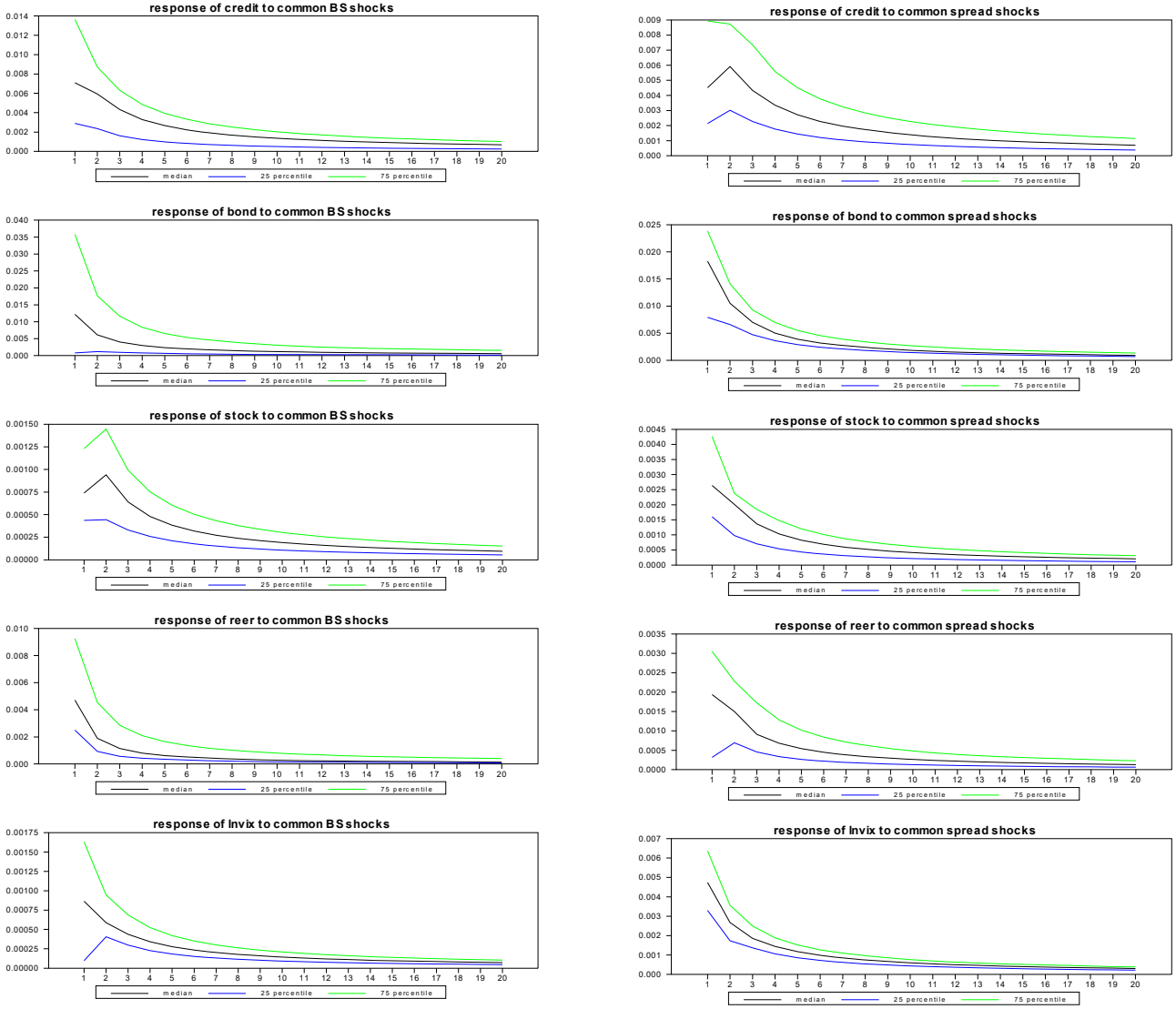


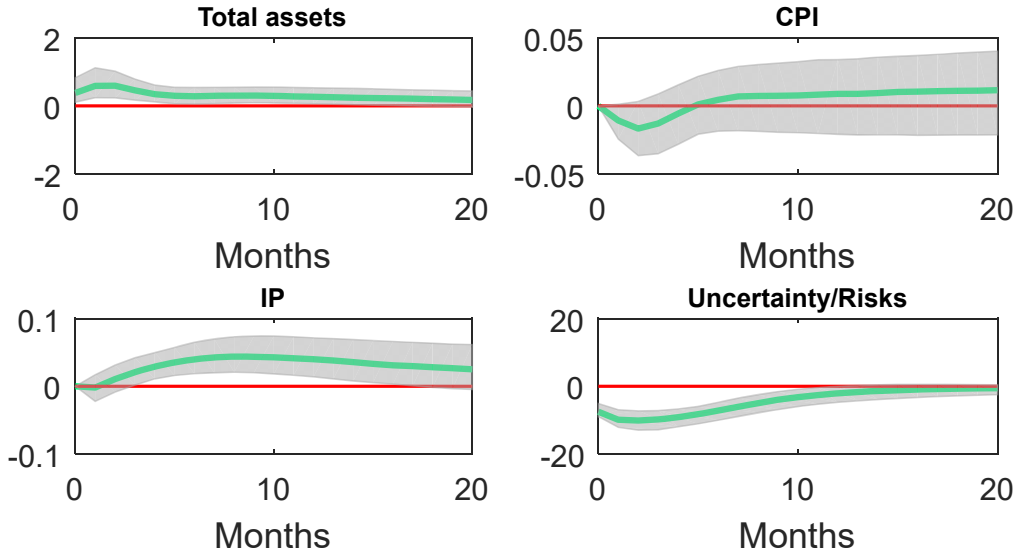
Figure B4. VDs (Financial Block with VIX)



APPENDIX C. ROBUSTNESS ANALYSIS FOR THE US SVAR

Figure C1. IRFs (using BBB-AAA corporate bond spread)

(a) Identification I



(b) Identification II

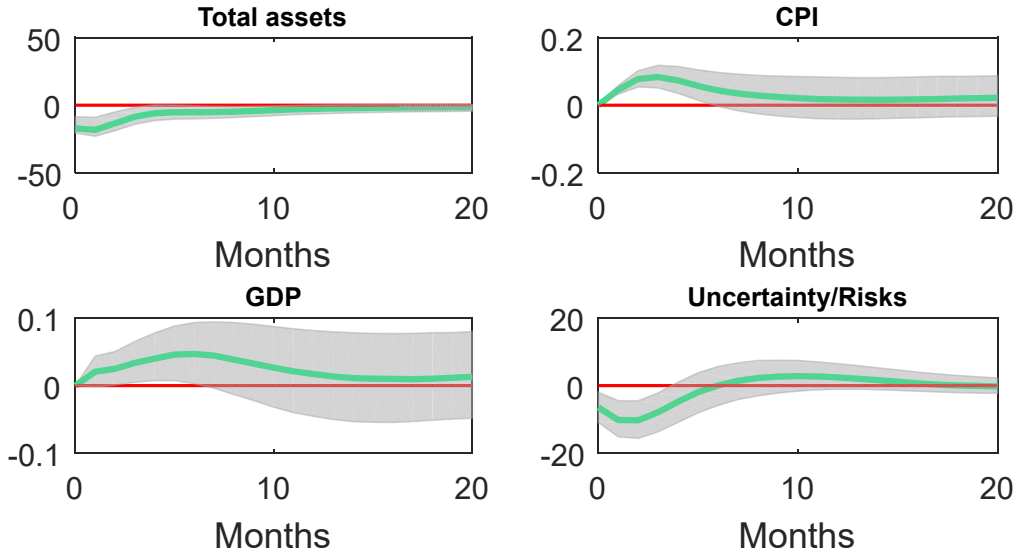
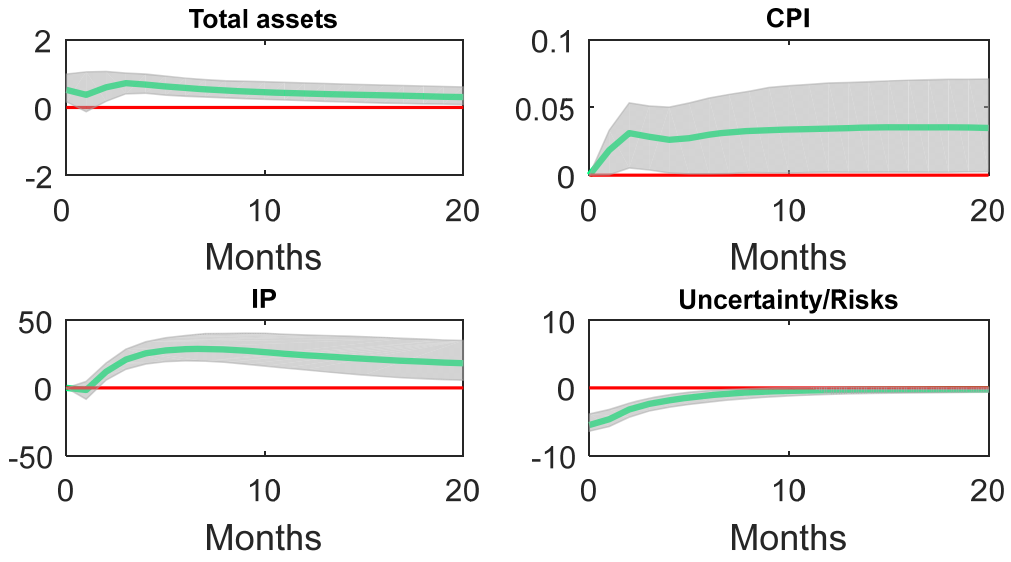


Figure C2. IRFs (using IP)

(a) Identification I



(b) Identification II

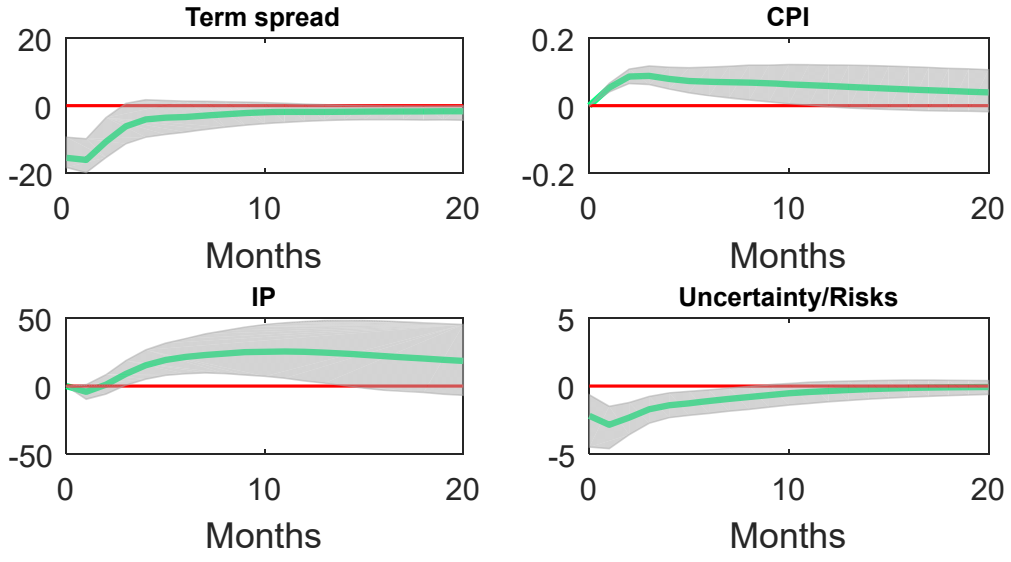
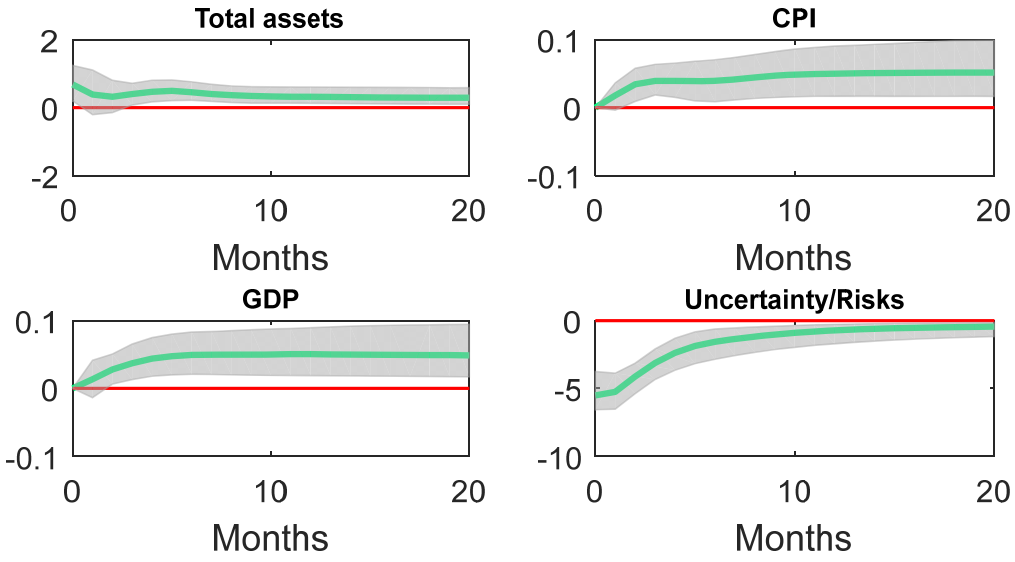


Figure C3. IRFs (using CPE)

(a) Identification I



(b) Identification II

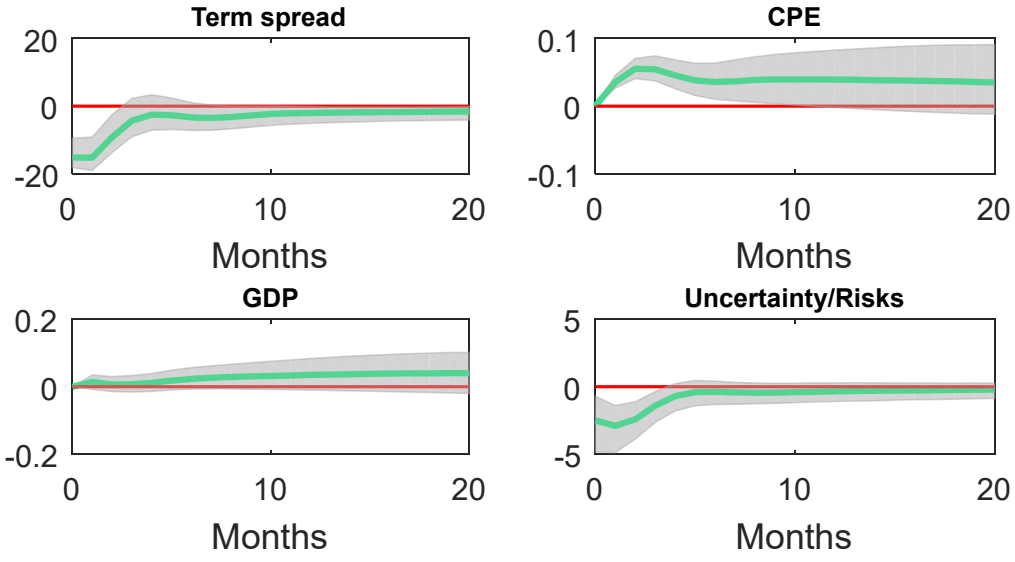
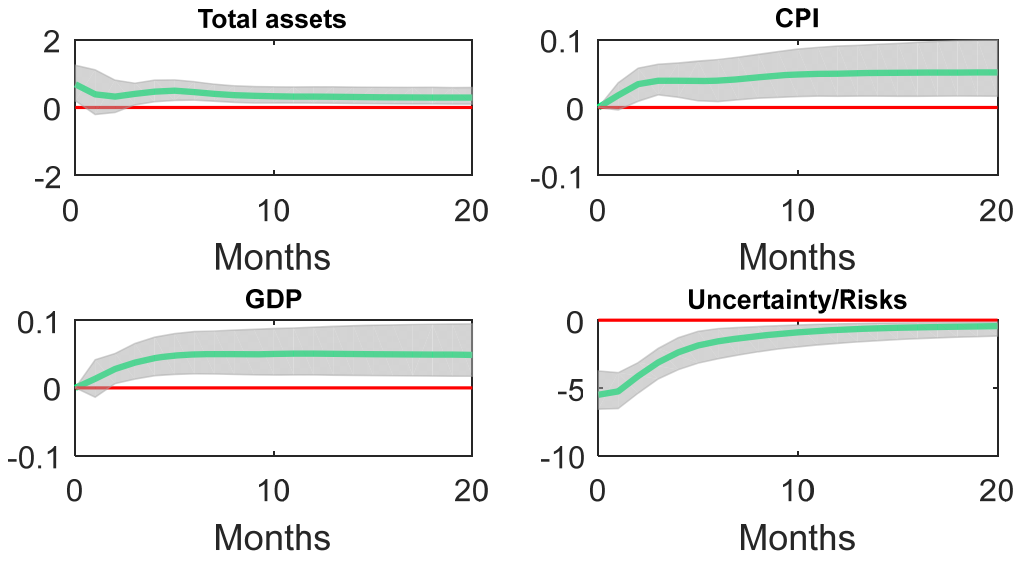


Figure C4. IRFs (using sample period ending in September 2013)

(a) Identification I



(b) Identification II