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Abstract

This paper evaluates the financial spillovers between the US and emerging market economies (EMEs) using the methodology advocated by Diebold and Yilmaz (2009). Based on (i) cross-asset returns of sovereign bond, equity, and foreign exchange, and (ii) 27 individual long-term sovereign bond yields, we consistently find that bond market spillovers between the US and EMEs have strengthened following the tapering tantrum in May 2013. This implies that a US monetary tightening would have potent spillovers on other economies, and especially on financial markets' performance outside the US particularly in EMEs. The repercussions from EMEs to US are also significant and would generate undue pressure on the US affecting subsequent policy actions. The two-way interactions between the US and EMEs can pose challenges for central banks in formulating policies independently.

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JEL classifications: C32, F34, G15, H63

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1. Introduction

The impact of US unconventional monetary policy (UMP) on emerging market economies (EMEs) is widely debated in policy circles and academic literature. When Chairman Bernanke announced in May 2013 that the US Fed would start an earlier than expected tapered end to UMP (the tapering tantrum), EMEs markets plummeted.[1] While the US is commonly regarded as a source of financial spillovers to EMEs, little research has been done on the reverse. The spillovers from EMEs to the US can, however, be large, given that (i) EMEs have played a major role in global financing flows after years of UMP adopted by major advanced economies (AEs); (ii) as EMEs have been net receivers of funds in recent years, their corporate leverage has risen to record levels;[2] and (iii) in terms of trade and financial linkages, EMEs have become more integrated into the global economy and financial system over the past decade.[3] Thus, any adverse change in fund flows or in EMEs' economic fundamentals could amplify shock transmission from EMEs to AEs and the rest of the world.

This paper studies financial spillovers between the US and EMEs and raises the following three questions: (i) which asset markets are affected the most by shocks originating in the US and EMEs? (ii) to what extent can spillovers be attributed to a specific market and region of economies? (iii) has the nature of spillovers changed since the tapering tantrum? The answers to these questions could potentially provide useful guidance for policymakers in monitoring contagion effects across markets and economies.

We first give an overall picture of spillovers by investigating how spillovers within and between the US

[1] Aizenman et al. (2014) and Chen et al. (2016) provide empirical evidences on the spillovers of the US UMPs to EMEs during the tapering tantrum.
[2] The IMF (2015) reported that the listed firms' leverage, defined as the ratio of total liabilities to total equity, has risen notably in emerging Asia, the emerging Europe, Middle East, and Africa (EMEA) region and Latin America during years between 2007 and 2013.
[3] The IMF (2016) commented that EMEs have contributed more than half of global growth over the past 15 years, and their share in global GDP has risen to 38 percent, and trade between advanced and EMEs are now exceeding trade between advanced economies. Meanwhile, advanced economy banks doubled their exposure to emerging market economies, and bond flows to emerging market economies strengthened continuously.

and EMEs have changed over time. Specifically, we consider three asset classes in the analysis, which include (i) stocks; (ii) sovereign bonds; and (iii) the US dollar (USD).[4] We find that the impact of sovereign bond market shocks, regardless of whether the shocks originate in the US or EMEs, on other financial markets has increased considerably following the tapering tantrum.[5]

Given the growing importance of bond market shocks, the analysis in the second part of this paper takes a closer look at 19 EMEs sovereign bond markets to identify key economies that are most contagious with regard to the US and most responsive to the US. We also include several major advanced economies' sovereign bond yields in the analysis to take into account global market conditions considered by the FOMC in deciding US monetary policy. Our results consistently show a considerable increase in bond-market spillovers between the US and EMEs in recent years. Contributions of spillovers are more from economies in Emerging Europe and Africa, compared to Latin America and Asia. Such an increase in bond-market spillovers from EMEs to the US is likely due to investors' search for yields amid an uncertain global economic outlook, and the insufficiency of safe assets globally.

We use the methodology developed by Diebold and Yilmaz (2009, 2012) to measure the strength and direction of financial linkages between economies. The method extracts a spillover measure from a generalised forecast error variance decomposition (GFVD) of an underlying vector autoregressive model (VAR). This methodology explicitly tracks spillovers for all endogenous variables, from pairwise to system-wide, in a coherent and mutually consistent way. This is in contrast to conventional spillover measures derived from correlation and covariance models that can only measure pairwise association among the variables of interest. Given this desirable feature, the method is widely applied in many

[4] The three markets are chosen because sovereign bond and stock markets are by far the most important asset classes for risk diversification both from practical and theoretical perspectives, and USD is a well-known safe-haven in times of crisis. These markets are therefore expected to link up together closely by common information flows and cross-market hedging activities.

[5] From a shorter-term perspective (based on daily information and a rolling window of one-year), IMF (2016) finds that the spillovers between sovereign bond markets of the AEs (including the US) and EMEs are not significant, while those between equity markets and between foreign exchange markets are significant.

empirical studies in the context of contagion (for example, Alter and Beyer (2014), Claeys and Vasicek (2014), Apostolaskis and Papadopoulos (2014), Louzis (2015), Liow (2015)).[6] However, this approach is limited in that it does not examine the cause of the spillovers, it only provides a ranking of the shocks based on the historical patterns of variables in the VAR.

The rest of the paper is organised as follows. Section 2 provides a brief outline of the VAR and GFVD. Section 3 discusses the data. The first part of Section 4 assesses the spillovers among the three asset classes in the US and EMEs. The second part of Section 4 discusses spillovers in the global sovereign bond markets. Section 5 provides various robustness checks for the assumptions of the VAR. The last section concludes.

2. Econometric methodology

The workhorse model underlying the Diebold and Yilmaz (2009, 2012) methodology is a VAR with GFVD. As suggested by Koop et al. (1996) and Pesaran and Shin (1988), the variance decomposition (VD) of VARs using GFVD is invariant to the variable ordering, as opposed to the traditionally used Choleski decomposition.

Specifically, we consider the following *P*-order VAR model:

$$x_t = \sum_{i=1}^{p} \Theta_i x_{t-1} + \Phi w_t + \varepsilon_t \tag{1}$$

where $x_t = (x_{1t}, \dots, x_{Nt})$ is a $N \times 1$ vector of endogenous variables, w_t is a $M \times 1$ vector of exogenous variables, $\Theta_i, i = 1,2, \dots p$ and Φ are $N \times N$ and $N \times M$ coefficient matrices and $\varepsilon_t \sim (0, \Sigma)$

[6] The method has been used to assess sovereign credit markets and banks in Euro area (Alter and Beyer (2014)); European sovereign bond markets (Claeys and Vasicek (2014)); advanced economies' stress spillover (Apostolaskis and Papadopoulos (2014)); Euro area financial markets (Louzis (2015)); G7 countries' various asset classes (Liow (2015)).

is a vector of independently and identically distributed disturbances. Assuming Eq. (1) is covariance-stationary, we can rewrite its moving average representation as:

$$x_t = \sum_{i=0}^{\infty} A_i\, \varepsilon_{t-i} + \sum_{i=0}^{\infty} Q_i\, w_{t-i} \tag{2}$$

where A_i are derived by the recursion $A_i = \Theta_1 A_{i-1} + \cdots + \Theta_p A_{i-p}$ with A_0 being an $N \times N$ identity matrix with $A_i < 0$ for $i < 0$, and $Q_i = A_i\Phi$. The *H*-step-ahead GFVD is then given by:

$$\theta_{ij}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} \left(e_i' A_h \Sigma e_j\right)^2}{\sum_{h=0}^{H-1} \left(e_i' A_h \Sigma A_h' e_i\right)} \tag{3}$$

where σ_{jj} is the standard deviation of the error term for the j^{th} equation and e_i is a selection vector, with one as the i^{th} element and zeros otherwise. When considering $i \neq j$ (for $i, j = 1, \ldots, N$), this GFVD is regarded as the "cross variance shares" that measures the fractions of the *H*-step-ahead error variances in forecasting x_{it} due to shocks originated from x_{jt}. It is also interpreted as the "spillovers" which measures the extent that the shocks originated from x_{jt} transmit to x_{it}. When considering $i = j$, the GFVD in Eq. (3) is regarded as the "own variance shares" which is the fractions of the *H*-step-ahead error variances in forecasting x_{it} due to shocks originated from itself.

Each entry of the variance decomposition matrix $\theta_{ij}(H)$ (for $i, j = 1, \ldots, N$) is normalised by the row sum to yield:

$$\tilde{\theta}_{ij}(H) = \frac{\theta_{ij}(H)}{\sum_{i=1}^{N} \theta_{ij}(H)} \tag{4}$$

and by construction, $\sum_{j=1}^{N} \tilde{\theta}_{ij}(H) = 1$ and $\sum_{i,j=1}^{N} \tilde{\theta}_{ij}(H) = N$. This normalisation allow us to decompose the forecast error variance of the return of an asset *i* into the percentage of its own shock $\tilde{\theta}_{ii}$ and the percentages of shocks from other economies $\tilde{\theta}_{ij}$ (for $i, j = 1, \ldots, N, i \neq j$), which facilitates easier identification of key shock origins and easier comparison among these shocks.

Using the normalised variance decomposition matrix, we can construct the total spillover index to capture the cross-asset or cross-market spillovers, which is defined as:

$$S(H) = \frac{\sum_{i,j=1,i\neq j}^{N} \tilde{\theta}_{ij}(H)}{N}. \tag{5}$$

In other words, it is an average of all the normalised variance decompositions in the off-diagonal matrix that represents the average spillovers across all asset classes.

The estimated spillover effect above is static in nature. In this study, we conduct a rolling window analysis to assess the extent and nature of spillover variation over time. This approach is proved to be useful to depict potentially important secular and cyclical movements of spillovers in Diebold and Yilmaz (2009, 2012) and the subsequent studies.

3. Data

In the first part of analysis, we obtain the EMEs' sovereign bond index from JP Morgan Chase and all other data from Bloomberg. The equity market data for the US and EMEs refer to the Standard & Poor's 500 Index and the MSCI Emerging Markets Index respectively.[7] For sovereign bond data for the US and EMEs, we use the 7 to 10 year US Treasury Index and the GBI-EM Broad 7 - 10 Years Index respectively.[8] It is noteworthy that both bond indexes are denominated in local currencies and

[7] The MSCI Emerging Markets Index captures large and mid cap representation across 23 EMEs. With 836 constituents, the index covers approximately 85% of the free float-adjusted market capitalization in each country. The included EMEs are Brazil, Chile, China, Colombia, Czech Republic, Egypt, Greece, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Peru, Philippines, Poland, Russia, Qatar, South Africa, Taiwan, Thailand, Turkey and United Arab Emirates.

[8] The JP Morgan GBI-EM Broad Index includes 18 EMEs consisting of Brazil, Chile, China, Colombia, Hungary, India, Indonesia, Malaysia, Mexico, Nigeria, Peru, Philippines, Poland, Romania, Russia, South Africa, Thailand, and Turkey.

include the reinvestment of coupon interests as well as the capital gain (i.e., total return index). Finally, we use the DXY index to measure the movement of the USD against other major currencies.[9]

In the second part of our analysis, we obtain zero-coupon 10-year sovereign bond yields for individual economies from Bloomberg. To make the assessment more comprehensive, we include seven AEs that have a sovereign bond market worth more than one trillion USD as at June 2015. The selection criteria of EMEs are based on the availability of long-term yields and some criteria commonly used in previous studies.[10] The list of 27 economies (8 AEs and 19 EMEs) and their bond market size are presented in Figure 1. It is worth notating that the total bond market size of AEs (panel A) is five times more than that of EMEs (panel B).

In each VAR specification, two exogenous variables are used to control for the effect of global factors that could affect the financial markets in both US and EMEs simultaneously. They are (i) the Chicago Board Options Exchange Standard & Poor's 500 Implied Volatility Index (VIX) which proxies for the global risk appetite,[11] and (ii) the 10-year US Treasury term premium estimated by the Federal Bank of New York which proxies for the effect of UMP adopted by the US Fed.[12] In addition, we also include the DXY index as the third exogenous variable in the second part to control for the effect of the USD appreciation.

Instead of daily information, in this study, we use weekly returns to address the different time-zones problem given that the selected economies locate in different continents, and to minimise estimation distortion by capturing too much irrelevant fluctuations.[13] The samples cover periods from January

[9] The DXY index measures the value of USD against other major currencies including the Euro, Japanese yen, British pound, Canadian dollar, Swiss franc and Swedish krone.

[10] The selected EME has to satisfy either one of the following three criteria. (1) A member of either the IMF's emerging or developing economies or World Bank's low and middle-income countries; (2) Constituents of Barclays, JP Morgan, Markit or Merrill Lynch emerging-market government bond indices; and (3) Stock of public debt exceeding USD 10 billion or long-term sovereign credit rating above BB/Ba.

[11] Forbes and Warnock (2012) argue VIX goes a long way in explaining the direction and movement of capital flows globally. Recent studies such as Bruno and Shin (2015) and Rey (2015) further argue VIX can be used to proxy for global liquidity conditions, with a declining VIX representing abundant global liquidity, and vice versa.

[12] As Bernanke (2013) argues, UMPs aim to lower the term premium and ease the boarder financial conditions. More details of the methodology for calculating the term premium can be found in Adrian et al. (2013).

[13] We use the Friday closing prices in the estimation.

2002 to February 2015 in the first part of the empirical analysis and from April 2007 to February 2016 in the second part.[14]

We estimate Eq. (1) with an AR order 1 and report a 10-week-ahead GFVD in the analysis. A rolling window of 200-week is considered in the analysis to assess how spillovers evolve over time. The window size is chosen because it represents a forecasting horizon over the medium-to-longer term that is relevant for making longer-term monetary policy decisions. Robustness checks for the different AR orders and the sizes of the rolling window are provided in Section 5.[15]

4. Empirical Results

4.1. Cross-asset analysis

In this section, we examine the spillover effect using the two sovereign bond indices, two equity indices, and the DXY index as the endogenous variables in the VAR specification.

Figure 2A plots the overall spillover index specified in Eq. (5), which measures the total spillovers across the three asset classes and between the US and EMEs. The index fluctuates largely between 17% and 29% throughout the sample period, suggesting a considerable level of overall cross-asset spillovers. It surges apparently in May 2013 before it sustains at a higher level, reflecting a stronger spillover effect amid concerns that the Fed would taper its asset purchases.

Figures 2B and 2C depict the VDs of the US Treasury market and stock market respectively. In the US Treasury market (Figure 2B), 30% of the VD can be explained by the four cross-asset shocks in

[14] Individual sovereign bond data of some EMEs is not available prior to 2007. A balanced panel of individual bond yields is required for consistent comparison across different time periods.
[15] Estimation results remain almost the same when the forecasting horizon is more than 10 weeks, suggesting that our GFVD figures have already converged.

end-2015,[16] in which 15% of the VD is explained by EMEs bond shocks. Since May 2013, EME bond shocks have a considerable increase in contribution to the VD of US Treasury bond, which leapfrogs DXY shocks into the largest contributor among the four shocks. In the US stock market (Figure 2C), the contribution of EME equity shocks is the largest among the four cross-asset shocks during the past 10 years, while the total contribution of other shocks has remained limited at around 5%. These results suggest that EMEs' shocks can impact the US financial markets, particularly through sovereign bond markets after the tapering tantrum.

Figures 2D and 2E depict the VD of the EMEs' sovereign bond and stock markets respectively. Focusing on EMEs bond markets (Figure 2D), around 30% of the VD can be explained by the four cross-asset shocks in end-2015. US bond shocks have been the largest contributor among these shocks since late 2008. Its contribution, together with that of EME equity shocks, has increased substantially since May 2013.[17] For the EMEs stock markets (Figure 2E), both contributions of US and EMEs bond shocks have risen significantly since May 2013, while those of US equity and DXY shocks have plummeted since 2012 although they used to be the most pronounced contributors in the past. These results suggest that EMEs' financial markets have been more prone to the spillovers from sovereign bond markets after the episode of tapering tantrum.

For the VD of the DXY index (Figure 2F), US bond shocks are becoming more significant. In contrast, the contributions from EMEs remain relatively limited. While the share of EMEs bond shocks has increased since 2011, these are offset by a rapid decline in EMEs equity shocks.

In sum, our empirical results show that, spillovers between sovereign bond markets of the US and EMEs have escalated tangibly after the tapering tantrum. For other cross-asset spillovers, the effect is

[16] The remaining 70% is explained by the US Treasury's own variance. Since it is not the focus of our analysis, it is omitted in the discussion.
[17] The contribution of EMEs equity shocks has also shown a pick-up since May 2013, with an increase from 5% to 15% during the past 3 years.

usually limited to one-way with most of them being marginal.

4.2 A closer look into the global sovereign bond market

This section focuses on bond market spillovers using individual sovereign bond yields to identify which EMEs are more systemically important. The analysis is based on 27 bond yields as the endogenous variables. For ease of discussion, we classify the 19 EMEs into three groups: (i) Emerging Europe and South Africa, (ii) South Amercia, and (iii) Asia.[18]

Figures 3A and 3B depict US-EMEs and US-AEs bond-market spillovers respectively. As shown in Figure 3A, the VD of US Treasury bond yields explained by EME shocks (EME shocks on US) and that of EME sovereign bond yields explained by US shocks (US shocks on EMEs) have increased considerably after the tapering tantrum in May 2013. Although US shocks on EMEs always contribute a larger spillover effect than the other way round, the contribution of EME shocks on US has almost doubled over the last two years. In comparison, the contributions of AE shocks on US and the other way round, as shown in Figure 3B, are relatively steady, with symmetrical fluctuation around 40% throughout the sample period. These results reflect that, while the shocks from the US Treasury bond market remains more influential in the EME sovereign bond markets, the reverse spillover effect cannot be negligible.

To shed light on which EMEs contribute to the escalating spillover effect to the US, Figure 3C provides a regional breakdown of the VD of the US Treasury bond yield (i.e. the blue line of EME shocks on US in Figure 3A). As can be seen, emerging Europe and Africa have picked up substantially in share since mid-2013 and have become the largest contributors among the three groups. Meanwhile, Asia's share,

[18] In constructing other economies impact on the US, we first note that there are 26 shocks from other economies in the VD of the US Treasury. We can then classify the shares of AEs and EMES on the US by summing the relevant individual component. The regional classification of EMEs is done in a similar fashion. In constructing the US impact on others, we need to extract the US shocks appearing in each of the 26 variance decompositions of other economies and group them accordingly.

which explains most of the VD of US Treasury bond yield among the three EME groups before mid-2012, falls and steadies at a level of 10% in the last four years. At end-2015, each individual country member of the Emerging Europe and Africa accounts for an average of 2.3% (or 14% in total) in the VD of US Treasury. Similarly, an economy in Latin America and an economy in Asia each accounts for an average of 1.8% (or 9% in total) and 1.4% (or 11% in total) in the VD of US Treasury respectively.

To evaluate the responsiveness of EMEs to US shocks, Figure 3D provides a regional breakdown of the VD of EME sovereign bonds (i.e. the red line of US shocks on EMEs in Figure 3A). Recently, there is a growing importance of US shocks on Emerging Europe and Africa, with the shock contributing an average of 2.8% (or 17% in total) to the VD of these EMEs in end-2015. Meanwhile, US shocks also have a significant impact on the other two EMEs groups, with an average impact of 2.5% (or 20% in total) and 2.2% (or 11% in total) on the VD of Asian and Latin American bond markets respectively.

The fact that sovereign bond yields in the US and EMEs have increasingly synchronized can be attributed to the following two reasons. First, as policy rates remain low in many economies, search for yield behaviour has manifested into a yield compression globally as long-term sovereign bonds offer an attractive risk-adjusted returns against an uncertain global economic outlook. Second, banks and insurers are now required to hold more safe assets such as government securities because of the more stringent liquidity ratios specified in Basel III and Solvency II. Moreover, recent studies argue that there is a shortage of safe assets globally (Caballero (2010), Gourinchas and Jeanne (2012)). The combination of these push and pull factors has further compressed sovereign bond yields and translated into a seemingly higher connectedness between the US and EMEs.

5. Robustness checks

We conduct two robustness checks for the VAR considered in section 5.1 and 5.2 to ensure that our spillover indices are not sensitive to (i) the AR-order of the VAR model and (ii) the size of rolling window. First, we re-estimate the spillover indices using three lag lengths from VAR(1) to VAR(3). A higher AR-order is not used since the number of estimated parameters will increase significantly (especially in the individual bond yield VAR), thus reducing the degrees of freedom in the estimation of a rolling window constructed from limited observations of weekly data. Second, we re-estimate the VAR by increasing the size of the rolling window from 150 weeks to 250 weeks, with a 50-week increment. These window sizes, ranging from 3 to 5 years, are selected since they represent a forecasting horizon over the medium-to-longer term and are commonly used in previous studies using weekly data. For presentation purposes, we only report robustness checks for the overall spillover index of the cross-asset VAR in Figure 1A and bond market spillovers between the US and EMEs in Figure 3A.[19]

Figures 4A and 4B report the spillover index of the cross-asset VAR under different lag lengths and rolling windows. As can be seen, compared to the benchmark VAR(1) model, the overall spillover indices rise by no more than 5% in general, with some exceptions around extreme changes in the benchmark index. Thus, our results appear to be largely robust when a higher AR order is applied in the VAR specifications.

Figure 5 and 6 report robustness checks for the impact of EMEs shocks on the US and US shocks on EMEs respectively. Regardless of the AR order and the size of the rolling window used in the estimation of the spillovers from EMEs to US, or the other way round, the upward trend appears to remain apparent following the tapering tantrum. This suggests that our results on individual bond yields are robust to VAR specification and window size.

[19] The plots for other variables of interest are available upon request.

6. Conclusion

This paper evaluates the financial spillovers between the US and EMEs using the methodology developed by Diebold and Yilmaz (2009, 2012). We find that, compared to all cross-asset classes, sovereign bond market spillovers between the US and EMEs have strengthened noticeably following the tapering tantrum in May 2013. Among all the selected EMEs, Emerging Europe and Africa are found to be more contagious with regard to the US and more responsive to the US market shocks. This analysis is important from a monetary policy perspective. On the one hand, the exit from the zero lower bound in the US may have potent spillovers on EMEs. On the other hand, any monetary policy shocks originated from other economies, particularly in EMEs, can generate undue pressure on the US and affect its subsequent policy decisions. This two way interactions between the US and EMEs can pose challenges for central banks in formulating policies independently.

There are two important caveats in this study. One caveat is that the empirical analysis provides an overview of financial spillovers over the past decade only. It is mainly due to data scarcity of some important EMEs and the restriction that a balanced panel of sovereign bond yields is required for a consistent comparison of EMEs contributions across different time periods. Thus, any information that covers a longer history may be useful for contrasting the current spillover effect with those seen in the pre-crisis period. Another caveat to the Diebold and Yilmaz (2009, 2012) methodology is the absence of a structural interpretation of the spillovers. The fact that world asset markets have seemingly become more interrelated could be very much due to the global financial cycle hypothesis put forward by Bruno and Shin (2015) and Rey (2015). Understanding the transmission mechanism of bond-market spillovers is left for future research.

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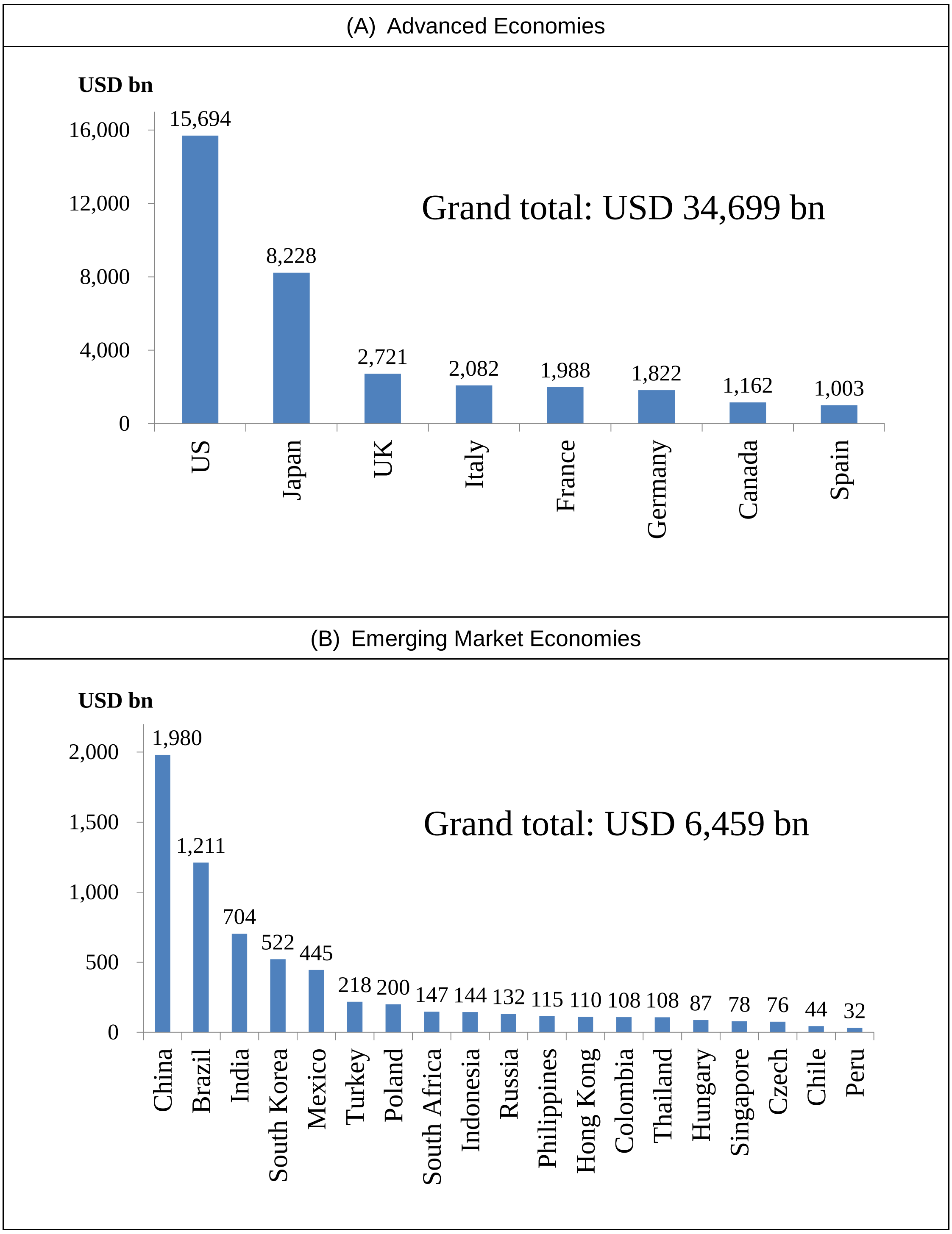
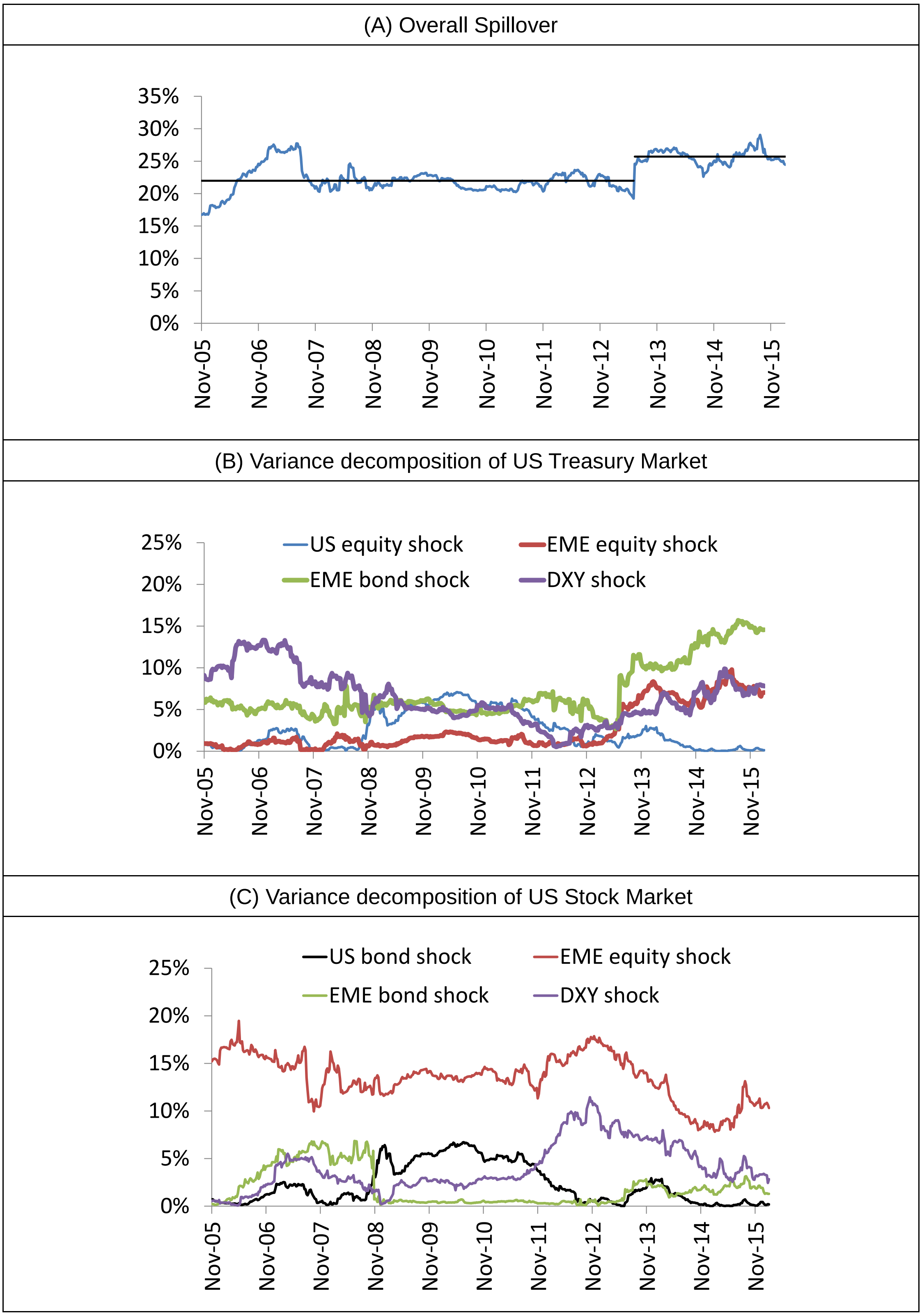
Figure 1 Size of the sovereign bond market for economies as of Jun 2015

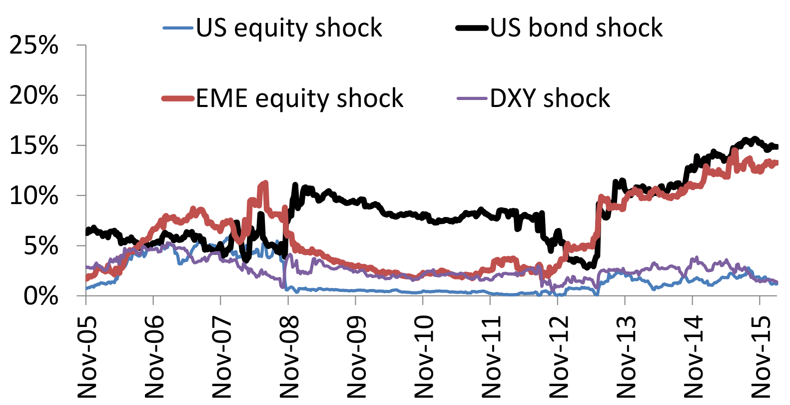


Source: Bank for International Settlements

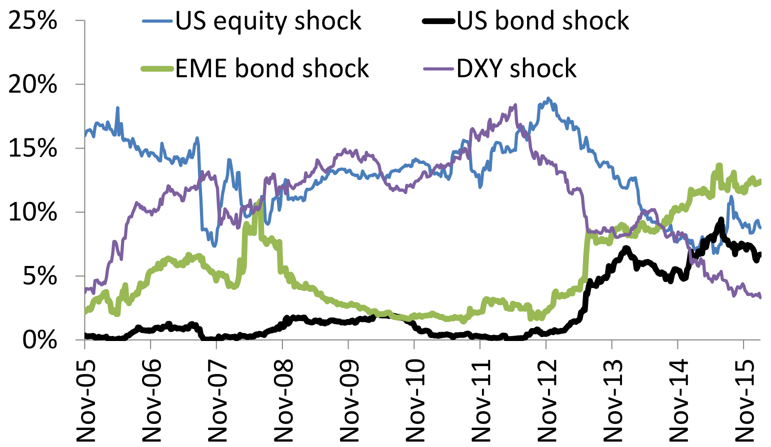
Figure 2 Cross-asset VAR result



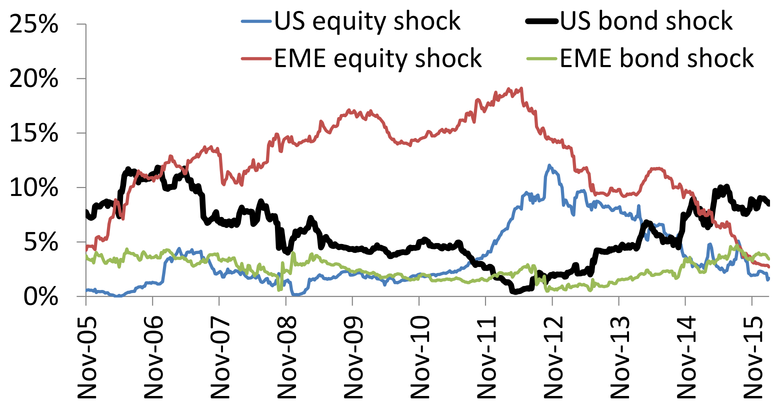
(D) Variance decomposition of EMEs sovereign bond markets



(E) Variance decomposition of EME stock markets



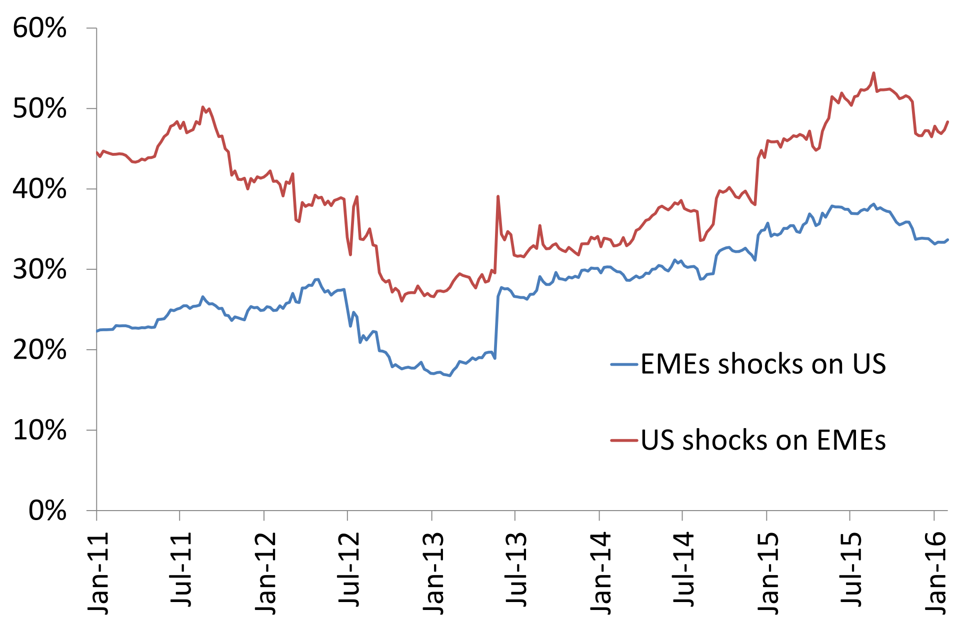
(F) Variance decomposition of the DXY Index



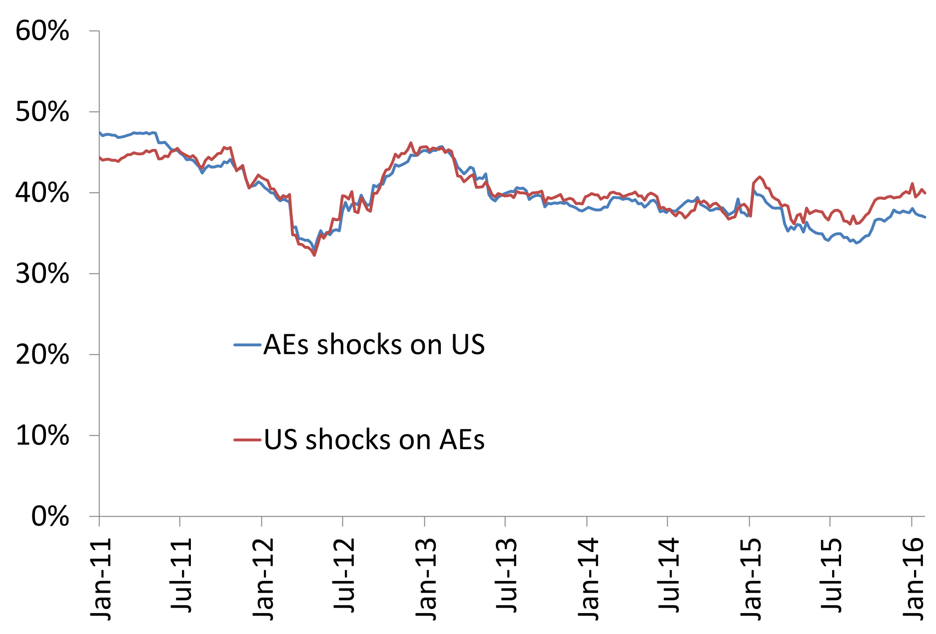
Note: The spillover index in panel A is calculated according to Eq. (5). Panels B to F shows the generalised forecast error variance decomposition for each of the variables in the VAR. The response to the own market shock is not included and can be determined from residuals by subtracting the sum of the four shocks from 100% in Panels B to F.

Figure 3 Individual bond yield VAR result

(A) Bond market spillovers between the US and EMEs

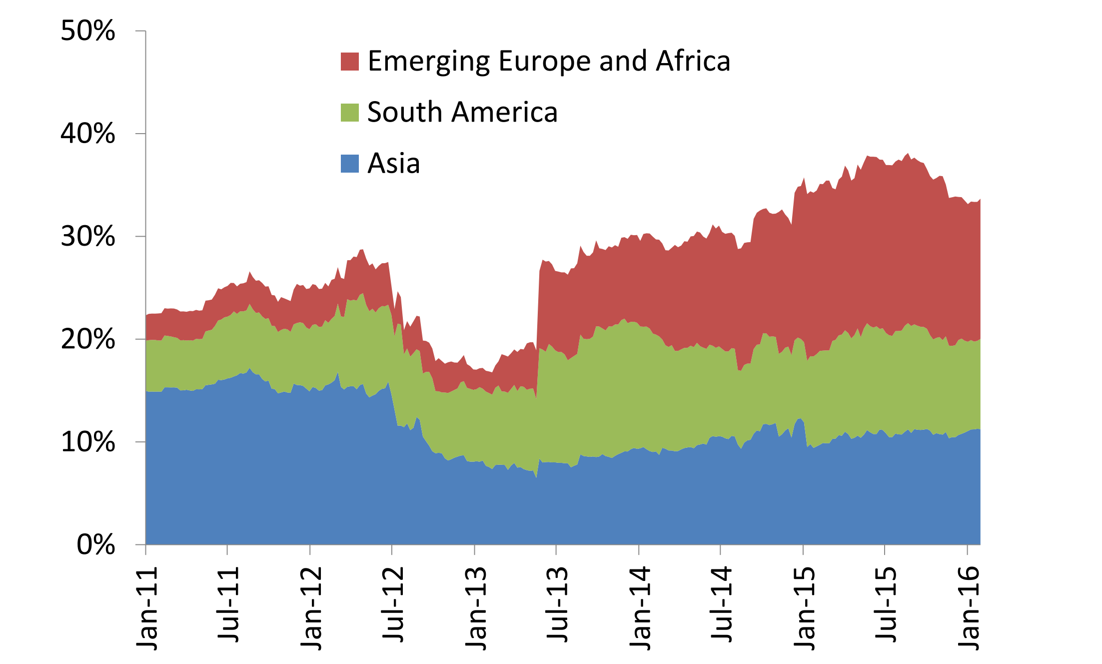


(B) Bond market spillovers between the US and AEs

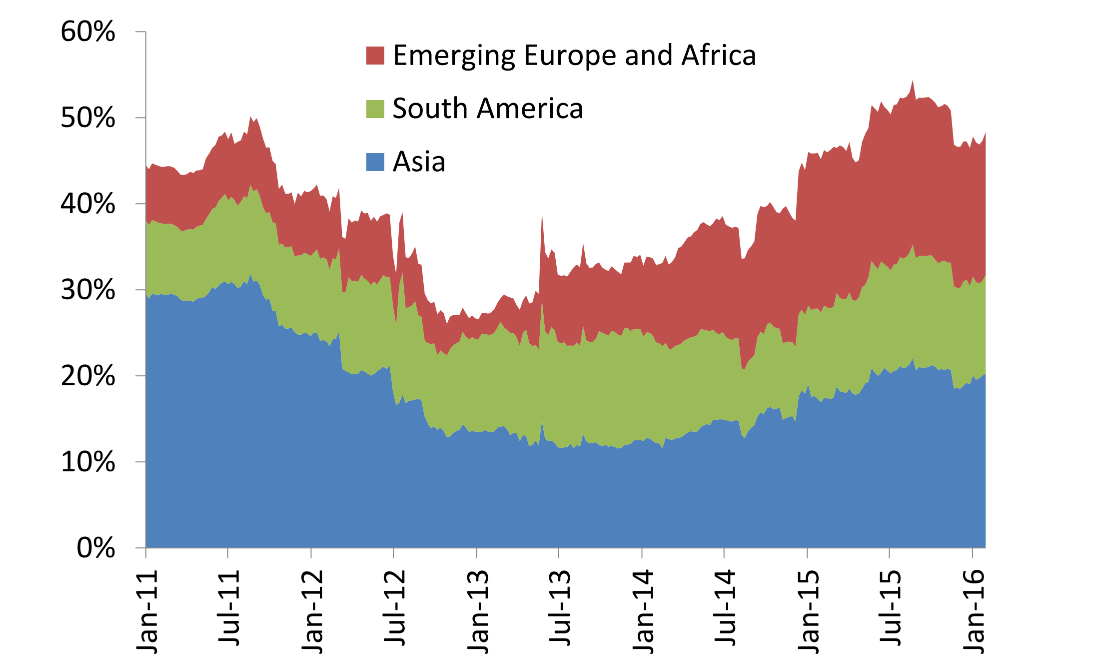


Note: EMEs shocks on US (the blue line in panel A) is constructed from the VD of US Treasury by summing the individual EMEs shocks on the US. US shocks on EMEs (the red line in panel A) is constructed from by extracting the contributions of US shocks from each of the VD of the EMEs. The two lines in panel B for the bond-market spillovers between the US and AEs are constructed in a similar fashion.

(C) Regional breakdown of EMEs shocks on the US



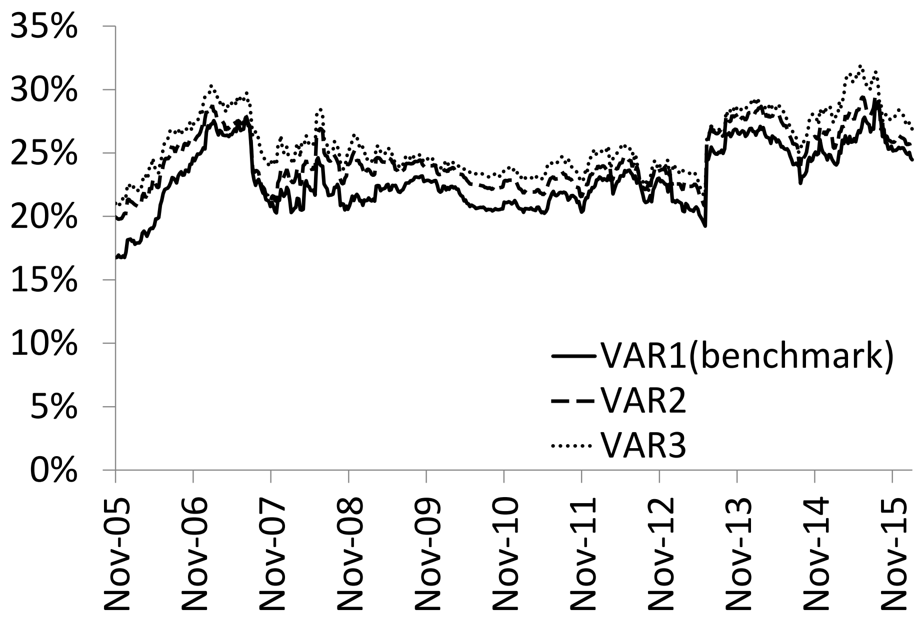
(D) Regional breakdown of US shocks on EMEs



Note: Panels C and D provide a regional breakdown of the blue line and red line in Panel A respectively.

Figure 4 Robustness check for the cross asset VAR

(A) Different VAR lag lengths



(B) Different size of the rolling window

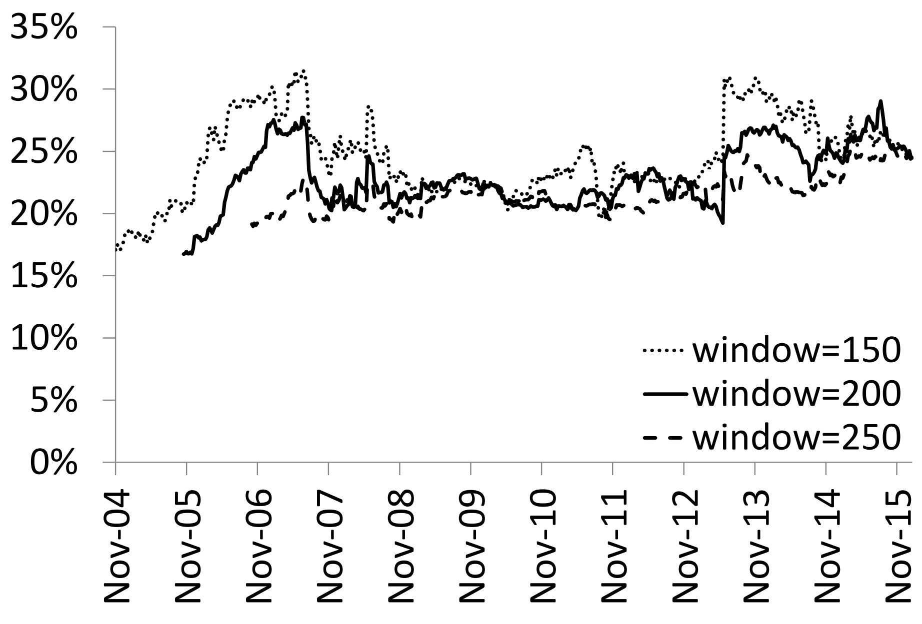


Figure 5 Robustness check for EMEs shocks on US

(A) Different VAR lag lengths

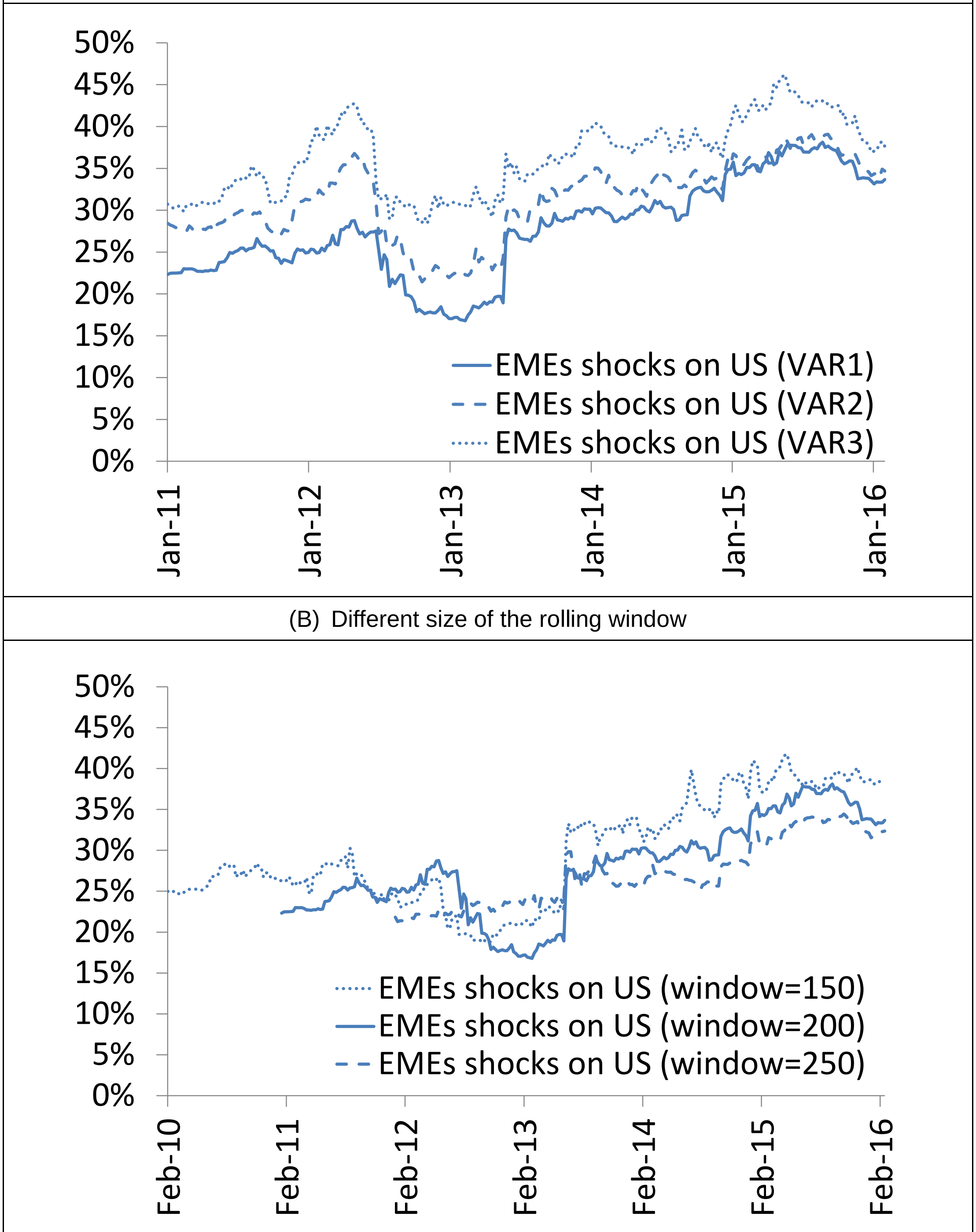
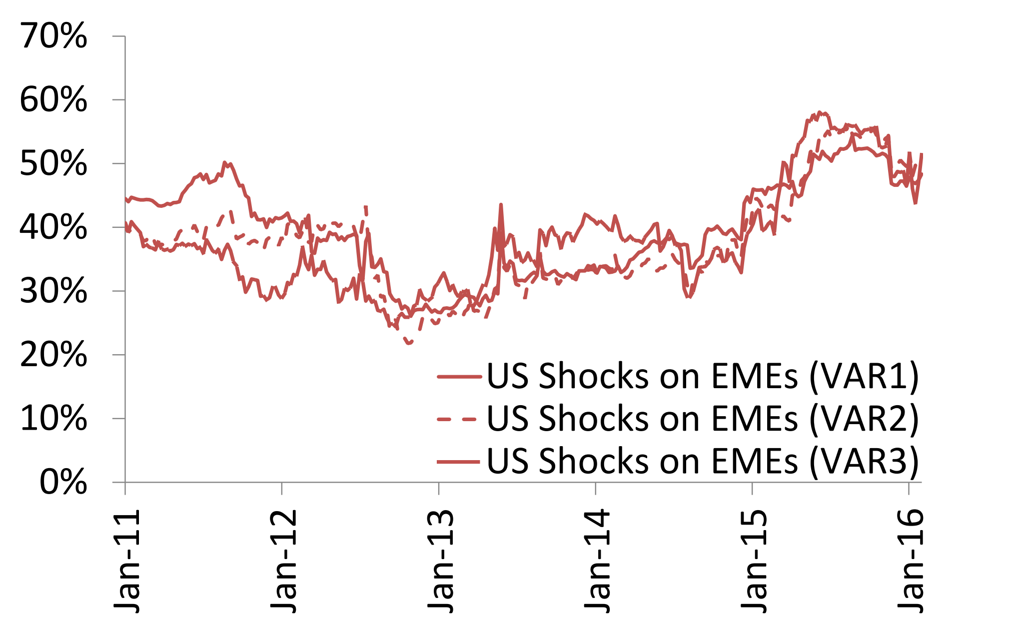


Figure 6 Robustness check for US shocks on EMEs

(A) Different VAR lag lengths



(B) Different size of the rolling window