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190

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WHAT ARE THE INTERNATIONAL CHANNELS THROUGH WHICH A US POLICY SHOCK IS TRANSMITTED TO THE WORLD ECONOMIES? EVIDENCE FROM A TIME VARYING FAVAR.

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Abstract

In this paper, we examine the international transmission of US monetary policy shocks across euro area and Asian countries by using a FAVAR model. We first examine all possible channels through which a policy shock is transmitted to each country. In general the transmission of the shock hides considerable heterogeneity across the countries. We find that the trade balance is important in explaining GDP spillover effects in the case of Singapore. Wealth effects along with the world interest rate channel explain the negative propagation of the US shock to the GDP of Hong Kong, the Philippines and Singapore. The exchange rate channel can explain the positive spillover effects on GDP in Korea and Japan. For the euro area, an endogenous response of the euro area monetary authority is observed. The wealth effect through the role of effective exchange rates seems adequate to describe the transmission of the shock to European countries. For Germany and Italy the decline in lending and spending reveal the importance of the balance sheet channel in the shock transmission. Second, we investigate to what extent the transmission mechanism has changed over time. For the 2007 financial crisis, our results indicate that the majority of the countries in both regions witness an increase in the size of the shock to real activity, inflation and credit variables in the post crisis period.

JEL classification: C38, E52, F41

Keywords: Monetary Policy, International Transmission Mechanism, FAVAR, Bayesian Statistics, Time Varying Parameters

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1. Introduction

The FED has often followed an expansionary policy in order to dampen the negative effects from a decline in asset prices and provide liquidity until the stock market recovers. Examples are its intervention in 1998 after the Asian crisis or in 2001 after the dot.com bubble. In the latter case, policymakers lowered rates eleven times in order to fight recession. However, the recent financial crisis was like nothing FED has faced since the 1930s. In late 2008, it cut the federal fund rate (FFR) to nearly zero levels, where it has remained until now. Despite the fact that policymakers reduced interest rates to historical lows, credit standards tightened and the cost of credit increased (Krugman, 2008). Since the FED was unable to cut its short-term rate below zero, it embarked on three rounds of quantitative easing.

In a recent statement, the FED announced that, at some time in the future, the FFR should return to more normal levels. This will be the first rate increase since 2006 when Bernanke raised rates four times to cool housing markets. Thus it is of great interest to explore the propagation of a possible US contractionary policy shock for the first time after the onset of the recent financial crisis. In addition, in a world economy which has experienced increased global integration in terms of both trade and financial transactions, such US policy rate shocks will not only affect the US itself but will spillover to other countries as well. Thus some natural questions to ask here are: First, how exactly are developed and developing countries affected by an external US contractionary policy shock? Second, to what extent has the international transmission mechanism changed with the global financial crisis?

To shed light on these issues we look at all the possible the channels through which a US policy shock is propagated both in the US and to foreign countries. We use a time varying factor augmented VAR (FAVAR) model estimated using Bayesian techniques. The main results we obtain are as follows: All major channels and sub-channels (trade, wealth effects, expectations, Tobin's q and credit channels) seem to be important in the domestic transmission of a contractionary US policy shock. As concerns the transmission channels to East Asia, they differ according to each country. First, a US contractionary policy shock results in a GDP decline for all countries except Korea and Japan. For all East Asian countries except Singapore and Japan (to a lesser extent), the trade balance does not appear to play any role in the transmission of the US policy shock. Wealth effects along with the world interest rate channel explain the negative GDP spillover effects found in Hong Kong and Philippines. By contrast, these channels do not seem to work well for countries affected positively by the US shock, i.e. Japan and Korea. In these two countries, we find that the exchange rate channel in effective terms contributes to GDP growth. We also find that in response to rising output, the central banks of Korea and Japan respond endogenously by increasing their rates.

Regarding euro area countries, we find that the expenditure switching effect, through the role of the trade balance, is only consistent with the dynamics in Spain. The positive effect on the GDP of euro area countries is mainly driven by wealth effects through the exchange rate. Policy endogeneity holds for all countries in this region. In addition, we document that for Germany and Italy a tightening US policy leads to a significant decline in asset prices, lending and spending which highlights the role of the balance sheet channel in these two countries.

Next, we report if there is evidence of a changing transmission mechanism through time. We find that the responses of foreign macroeconomic variables to a US monetary policy shock have changed dramatically over the whole sample. In particular, the impact of the US policy shock on GDP growth decreased in all euro area and most East Asian countries during the financial globalization period compared to the pre globalization period. This can be justified by the decline in the role of US with the emergence of other large developing economies. For the more recent period, we find that the impact on GDP has increased almost everywhere during the financial crisis. The strong impact of US monetary tightening on other economies suggests that foreign central banks should follow a credible monetary policy in response to the US shock in order to stabilize output.

The paper is organized as follows. Section 2 presents a description of the transmission channels together with the relevant literature. Section 3 presents the FAVAR model in the international context. It also explains the identification and estimation of the model and, finally, the dataset used in our analysis. Sections 4 and 5 present the results. Section 4 provides a rich discussion of all the possible transmission channels and sub-channels of the US policy shock to both the US and non US economies. Section 5 describes how international monetary policy transmission has changed as a result of financial globalization and the recent subprime crisis. Finally section 6 summarizes the results. The Appendices provide details on the estimation procedure.

2. Description of transmission channels and related literature

The transmission of a monetary policy shock operates via four major channels namely investment, consumption, credit and international trade. These channels are further separated into many sub-channels. For example, the transmission of the shock via investment may occur through the interest rate channel and Tobin's q. Transmission through consumption mainly reflects wealth effects in the sense that a tightening monetary policy reduces the demand for assets, thereby causing their prices to fall and reducing agents' total wealth. Credit channels which arise from the presence of asymmetric information in the credit markets can be further divided into the traditional bank lending channel and the balance sheet channel. The latter is the channel in which we focus on this study. Boivin et al. (2010) provide further details on how these three channels work in the domestic context.

In the international context, the transmission of a monetary policy shock might be well described by the traditional Mundell-Fleming-Dornbusch model (MFD). Under MFD, two important transmission mechanisms may exist. The first is the income absorption effect, which captures the change in foreign demand for domestic products due to changes in foreign economic activity. The second is called the expenditure switching effect and it captures the change in the domestic trade balance as a consequence of exchange rate movements. These two mechanisms move the trade balance in opposite directions. Thus, the final effect on output (both domestic and total) is ambiguous. A full exposition of the MFD model is provided by Obstfeld and Rogoff (1996). The following schematic depicts how exactly the MFD model works under these two different mechanisms.

$i_d\uparrow \rightarrow E\uparrow \rightarrow TB_d\downarrow \rightarrow TB_f\uparrow \rightarrow Y_f\uparrow$

or

$i_d\uparrow \rightarrow Income_d\downarrow \rightarrow IM_d\downarrow \rightarrow TB_d\uparrow \rightarrow TB_f\downarrow \rightarrow Y_f\downarrow$

Under the expenditure switching effect, a monetary tightening ($i_d\uparrow$) results in real exchange rate appreciation ($E\uparrow$) which causes the trade balance ($TB_d\downarrow$) to deteriorate. This leads to an improvement of the foreign trade balance ($TB_f\uparrow$) and finally to a rise in the foreign output.

However a decrease in domestic income ($income_d\downarrow$) following a contractionary monetary policy decreases domestic import demand ($IM_d\downarrow$), which may improve the trade balance. As a result the foreign trade balance deteriorates and foreign output falls. This is the income absorption effect.

The ambiguous outcome of the transmission mechanism under MFD model has been modified by the development of a new framework. The intertemporal model of Svensson and Van Wijnbergen (1989) and Obstfeld and Rogoff (1995) works as follows.

$i_{us}\uparrow \rightarrow i_w\uparrow \rightarrow Cus$,Ius and C_f ,$I_f\downarrow \rightarrow$ YusandY$_f\downarrow$andIMus, EXus / IM_f, $EX_f\downarrow$

A US monetary tightening (i_{us}) will spread internationally since the US is a large open economy and its monetary policy affects the world's economies. Therefore, the rise in the US short-term rate causes the world real interest rate (i_w) to rise since world financial markets are highly integrated. Additionally, the rise in the domestic interest rate decreases the demand for current consumption (C_{us}) and also current investment (I_{us}). In the same way, the increase in the world real rate reduces consumption and investment in the foreign country (C_f, I_f). Consumption and investment and therefore output in both the US and non US countries may decrease since real interest rates rise in both US and the non-US countries. In this case both exports and imports of both the US and non-US economies decline (IMus, EXus/ IM_f, $EX_f\downarrow$).

There is also the possibility that some modified MFD models (some versions of which are also present in some intertemporal models) might explain the transmission mechanism. The following schematic depicts how exactly the wealth effect works.

$i_{us}\uparrow \rightarrow e_{us}\uparrow/e_f\downarrow \rightarrow \pi_f\uparrow \rightarrow$ total wealth$_f\downarrow \rightarrow C_f\downarrow \rightarrow Y_f\downarrow$

Accordingly, following a US monetary tightening ($i_{us}\uparrow$), the dollar appreciates/foreign currency depreciates and this raises foreign prices. The increase in inflation leads to a decrease in agents' total wealth which reduces consumption and total output.

The balance sheet is another channel which may work in the international context assuming that foreign policy endogeneity holds. The case of an endogenous response of foreign banks to an external monetary policy has been studied by Grilli and Roubini (1995) and Lubik and Schorfheide (2005). According to this mechanism, in response to a contractionary monetary policy of a large open economy, domestic inflation and output decline, the dollar appreciates and the final effect is an increase in foreign output ($Y_f \uparrow$) under the expenditure switching effect. In order to moderate the increase in output, the foreign monetary authorities might respond endogenously to these developments by increasing their short-term rates. The rise in foreign short-term rates may lead to a decline in equity prices ($P_{eq,f}\downarrow$) which lowers the net worth of firms through Tobin's q. With less cash flow, the firm has fewer internal funds and must raise funds externally. Since external funding is subject to asymmetric information, leading to adverse selection (AS) and moral hazard (MH), the fall in firms' net worth is important since it lowers the collateral they can post. This leads to a fall in investment and total output. The schematic is depicted below:

$i_{us} \uparrow \rightarrow Y_f \uparrow$ and so $i_f \uparrow$

thus:

$i_f \uparrow \rightarrow P_{eq,f}\downarrow$ (Tobin's q) $\rightarrow$ net worth f $\downarrow \rightarrow AS_{,f}$ / $MH_{,f}\uparrow \rightarrow Y_f\downarrow$

Our paper contributes to the literature in a number of ways. First, we examine how a US policy shock is transmitted in practice to specific developed and developing countries. For this reason, we consider two separate world regions. We choose major European countries to examine the effect in developed countries and East Asian economies to examine the effect on developing countries. We use a FAVAR model, which incorporates a large set of macroeconomic and financial variables representing various dimensions of these economies. Other studies which use information from a large set of macroeconomic variables to examine the international propagation of shocks include Boivin and Giannoni (2008), Mumtaz and Surico (2009) and Eickmeier et al. (2011). These papers, however, differ significantly from our study. The first paper uses a FAVAR model to study exactly the opposite effect, i.e. the impact of international events on the US economy. The second focuses on the effect of various international shocks on the UK economy while the third focuses on the effect of a US financial shock in selected foreign economies. Kim (2001), and Neri and Nobili (2006) examine the propagation of a US policy shock to the euro area but they use VAR models which rarely employ more than five to seven variables. Arguably, our approach is more realistic since central banks monitor and respond to much larger information set than typically assumed in VAR models. As concerns East Asia, the only relevant studies are those of Miniane and Rogers (2007) and Kim and Yang (2012). Again, both papers use VAR models and they only explore the effect of a US monetary policy shock on interest rates and exchange rates.

The second contribution is that we employ a model which allows us to estimate time-varying impulse responses for a wide variety of macroeconomic variables in EU and Asian countries. All previous studies except Eickmeier et al. (2011), who examine a financial shock, assume that the parameters remain constant over time. The most relevant study in the spirit of our paper is that of Kazi et al. (2013). The two analyses however differ along a number of dimensions, including the FAVAR estimation and the countries analyzed in the empirical application. Most importantly, their analysis provides a very limited picture of how the international transmission channels work based only on interest rates, stock prices and exchange rates. This leads to the third contribution. In order to investigate the richness of the international propagation of US policy shocks we examine their effects on a large number of variables that may be of interest other than just interest rates and exchange rates. Therefore we are able to provide a detailed analysis for each country of all the possible transmission channels (and sub-channels) which have not been covered previously.

Fourth, our paper is related to the growing literature studying changes in the monetary transmission mechanism over the years (e.g. Mumtaz et al., 2011; Boivin et al., 2008 and 2010;Korobilis, 2013). However, none of these studies have examined the changing US transmission mechanism internationally. To the authors’ knowledge, only the recent studies of Ilzetski and Jin (2013) and Fukuda et al. (2013) deal with the changing dynamics of the international transmission of a US shock. These papers mainly focus on the changing spillover effects in the pre financial crisis period. They both conclude that there is a significant change in the international propagation of US policy shocks in the later, more globalized, decades. In respect to these studies, we examine how monetary transmission has changed as a result of the deepening of financial globalization. In doing so, we extend the relevant literature in the following ways. First, while all previous studies focused on the changing international transmission by splitting the sample, our time varying FAVAR permits us to examine what was happening at different points in time. In this way, we avoid the estimation over different subsamples. The superiority of this technique is noted by Boivin and Giannoni (2006). They point out that the evolution of monetary transmission is quite complex to be captured solely by splitting the sample. Second, we investigate possible changes in the international propagation of US monetary policy shocks between the pre and post crisis period. Third, previous papers provide results for the changing dynamics only for the core foreign variables such as output, exchange rates and interest rates. In contrast, we look at the changing transmission of the shock to measures of real activity other than GDP and measures of trade activity other than nominal and effective exchange rates. We also consider the changing transmission of the policy shock to stock prices, credit variables and monetary aggregates.

3. Econometric framework

The information about the US and the world economies is summarized in the following vector of K latent factors $f_t = \left[f_t^{w}, f_t^{us} \right]'$, where w denotes the foreign economies. We also consider the US short-term interest rate R_t as the only observable factor, thus the dynamics of the unobserved factors together with the observable factor can be described using a VAR (p) model:

$$F_t = \mathrm{B}_{1t} F_{t-1} + \ldots \mathrm{B}_{pt} F_{t-p} + u_t \tag{1}$$

where $F_t = \left[f_t, R_t \right]'$ with f_t a (Kx1) vector of latent factors, B_{it} is a (KxK) coefficient matrix and $u_t \sim \mathrm{N}(0, \Omega_t)$,where Ω_t is a full (KxK) covariance matrix.

The unobserved factors are extracted from a large panel of N macroeconomic variables which provide a representation of the US and foreign economies. The original observed series X_t of (Nx1) dimensions are linked to the factors and the monetary policy tool by the observation equation:

$$X_t = \Lambda^f f_t + \Lambda^R R_t + w_t \tag{2}$$

where Λ_t^f is a (NxK), Λ_t^R a (Nx1) and $w_t \sim N(0, V_t)$ with V_t= diag (exp(ν_{1t}..., exp(ν_{Nt})) .

Note that the diagonality assumption of the covariance matrix V_t implies that the parameters in equation (2) can be estimated equation by equation using the following univariate regressions:

$$X_{it} = \Lambda_i^f f_t + \Lambda_i^R R_t + w_{it}\, ,\, for\ i = 1..N$$

Next, we relax the assumption of parameter constancy in both the transition and observable equations. More specifically, following Primicieri (2005) the error covariance matrix Ω_t of (1) can be decomposed as $A_t \Omega_t A_t' = \Sigma_t \Sigma_t'$, where Σ_t = diag($\sigma_{1,t}$,…,$\sigma_{K+1,t}$) and A_t is lower triangular matrix with ones in the main diagonal.

$$A_t = \begin{bmatrix} 1 & 0 & .. & 0 \\ \alpha_{21,t} & 1 & .. & .. \\ .. & .. & .. & 0 \\ \alpha_{(K+1)1,t} & .. & \alpha_{(K+1)K,t} & 1 \end{bmatrix}$$

It follows that (1) can be written as:

$$F_t = B_{1t}F_{t-1} + \cdots B_{pt}F_{t-p} + A_t^{-1}\Sigma_t n_t, \text{ where Var } (n_t) = I_K. \tag{3}$$

Now, stacking in a vector B_t all the coefficients in the R.H.S of (3) we have:

$$F_t = X_t' B_t + A_t^{-1}\Sigma_t n_t, \tag{4}$$

where $X_t = I_K \otimes [1, F_{t-1}', \dots, F_{t-p}']$ and $\otimes$ is the Kronecker product.

We introduce time variation in our model by assuming that the parameters of the matrices B_{it}, A_t, Σ_t, V_t evolve as random walks. Details on the evolution of the parameters can be found in Appendix A.1.

3.1 Identification method

We estimate the factors and the associated loadings from equation (2) by standard principal components. We first follow Bernanke et al. (2005) by restricting the factors according to $f^{'}f/T = I$, where T is the number of time periods. Then, according to Mumtaz and Surico (2009), we identify the US and the international factors as follows. The K_1 international factors are identified through the upper N x K_1 block of the matrix Λ^f which is assumed to be a block diagonal matrix. The dynamics of the US factors are captured by K_2 factors. These factors are identified through the bottom N x K_2 block of Λ^f which is a full matrix. In our model, we include four international factors to capture the effects of real activity, inflation, trade variables and asset prices including monetary aggregates. We also include four domestic factors to capture the dynamics of the US economy. When we experimented with three and five factors (as Bernanke at al. (2005) did)we find no significant changes in our impulse responses.

Second, we follow Bernanke et al. (2005) in order to identify the monetary policy shock in the VAR equation (1). We identify the US monetary policy shock as the only shock that does not affect contemporaneously the other domestic factors in the system. This implies that the underlying US series do not respond contemporaneously to policy innovations. Since a subset of series mainly financial variables are likely to respond to monetary policy innovations within the quarter, we need to remove the contemporaneous relationship between the federal fund rate (FFR) and the financial variables**.** To achieve this, we proceed as follows. We first divide our data set into slow moving and fast moving variables depending on how fast they respond to the US policy shock. Then we extract K_2+1 principal components from the US variables in X_t to obtain consistent estimates of C_t=(f_t^{US}, R_t). Notice that Bernanke et al. (2005) do not impose the constraint that FFRis one of the common components, so if FFR is really a common component it should be captured by the principal components. Third, we estimate slow moving factors $f_t^{US,slow}$ as the principal components of the US slow moving variables. Fourth, we estimate the following regression:

$$\hat{C}_t = b_1 f_t^{US,slow} + b_2 R_t + \theta_t \qquad (5)$$

from which we obtain $\hat{C}_t - b_1 f_t^{US,slow}$. Then the identification of the domestic monetary policy shock is achieved by recursively ordering: $f_t^{w}, \hat{C}_t - b_1 f_t^{US,slow}, R_t$ with R_t last in the VAR equation. This ordering imposes the assumption that both international and domestic latent factors do not respond to monetary policy innovations within the quarter.

3.2 Estimation and impulse responses

The latent factors can be treated as unobserved parameters and estimated along with the model parameters in one step, using Markov Chain Monte Carlo (MCMC). However this approach is computationally demanding, since already in this model extensive MCMC simulation methods are used to estimate the time varying nature of our model. Moreover, Bernarke et al. (2005) argue that the Bayesian estimation produces factors that do not capture real activity and inflation. We thus follow Stock and Watson (2005) by approximating the factors using standard principal components and then we estimate the parameters of our model conditional on the estimated factors.

We estimate the model using Bayesian techniques. We use 20,000 iterations discarding the first 16,000 as burn in. Alternative initial iterations or the use of a different percentage of burn in iterations, gave essentially the same results. Details of the prior and posterior distributions are provided in the Appendices A.1 and A.2 correspondingly. Here we summarize the estimation algorithm.

1. Simulate Λ_i and v_{ii} from the factor equation (2).

   Given initial values for the factors, the coefficients Λ_i are drawn from a normal distribution while the variance elements v_{ii} from an inverse gamma distribution.

2. Simulate parameters from the VAR equation.

Given initial estimates for the factors:

- We first draw B_t from a conditionally normal density using a standard state space filter and smoother (Carter and Kohn, 1994). Next, conditional on B_t we draw the covariance matrix Q from an inverse Wishart distribution.
- Given B_t we draw coefficient states $\alpha_{i,t}$ using the methods described in the previous step. We then draw the hyperparameter S conditional on estimates of A_t elements from an inverse Wishart.
- Last we draw volatility states $\log \sigma_t$ by using Kalman filter methods introduced in Kim, Shepard and Chib (1998) for nonlinear and non-Gaussian state space forms. Again, the corresponding covariance matrix W is drawn easily from an inverse Wishart posterior.

3. Go to step 1.

We follow Primicieri (2005) in order to estimate impulse responses as follows. First, we write the structural form of the reduced form VAR as in equation (3):

$$F_t = \mathrm{B}_{1t} F_{t-1} + \ldots \mathrm{B}_{pt} F_{t-p} + A_t^{-1} \Sigma_t n_t$$

Combining (1) and (3) the time *t* reduced form errors u_t are parameterized as:

$$u_t = A_t^{-1} \Sigma_t n_t$$

Where n_t are the structural time *t* shocks assumed to be $n_t \sim N(0, I)$ and A_t^{-1} captures the contemporaneous relations of the shocks. Impulse responses are estimated in two steps. First, we obtain the posteriors of B and Ω at every point in time by estimating the reduced form VAR from (1). Second, we let Ω_t=PP' be the Cholesky decomposition of the VAR covariance matrix Ωt by setting P=$A_t^{-1}\Sigma_t$. Then the structural shocks n_t are recovered based on the current time t sampled factors, state parameters and hyperparameters of the Gibbs algorithm.

3.3 Data

The dataset consists of quarterly observations spanning the period from 1986:Q1 to 2013:Q4. The series were downloaded from the Federal Reserve Economic Database (FRED), Datastream and the World Bank. The international dataset covers six major EU countries and five East Asian countries. The countries from the EU are: Germany, France, Italy, Spain, Belgium and the UK. The countries from East Asia are: Hong Kong, Korea, Singapore, Philippines and Japan. Notice that not all the variables were available for some countries from 1986.Where available, our real activity data contains GDP, government consumption, employment, unemployment, industrial production, private consumption and fixed investment. Our price data contains CPI, PPI and GDP deflator. The trade data contains exports, imports, export and import prices, terms of trade, trade balance, and effective exchange rates. Our asset and financial dataset includes short-term interest rates, long-term government bonds, stock market indices, consumer credit while money growth data includes M0 and M1. Residential loans and /or domestic credit are used as proxies for credit variables. While these variables were available for euro area countries and the UK on quarterly basis, they were not available for East Asian countries. We obtain domestic credit series from the World Bank. Since they are available on annual basis, we convert annual to quarterly data using a cubic spine interpolation.

Like the international data, the US dataset contains data on real activity, prices, trade, asset prices and monetary variables. We also include the term structure of interest rates, the spread between the yields on AAA corporate bonds and corresponding U.S. Treasury bonds, of maturities one and ten years, exchange rates (dollars in terms of the foreign currencies of all countries included in the sample), the one year ahead expectation of CPI inflation from the Michigan Survey, the one-year ahead expectation of CPI inflation and the GDP implicit deflator inflation from the Survey of Professional Forecasters. All the series (except for unemployment, interest rates, spreads and the Michigan inflation expectations index) were transformed to be approximately stationary. In addition, all series are demeaned and standardized in order to extract factors.

4. The channels of monetary transmission in the US and the world economies

4.1 Cross country differences

The transmission of the US policy shock internationally hides considerable heterogeneity across the countries. Looking at Figures 2 and 5 we observe that a surprise increase in the US short-term rate is positively transmitted to GDP (or industrial production)in all EU countries and some East Asian countries and negatively transmitted in Hong Kong, the Philippines and Singapore. Moreover, the magnitude of the effect also varies across the countries. For example, the GDP of the developed countries (EU and Japan) is more affected by the US policy shock compared to the developing countries on East Asia. The international transmission hides a significant degree of heterogeneity not only for the effect on GDP but also for many other important macroeconomic indicators of the foreign economies. The effect of the US policy shock on inflation for example (Fig. 2 and 5) may be positive and significant (Philippines, Korea, Japan, Germany and Italy), or negative and significant (Singapore) or even insignificant (Hong Kong, UK, Spain). As concerns interest rates, Hong Kong, Korea and the UK see a much larger increase in their short term rates than the other countries (Fig. 4 and 7). Similarly, the movements in foreign currencies with respect to other major currencies differ in the sign and magnitude of the effect. In particular, the real effective exchange rates (REER) of Hong Kong and Japan depreciate over time whereas all the other Asian and EU currencies appreciate on impact in response to the US contractionary policy shock (Fig. 3 and 6). In the following sub sections we provide a detailed analysis of the transmission of monetary policy disturbances in US, East Asia and EU.

4.2 Detailed transmission mechanism of the U.S. policy shock domestically

Before examining the effects abroad, we examine the domestic channels through which monetary policy exerts its influence on the US economy (see Fig. 1). The impulse responses in general act as expected under a contractionary policy shock. Output decreases gradually, prices eventually go down and monetary aggregates also decline. Consistent with the relevant literature (see Bernanke et al., 2005 and Korobilis, 2013), the negative correlation between nominal interest rates and inflation suggest that the FAVAR methodology properly manages to deal with the price puzzle observed in VAR models. Next, we also notice a negative correlation between interest rates and the money stock. Thus, the liquidity effect observed in the VAR literature is absent. Last, an apparent problem in open economy studies is the exchange rate and forward discount puzzle. Under Dornbusch's overshooting hypothesis, an increase in interest rates should cause the nominal exchange rate to appreciate instantaneously and then depreciate according to uncovered interest parity (UIP). Our results show that the exchange rate puzzle is not present in the FAVAR model. Figure 1 shows exchange rates defined as the national currency of each member country per US dollar, so an increase in the exchange rate shows appreciation of dollar. One notices that the contractionary policy shock leads to an initial depreciation for all foreign exchange rates. After the depreciation there is a gradual appreciation in the majority of the currencies which is fully consistent with Dornbusch overshooting hypothesis. These initial results suggest that the exchange rate channel does play a crucial role in the monetary transmission mechanism. We will verify the importance of this channel by looking at the REER in the next sections.

To further infer details about the transmission channels in the US we also look at the response of other variables. We begin with the trade balance. There is a slight improvement in the trade balance in the short term which dies out in the medium and long term. Thus the income absorption effect in the short run is consistent with the dynamics. Second, the rise in the short-term rate reduces consumption and investment via wealth effects and lowers equity prices via Tobin's q. Therefore, both channels are sensible ways to describe the effects of a tightening monetary policy in the economy. Third, we explore whether the expectation channel plays a significant role in the transmission mechanism. The results suggest that eventually there is a significant reduction in expected inflation as indicated by the index of consumer expectations, which implies that the expectations channel does matter in the transmission of a policy shock. Last, we investigate if contractionary monetary policy can exert an influence on the US economy by affecting the balance sheets of consumers and firms. To measure the impact of this channel we report the responses of two variables. These are consumer credit and the spread between the yield on AAA corporate bond and the three month T Bill. The latter can be seen as a proxy for the external finance premium. In accordance with theory, there is a reduction in the response of credit which means that consumers' access to the credit has reduced. There is also an increase in the size of the external finance premium which means that lenders are less willing to make loans.

4.3 Detailed transmission mechanism of the U.S policy shock to East Asia

The effect of a US policy shock on the East Asian countries can be seen in Figures 2, 3 and 4. Figure 2shows impulse responses of real activity and inflation measures, Figure 3 shows impulse responses of trade activity variables while Figure 4depicts asset price variables. A US shock results in a decline in GDP in all countries except Korea and Japan (Fig.2). The response of unemployment in Hong Kong and the Philippines is counter to theory since we would expect a rise in the unemployment rate following a decline in output. To further investigate the evolution of monetary policy, we examine which of the transmission channels might have been involved in international transmission of the shock.

We begin by analyzing the role of the trade balance channel. Under MFD, the final effect on the foreign output is ambiguous. On the one hand, the higher US policy rate results in dollar appreciation which makes domestic goods in the US more expensive than foreign goods. This leads to a deterioration of the trade balance, an improvement in the foreign trade balance and finally an increase in foreign output. However, a rise in interest rates may have exactly the opposite effect on foreign output. Following a contractionary policy, domestic income is reduced. Thus the demand for the domestic imports is also reduced, leading to an improvement in the US trade balance through the expenditure switching effect. Our results indicate that a monetary tightening leads to a slight initial increase in the trade balance (Fig. 3) for Hong Kong and Philippines which very soon dies out and can thus be considered negligible. The same holds for Japan. The income absorption effect is consistent with the results for Singapore since there is a significant worsening of its trade balance which justifies the fall in output. Last, although the trade balance does not explain the rise in output in Korea, it is a significant transmission mechanism since there is a clear reduction in its response. In sum, the trade balance channel cannot satisfactorily describe the international transmission mechanism to East Asian countries with the exception of Singapore.

Second, we explore the role of the international wealth effect channel in the transmission mechanism. According to this channel, a US monetary tightening results in the depreciation of the foreign currency leading to an increase in foreign inflation. Then- in line with the Pigou effect -foreign output decreases due to the decrease in real balances of wealth. Figure 2shows that this channel might operational for Hong Kong and the Philippines since there are significant increases in inflation which may cause GDP to fall.

Another channel through which shocks are transmitted internationally is through the world interest rate (intertemporal model of Obstfeld and Rogoff, 1995). According to this, the final effect of the US monetary tightening to the foreign economies will be a reduction in consumption, investment and therefore output. Imports and exports will also decrease since residents in both the US and the world economies reduce the demand for goods and services in the US and non US countries. To assess the relevance of the world markets in the transmission of the monetary shocks to East Asia we study the responses of the aforementioned variables. Consistent with the theory, consumption and investment (Fig. 2) fall in Hong Kong while the response of investment in Singapore does not work well. To further recognize the importance of this channel for these countries we report the responses of exports and imports (Fig. 3). The final effect of the US shock is a substantial decrease in both imports and exports for Hong Kong, Singapore and Philippines. This makes the world interest rate channel a significant channel for these three countries.

Overall it can be argued that the combination of the wealth effect channel along with the world interest rate and (to a lesser extent)the trade balance are quite helpful in explaining the negative GDP responses in Hong Kong, the Philippines, and Singapore. However, none of these channels manage to describe adequately the spillover effects to Korea and Japan. The positive effects on consumption, investment and finally output in both countries (Fig. 2) might be a result of the foreign currency depreciation with respect to other currencies of trade partners. Therefore we examine if the exchange rate channel may be operating in these countries. Indeed, as Figure 3 depicts, the REER for Japan and Korea depreciate and as a result exports in both countries increase which means that this channel works well for these countries.

We also examine whether central banks appear to respond to the US tightening**.** Japan and Korea increase their short-term rates in order to mitigate the boost to inflation and economic activity observed after the US policy shock (see Grilli and Roubini, 1995**)**.To examine this possibility we look at the responses of short-term rates and monetary aggregates for these countries. Following a rise in output and inflation (see Fig. 2), we notice that there is a significant rise in the short-term rates for Japan and Korea (Fig. 4) which is consistent with our hypothesis. In addition, there is also a significant reduction in the monetary aggregates (M1) for both countries. Notice also that this channel does not contribute to the transmission of external shocks to the rest of East Asia countries since the responses in short rates and monetary measures either have opposite signs or move in line with theory but are insignificant.

4.4 Detailed transmission mechanism of a policy shock to the EU

Figures 5-7 show the impulse responses of the largest EU economies to a US monetary policy shock. In all cases, a monetary tightening leads to gradual increases in output (either real GDP or industrial production, Fig. 5). Notice that the rise in foreign output produces a significant reduction in unemployment for all the countries except Germany. In line with the analysis in the previous section we discuss the transmission channels that may generate the positive spillover effects for the EU.

First we can exclude the intertemporal model since, according to this theory, we would expect a significant reduction in GDP in EU countries as a result of the US shock. Next, in order to verify if the increase in the foreign output is consistent with the expenditure switching effect, we examine the significance of the trade balance channel in the international transmission. If this channel works then a significant increase should be found in the trade balance in order to justify the increase in output. Our results indicate that this channel does not explain the positive spillover effects observed on GDP since we would expect a rise in trade balance in euro countries. An improvement in the trade balance is only observed for Spain (Fig. 6).Next, we look at the role of exchange rates in the transmission of the shock. Judging from the bilateral exchange rate responses (Fig. 1), the depreciation of both currencies (euro and pound) against the dollar may provide a good explanation of the rise observed in foreign output in EU countries. However this is not consistent with the response of exports in

EU countries and the UK; exports fall which is not consistent with the currency depreciation.

To consider the role of exchange rates in the transmission mechanism we look at the REERs since they provide more accurate measures of price competiveness. The REER is the nominal effective exchange rate divided by the price deflator index of each country. Figure 6 shows that in contrast with bilateral exchange rates, there are significant appreciations in all REERs. This is in line with Edwards (1995). The appreciation in the REERs confirms the deterioration in export performance for all European countries as a result of the shock. The appreciation of the effective exchange rate, combined with the decrease in inflation (Fig. 5) for all EU countries, explains the increase in consumption (Fig. 5) and therefore GDP through the wealth effects. We conclude that that the wealth effects through the exchange rate channel do play a significant role in the transmission of the US shocks to the EU.

We also examine if foreign policy endogeneity is present in the EU countries. Indeed, we find that in response to rises in output, short-term rates (Fig. 7)increase in all countries except Germany. Moreover, we notice a significant reduction in the monetary aggregates (Fig. 7), which further confirms the hypothesis that short-term interest rates in the euro area respond endogenously to a US monetary contraction.

Consistent with the hypothesis of policy endogeneity in the EU, there is another channel that might work which is the balance sheet channel. If foreign central banks follow a contractionary policy- as a result of the US policy shift –this leads to a decline in asset prices which lowers the net worth of firms. Lower net worth means less collateral available and increasing adverse selection and moral hazard problems. As a result, there will be a decline in lending, spending and aggregate demand. This appears to closely follow the case of Germany and Italy. First, notice that equity prices decline in response to a rise in the short-term rates (Fig. 7). Then there is a clear reduction in the responses of consumer credit or/and bank lending which suggests that the consumers' access to credit is diminished. Obviously, this channel also offers an explanation of why the response of consumption in Germany is negative. Notice that there is an ambiguous effect for the responses in UK since the resulting negative asset price effects in the UK are not sufficient to lead consumer credit to lower levels. For the rest of the countries this channel does not seem to matter for the international transmission.[1]

4.5 Policy Implications

The financial crisis that started in 2007 has had different effects across the world economies. While before the 2007 crisis macro-financial linkages had ensured a more homogeneous transmission of an exogenous shock to other countries, since 2008 the interconnections between market segments have largely broken, also across borders. Thus the monetary transmission mechanism has operated in a context of heterogeneity in the global economies which means that policymakers in both the euro area and East Asian countries plan the performance of the monetary policy stance in a different way.

The previous findings are related to policymaking in both a direct and an indirect way. The description of the transmission channels through which the US policy shock is transmitted internationally is the indirect way. More specifically, the insignificant role of the trade balance, the importance of the wealth effects for both regions, the strong impact of the world real interest rate channel and the exchange rate channel in Asian countries, the considerable role of the balance sheet channel in some euro area countries, all shed light on the correct theoretical models for international monetary policy analyses.

In particular, as concerns East Asian countries, monetary policy authorities in Singapore and Korea should take into account the role of the trade balance when forecasting the implications of US monetary policy actions on their economies. The central banks of Hong Kong, Philippines and Singapore should focus their forecasts on transmission through wealth effects. In addition, the monetary authorities in Hong Kong, Singapore and the Philippines should attention to the transmission of a US shock via the world interest rate channel. This is because all these countries witness a significant reduction in many macroeconomic variables affected by this channel (consumption, investment, exports and imports).

[1] Consistent with the discussion in the previous section, the balance sheet channel might also works for Japan and Korea since policy endogeneity holds only in these countries. However the examination of the responses rejects this hypothesis for both countries since equity prices and consumer credit move in opposite directions.

Overall it can be argued that the combination of the wealth effect channel along with the world interest rate channel and (to a lesser extent) the trade balance are quite helpful in explaining the negative GDP responses in Hong Kong, Philippines, and Singapore. However, none of these channels manage to describe adequately the spillover effects to Korea and Japan. Our results indicate that the only channel explains the GDP spillover effects in Korea and Japan is the exchange rate channel which means that policymakers should focus on their currencies when forecasting the implications of a US monetary tightening..

As with East Asian countries, in all EU countries except Spain, the trade balance channel cannot adequately describe the transmission of the shock. Moreover, the significant reduction observed in individual inflation rates as a result of the appreciation of the effective exchange rates also denotes the important role of the wealth effects in the transmission of the shock. This suggests the need to focus on exchange rates and inflation when forecasting the impact of tightening in the US. Additionally, an extra channel which plays a significant role in the transmission of the shock in two euro countries, i.e. Germany and Italy, is the balance sheet channel. Our results indicate that there is a clear reduction in the equity prices and consumer credit as a result of the US shock. This implies that the role of credit markets in the transmission of the shock especially in these two large euro area countries should be seriously considered.

Aside from the indirect effect described above, there is also the direct effect. The examination of some of the variables of primary interest such as output and inflation are directly related to the policymaking. For example, in the US, the monetary tightening leads in a short improvement of its trade balance. Since the US is a country with trade deficit, it can use contractionary policy to improve its trade balance. Similarly, a monetary tightening achieves lower inflation. By contrast, a rise in the policy rate has no significant effects in imports and exports thus a US monetary contraction is not a desirable policy in this case.

In the international context, the case of an active foreign monetary policy as a result of the US shock is given by the endogenous responses of two East Asian countries central banks, i.e. Korea and Japan and the monetary authority in euro area. In particular, our results indicate that a US contractionary policy leads to a significant increase in the output of EU countries. This means that in terms of GDP growth, these countries will initially see the US monetary tightening as a desirable policy. However, over the long term, the foreign central banks of all these countries will strongly respond by increasing their short-term rates order to cool economy boost and inflationary pressures from the unexpected US shock. Indeed, the responses of output for all EU countries and Korea and Japan show that after 12 months the initial increase in the level of economic activity has faded. This fading is the result of the endogenous monetary policy response of the foreign central banks.

5. Investigating the changing transmission mechanism of the U.S. shock

In contrast with the relevant literature which deals with changes in the transmission mechanism by estimating the FAVAR model over different subsamples (see Boivin et al., 2009 and Mumtaz et al. 2011), our time varying model permits us to examine what was happening at different points in time. In addition, as Boivin and Giannoni (2006) point out, the evolution of the monetary transmission is too complex to be captured solely by splitting the sample. We determine whether the monetary transmission mechanism has changed through the years as a result of two important worldwide phenomena, i.e. a) the globalization of finance and b) the US subprime crisis. For this reason, we choose in our analysis four representative dates, i.e. 1987, 1999, 2007 and 2013. We choose1987 as it is considered the beginning of global integration (Kose et al, 2007)and therefore it can be seen as a representative date of a less integrated period. The date 1999 has been chosen for three reasons. First it gauges the impacts of the gradual deepening of financial integration (compared with 1987). Second, it is a benchmark date for euro area countries since it is the year of the adoption of the common currency, while it is also a time period after the Asian crisis of 1997. Therefore many significant changes might be observed in the propagation of US policy shock to most of the countries in the sample. Last, 2007 represents the pre-crisis period while 2013 is indicative of the post financial crisis period. Our results focus on the effect after one year and posterior medians of impulse responses on these four representative dates.

5.1 How has the monetary transmission evolved in U.S.?

We begin by analyzing the changing transmission mechanism in the US. Table 1 shows that the effect on real activity variables (except unemployment) is of greater magnitude during the latest years (2007 and 2013) compared with the earlier years (1987 and 1999). As an additional comment, one could also note that GDP, consumption and investment respond more in the pre-crisis period (2007) rather than in the post-crisis period (2013). In accordance with real activity variables, inflation responses are also large before the outbreak of the crisis but small and insignificant in its aftermath. In terms of asset prices and monetary variables, the impact of the policy shock is strong in most of the variables (with the exception of mid and long-term rates) at all points in time. The effect is stronger for stock indices, short-term rates and monetary aggregates in the pre-crisis period compared to post-crisis. In addition, during the post-globalization period (1999) the impact on all variables (except for the short-term rate) has increased compared to pre-globalization period.

The estimates of trade activity variables display very similar patterns to those presented above. In particular, the terms of trade and the REER are stronger in 2007 (compared with 2013) and in 1999 (compared with 1987). The responses of imports and exports show no signs of change between the pre and post-financial crisis period. On the contrary, there are important changes in the responses of both variables in the earlier years. Notice that with greater financial integration (compared with the pre-globalization period), the spillover effects on both variables become weaker.

Last, we report the results from the nominal exchange rates of dollar against East Asian currencies, the euro and the British pound. There is a clear evidence of time variation for all exchange rates. However the magnitude of the effect differs across the different regions. In particular, both the euro and the pound are affected more after the financial crisis period, while the opposite holds for Asian currencies. In addition, all Asian currencies depreciated before the crisis but most of them appreciated after 2007. The depreciation of the dollar against the Asian currencies in the post crisis period is consistent with the overshooting hypothesis stating that an increase in the short-term rate will cause the nominal exchange rate to appreciate instantaneously (not shown here since we focus on the effect one year after the shock) and finally depreciates. By contrast, a possible explanation for the consistent dollar appreciation in the years before financial crisis is the fact that the US was considered as a ‘safe haven’ by investors.

5.2 How has the monetary transmission evolved in the world economies?

We first report the results for each different sector of the economy (sections 5.2.1, 5.2.2 and 5.2.3).Then, in section 5.3 we provide an economic explanation of our findings.

5.2.1 Time variation in real activity variables

Table 2 depicts the changing transmission mechanism through the foreign real activity variables. The impact of US policy shocks on GDP between 1987 and 1999 has decreased for almost all countries (except Hong Kong and Philippines). In general, we find that all real activity variables in most of the non US countries fall in response to a contractionary US policy shock under global integration**.**

In the more recent period (pre and post crisis), the magnitude of the effect on GDP is far smaller than the pre-globalization period. This means that the effect of a US policy shock on foreign output has diminished through time. Note that, between 2007 and 2013, the pass through of policy shocks to output has increased in all countries with the exception of Singapore. What is more, during these latest periods, the transmission mechanism generates not only positive (as in the earlier years, 1987 and 1999) but also negative spillover effects, only in some East Asian countries.

The impulse responses of unemployment are in general statistically insignificant for the whole period examined. Consistent with the responses in output, the impact on GDP components such as consumption and investment is larger in 1987 compared to 1999 for all countries. During the crisis, for most of the countries (Japan, Korea, France, Italy and UK) the effect on consumption and investment has risen compared with the pre-crisis period.

5.2.2 Time variation in trade and price variables

In terms of trade variables, Table 3 shows that the negative impact on exports has risen for almost all countries in 2013which is indicative of the worldwide trade breakdown in the aftermath of the crisis. The only countries which see their exports affected less by the shock are Korea and Singapore. One also notices that in the pre-crisis period, the responses of export measures are all negative except Germany. This result confirms Germany's strong export performance in the pre-crisis period since it appears that its exports stay unaffected by foreign contractionary policy shocks. Further, we find that in contrast to the responses in the more recent years (2007 and 2013), there is a positive effect on exports in almost all countries during the earlier years. Moreover, the impact of a US monetary policy shock is general weaker in the post globalization period compared to the pre-globalization period.

For the rest of trade variables, the signs and magnitude of import responses are similar to those of exports at all representative dates. There is also no evidence of significant time variation in the trade balance in any period. In the case of exchange rates, there is a distinguishable pattern between the two regions in the latest years. All Asian currencies show stronger spillover effects - in real effective terms -before the crisis in comparison with 2013,while all REERs from EU countries how a larger response during the post crisis period. Evidence of time variation in exchange rates is also observed between the pre and post globalization periods but there is no clear pattern of the REER responses between these two periods. Additionally, the negative signs observed mainly in the REERs of East Asia economies through time, indicate that a US contractionary policy shock gives these countries the opportunity to increase their exports since their currency relative to other major currencies depreciate.

Concerning aggregate price variables, the impulse responses of inflation (both CPI and GDP deflator) show significant time variation between 2007 and 2013. On average, the response of inflation is large and negative (except for Korea and The Philippines) during the post crisis period while before 2007 the magnitude of the effect is smaller and positive in many cases**.** Similarly, the inflation responses show signs of change over time between 1987 and 1999, while the responses are mainly negative and stronger in the pre -globalization period.

5.2.3 Time variation in asset price variables

We analyze the responses of some key asset price variables through time as it can be seen in Table 4. First, notice that short-term rates respond more to a US policy shock in the pre globalization period (compared with post globalization period) and in the pre-crisis period (compared with post crisis period). The only exceptions are Hong Kong and Singapore. During the post crisis period, the impact of US policy shocks on stock prices has decreased in all countries but Spain, while the pattern is exactly the opposite for credit responses (residential loans and consumer credit). In particular, in the post crisis period, the magnitude of the effect is greater for all Asian countries except Korea and Singapore where there is no change in the responses of consumer credit. The same holds for all EU countries but Spain, in which the effect on consumer credit and residential loans was diminished after the outbreak of the crisis. A similar distinctive pattern for Spain is observed in the early years, since this is the only country whose credit responses strengthen during the globalization period. Last, we look at the responses of monetary aggregates (M0 and M1). Generally, the estimates show large variation over time. During the crisis money reactions in some countries have risen compared to pre-crisis period while others have declined. Thus we cannot say with certainty in which period the magnitude of the effect is stronger.

5.3 Implications of the changing transmission mechanism

Our results can be summarized in the following three points. First, the transmission mechanism of a policy shock originated in US has changed during global integration. We find that the deepening of global integration dampens the effect of the US policy shock to the foreign economies. This result can be justified either by the decline in the role of US with the emergence of other large economies such as China during the period of global integration or /and by the tendency of Asian countries to move towards free floating exchange regimes after the Asian crisis in 1997 (see Fukuda et al., 2013).

Second, there is strong evidence that the propagation of US shocks has changed through time and, particularly in the pre and post financial crisis period. In general, effects are larger in the post crisis period in almost all countries. More specifically, the transmission of the shock to real activity, trade and inflation has increased after the crisis while only the transmission on stock prices has decreased. This means that the sensitivity of core variables of the foreign economy to the US shock is greater than that of financial variables. In total, the strong impact of the US monetary tightening in the EU and East Asia suggest than foreign central banks should follow a credible monetary policy in response to the US shock in order to stabilize fluctuations in output and mitigate the negative effects in many other economic sectors.

Third, after the Asian crisis of 1997, most emerging countries have moved towards both inflation targeting policy and more flexible exchange rate regimes. Therefore, by studying the changing transmission mechanism, we are able to shed light on the role of exchange rate regimes in the transmission of a US monetary policy shock. In this direction, a very interesting result is the fact that some Asian countries experienced a decrease in the magnitude of the effect on many economic variables after the outbreak of crisis (Korea and Singapore in exports and credit variables, Korea and Philippines in price variables and Singapore in GDP). Taking into consideration that all these economies use either free floating regimes (Philippines, Korea and Japan) or managed regimes (Singapore), this finding is consistent with the view that more flexible exchange rate regimes help mitigate the impact of external shocks originated from financial crises (Furceri and Zdzienicka, 2010).

6. Concluding remarks

In this paper we examine the international transmission of a US contractionary monetary policy shock for some key European and East Asian economies. We use a time varying FAVAR to exploit the richness of the transmission channels across the countries and the fact that significant changes in the size of US policy shock have occurred over time. Our analysis shows that, first, all major channels (trade, wealth effects, expectations, Tobin’s q and credit channels) seem to be important in the domestic transmission of a US policy shock.

Second, we find considerable heterogeneity across the foreign countries responses to a US policy shock. This heterogeneity is further analyzed by examining all the possible international transmission channels. We find that the trade balance cannot satisfactorily describe the shock transmission for all Asian countries except Singapore. The wealth effects along with the world interest rate channel do explain the negative spillover effects in Hong Kong, Philippines and Singapore. For Japan and South Korea, we find evidence in favor of the shock transmission through exchange rates. Third, the transmission mechanism in EU countries seems to be consistent with the wealth effects through the exchange rates. Moreover, foreign policy endogeneity holds for EU countries since the foreign central banks respond to GDP changes by increasing their short term rates. In addition, for Germany and Italy the decline in lending and spending reveal the importance of the balance sheet channel in the propagation of the shock.

Finally, in terms of variation over time we find significant changes in the size (and the sign) of the US policy shock through the time. In particular, we find that the deepening of global integration dampens the effect of the US policy shock to all foreign economies. As concerns the recent financial crisis, we find that the majority of the countries in both regions have witnessed an increase in the size of the shock to GDP, inflation, trade and credit variables during the post crisis period.

Appendix

A.1 Time Varying components

Recall that our time varying FAVAR model consists of the following equations:

$$F_t = \mathrm{B}_{1t} F_{t-1} + \ldots \mathrm{B}_{pt} F_{t-p} + u_t$$

$$X_{it} = \Lambda_i^f f_t + \Lambda_i^R R_t + w_{it}$$

The dynamics of the FAVAR model's time varying parameters are specified as follows: First for the observation equation given by (2):

$$X_t = \Lambda^f f_t + \Lambda^R R_t + w_t$$

The diagonal elements of the covariance matrix V_t will evolve as follows:

$\nu_{i,t} = \nu_{i,t-1} + \psi_t$, where $\psi_t \sim \mathrm{N}(0, \xi_t)$

Secondly, for the VAR model given by (1):

$$F_t = \mathrm{B}_{1t} F_{t-1} + \ldots \mathrm{B}_{pt} F_{t-p} + u_t$$

the elements of the vectors B_t and A_t are modeled as random walks while $\sigma_t$is assumed to evolve as a geometric random walk:

$$B_t = B_{t-1} + \eta_t, \qquad \text{(A.1)}$$

$$\alpha_t = \alpha_{t-1} + \rho_t, \qquad \text{(A.2)}$$

$$\log\sigma_t = \log\sigma_{t-1} + \mu_t \qquad \text{(A.3)}$$

We assume that all the innovations in the VAR, $\left[u_t', \eta_t', \rho_{t,}' \mu_t'\right]' \sim \mathrm{N}(0, \mathrm{P})$ with

$$P = \begin{bmatrix} \Omega & 0 & 0 & 0 \\ 0 & Q & 0 & 0 \\ 0 & 0 & S & 0 \\ 0 & 0 & 0 & W \end{bmatrix}$$

where I_K is a K dimensional identity matrix and Q,S,W are positive definite matrices.

A.2 Prior Distributions

We begin by the setting the priors for the factor equation. The prior for the factor loadings is as follows:

$\left[\Lambda_i^f, \Lambda_i^R\right] \sim \mathrm{N}(0_{1xK}, 4\mathrm{I}_\mathrm{K})$, while the prior of on the diagonal elements of V_t is equal to

$v_{t0} \sim \mathrm{N}(\mu_0, v_0)$ where μ_0 =0 and v_0 =4.

Last, the prior for the hyperparameter ξ_t is assumed to be inverse gamma

$\xi_t \sim IG(0.01, 0.01)$.

Next we follow Primicieri (2005) to set the priors for the VAR coefficients. The first ten years of the sample are used to calibrate the prior distributions. The prior of the VAR coefficients is equal to

$B_0 \sim \mathrm{N}(\hat{\mathrm{B}}_{OLS}, 4V(\hat{\mathrm{B}}_{OLS}))$, where $\hat{\mathrm{B}}_{OLS}$ is the OLS point estimate and $V(\hat{\mathrm{B}}_{OLS})$ is its variance in a time invariant VAR, estimated on the ten year subsample. In the same way, the prior of the off-diagonal elements of A_t is equal to:

$\mathrm{A}_0 \sim \mathrm{N}(\hat{\mathrm{A}}_{OLS}, 4V(\hat{\mathrm{A}}_{OLS}))$

The prior for the diagonal elements of the VAR covariance matrix is as follows:

$\log \sigma_0 \sim \mathrm{N}(\log \hat{\sigma}_{OLS}, \mathrm{I}_K)$. Turning to the hyperparameters of the VAR equation, the priors on Q, W, S are assumed to be inverse Wishart:

$Q_0 \sim IW(0.01^2 \cdot (\dim(\mathrm{B})+1) \cdot V(\hat{\mathrm{B}}_{OLS}), (\dim(\mathrm{B})+1))$

$W_0 \sim IW(0.01^2 \cdot (\dim(\alpha)+1) \cdot \mathrm{I}_\mathrm{K}), (\dim(\mathrm{A})+1))$

$S_0 \sim IW(0.1^2 \cdot (\dim(\sigma)+1) \cdot \mathrm{I}_\mathrm{K}), (\dim(\sigma)+1))$

where dim (B) , dim (A) and dim(σ) are the dimensions of each of the three matrices, which can be found by stacking in vectors the parameters as follows:

B_t =(vec(B_{1t})',.. vec(B_{pt}))' , σ_t = (logσ'_{1t}… logσ'_{Kt}) and α_t =($\alpha'_{j1,t}$,…$\alpha'_{j(j-1),t}$ for j=1,..K+1.

A.3 Posterior Distributions

Drawing the parameters of factor equation

In line with Bernanke at al. (2005), the diagonal elements of V_t are drawn from the following inverse gamma distribution:

$v_{ii} \sim iG(\overline{v}_{ii}, T + v_0)$ where $\overline{v}_{ii} = \mu_0 + \hat{e}_i^{'}\hat{e}_i$ with $\hat{e}_i$ denoting the residual $X_{it} - \Lambda_t F_{it}$

The factor loadings Λ_i are sampled from:

$$\Lambda_i \sim N(\overline{\Lambda}_i, v_{ii}\overline{\mathrm{M}}_i^{-1})$$

where $\overline{\Lambda}_i = \overline{\mathrm{M}}_i^{-1}(F_{it}^{'}F_{it})\hat{\Lambda}_i$ with $\hat{\Lambda}_i$ representing an OLS estimate, $\overline{\mathrm{M}}_i = \overline{\mathrm{M}}_0 + (F_{it}^{'}F_{it})$ with $\overline{\mathrm{M}}_0$ =I.

Sampling VAR parameters using a MCMC algorithm

Based on Primicieri (2005), we draw the parameters B_t, A_t, $\log\sigma_t$ by bringing the models defined in the observation equation (4) and the transition equations (5), (6) and (7)into a linear and Gaussian state space form so as to compute using standard Kalamn filter recursions. We first show how to draw the coefficient states B_t which is the most obvious part. The conditional distribution of B_t can be written as:

$$p(\mathrm{B}^T | F^T, A^T, \Sigma^{\mathrm{T}}, \mathrm{P}) = p(\mathrm{B}_T | F^T, A^T, \Sigma^{\mathrm{T}}, \mathrm{P}) \prod_{t=1}^{T-1} p(\mathrm{B}_t | \mathrm{B}_{t+1}, F^t, A^T, \Sigma^{\mathrm{T}}, \mathrm{P})$$

with $\mathrm{B}_t | \mathrm{B}_{t+1}, F^t, A^T, \Sigma^{\mathrm{T}}, \mathrm{P} \sim \mathrm{N}(\mathrm{B}_{t|t+1}, \mathrm{N}_{t|t+1})$

where $\mathrm{B}_{t|t+1} = \mathrm{E}(\mathrm{B}_t | \mathrm{B}_{t+1}, F^t, A^T, \Sigma^{\mathrm{T}}, \mathrm{P})$

and

$$\mathrm{N}_{t|t+1} = Var(\mathrm{B}_t | \mathrm{B}_{t+1}, F^t, A^T, \Sigma^{\mathrm{T}}, \mathrm{P}) .$$

To obtain $\mathrm{B}_{t|t+1}$ and $\mathrm{N}_{t|t+1}$, note that the system of equations defined earlier:

$$F_t = X_t' B_t + A_t^{-1} \Sigma_t n_t, \tag{4}$$

$$B_t = B_{t-1} + \eta_t \tag{A.1}$$

is a linear and Gaussian state space model. Thus we can proceed with standard Kalman filter forward and backward recursions (see Hamilton 1994). First, we calculate $\mathrm{B}_{t|t}$, $\mathrm{N}_{t|t}$, t =1,2,..T. The last iteration yields the mean and variance $\mathrm{B}_{\mathrm{T}|\mathrm{T}}$, $\mathrm{N}_{\mathrm{T}|\mathrm{T}}$ of the posterior distribution of B_T. Next, we treat this last drawn as extra information and we move backwards in time, using backward recursions, to obtain updated values

$\mathrm{B}_{T-1|T}, \mathrm{N}_{T-1|T}$, which is a draw for B_{T-1}. In a similar manner, we continue to draw values for B_t, t=T-2,T-3,..,1.

In the second step we draw the covariance states A_t as follows. First, notice that (4) an also be written as :

$$A_t(F_t - X_t'B_t) = \Sigma_t n_t = A_t F_t \quad \text{(A.4)}$$

where $F_t = F_t - X_t'B_t$ is observable since B^T is given from the previous step.

Since A_t is a lower triangular matrix with ones in the main diagonal, (A.4) can be written as:

$$F_t = Z_t a_t + \Sigma_t n_t, \quad \text{(A.5)}$$

where

$\alpha_t = \alpha_t - 1 + \rho_t$as defined in (A.2) and

Z_t is the following matrix of $(K+1)X\frac{(K+1)K}{2}$ dimensions:

$$Z_t = \begin{matrix} 0 & \dots & \dots & 0 \\ -F_{1,t} & 0 & \dots & 0 \\ 0 & -F_{(1,2),t} & \dots & \dots \\ \dots & \dots & 0 & 0 \\ 0 & \dots & 0 & -F_{(1,\dots K),t} \end{matrix}$$

With $F_{(1,..K),t}$ denoting the row vector $F_{1,t}, F_{2,t,}, \dots, F_{K,t,}$.

Now, the problem with the model given by equations (A.5), (A.2) is the fact that the dependent variable $F_t$of the observation equation is also appeared on the R.H.S in Z_t. Therefore the model has a nonlinear form thus we cannot draw $\alpha_{i,t}$ equation by equation using standard Kalman filter recursions as in the case of B_t. For this reason, we need to make the additional assumption that the covariance matrix of α_{it} , S, is block diagonal, where each block consists from the parameters $\alpha_{ij,t}$ which are in the same row of A_t. For example, there are K blocks $\alpha_t^{block1} = \alpha_{21,t}$, $\alpha_t^{block2} = \alpha_{31,t}, \alpha_{32,t}$ ... so that each block on the diagonal of S is of perspective dimensions. Then we proceed exactly as in the previous step to drawn recursively from:

$$p(\alpha_{i,t} \mid a_{i,t+1}, F^t, \mathrm{B}^T, \Sigma^{\mathrm{T}}, \mathrm{P}) \sim \mathrm{N}(a_{i,t|t+1}, \Gamma_{i,t|t+1})$$

where

$a_{i,t|t+1} = \mathrm{E}(\alpha_{i,t} \mid a_{i,t+1}, F^t, \mathrm{B}^T, \Sigma^{\mathrm{T}}, \mathrm{P})$ and

$$\Gamma_{i,t|t+1} = Var(\Gamma_{i,t} \middle| \Gamma_{i,t+1}, F^t, \mathrm{B}^T, \Sigma^{\mathrm{T}}, \mathrm{P}).$$

In the third step, conditional on B^{T} and A^{T}, we proceed by drawing the volatility states $\log \sigma_t$. To do so, we first re-write equation (A.4) as:

$$A_t(F_t - X_t' B_t) = \Sigma_t n_t = F_t^* \qquad \text{(A.6)}$$

where now $F_t^* = A_t(F_t - X_t' B_t)$ is observable given B^{T} and A^{T} from the previous two steps. This system is nonlinear but it can be easily converted to a linear one by squaring and taking logarithms of (11) as follows:

$$log(F_{i,t}^*)^2 = \log\ \sigma_{i,t}^2 n_{i,t}^2\ = 2log\ \sigma_{i,t}\ + log\ n_{i,t}^2$$

or

$$log(F_{i,t}^*)^2 = 2log\ \sigma_{i,t}\ +\ g_{i,t}$$
(A.7)

where $g_{i,t}$=$log\ n_{i,t}^2$. Equation (A.7) together with

$$log\sigma_{\mathrm{t}} = \ log\sigma_{\mathrm{t}}{-}1\ + \mu_{\mathrm{t}} \qquad \text{(A.3)}$$

give a linear state space form. However the innovations $g_{i,t}$ are distributed as a $logx^2(1)$ thus the system is not a Gaussian one. To transform the system into a Gaussian we follow Kim, Shephard and Chib (1998) by defining a mixture of K normal approximations of the $f(g_t)$ distribution, as follows:

$$f\ g_t\ =\ {}_{j=1}^{K} q_j f_N(g_t | m_j - 1.2704, \upsilon_j^2)$$

where $\mathrm{f_N}$ is the normal density with components probabilities q_{j}, means m_{j} and variances υ_{j}.. We define $s^T\ =\ \mathrm{s}_1, \dots, \mathrm{s_T}\ '$the matrix of indicator variables selecting at every point in time which member of the mixture of normal approximations $f\ g_t$ has to be used for each element of n. Then the procedure is much like the previous steps. Then the system has an approximate linear and Gaussian state space form and much like in the previous steps of the sampler, this procedure allows to recursively recover:

$$log\sigma_{t|t+1} = E(log\sigma_t | log\sigma_{t+1}, F^t, A^T, B^T, P, s^T)$$

and

$$H_{t|t+1} = Var(log\sigma_t | log\sigma_{t+1}, F^t, A^T, B^T, P, s^T)$$

and recursively draw every $log\sigma_t$ from:

$p(log\sigma_t | log\sigma_{t+1}, F^t, A^T, B^T, P, s^T)$, which is $\mathrm{N}(log\sigma_{t|t+1}, H_{t|t+1})$.

Conditional on $log(F_{i,t}^*)^2\ ^T$ and the new $log\sigma_t$, it is possible to sample the new s^{T} to be used in the next iteration from the discrete density defined by:

$$p\left(s_{i,t} = j \mid log(F^*_{i,t})^2, log\sigma_t\right) \propto q_j f_N\left(log(F^*_{i,t})^2 \mid 2log\left(\sigma_{i,t}\right) + m_j - 1.2704, \upsilon_j^2\right),$$

$j = 1, \ldots, 7$, $i = 1, \ldots, K$.

Last, we draw the hyperparameters Q, S,W of the covariance matrix P, conditional on $F^t, \mathrm{B}^T, \Sigma^{\mathrm{T}}, \mathrm{A}^{\mathrm{T}}$, where each hyperparameter has an inverse-Wishart posterior distribution:

$$p(Q,S,W \mid F^t, \mathrm{A}^{\mathrm{T}}, \mathrm{B}^T, \Sigma^{\mathrm{T}}) = p(Q \mid F^t, \mathrm{A}^{\mathrm{T}}, \mathrm{B}^T, \Sigma^{\mathrm{T}}) \cdot p(S_1 \mid F^t, \mathrm{A}^{\mathrm{T}}, \mathrm{B}^T, \Sigma^{\mathrm{T}}) \cdot$$

$$\ldots \cdot p(S_{K-1} \mid F^t, \mathrm{A}^{\mathrm{T}}, \mathrm{B}^T, \Sigma^{\mathrm{T}}) \cdot p(W \mid F^t, \mathrm{A}^{\mathrm{T}}, \mathrm{B}^T, \Sigma^{\mathrm{T}}).$$

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Figure 1: Responses of US variables to a contractionary US monetary policy shock

Selected impulse responses of US variables to a contractionary US monetary policy shock. In this panel there are also depicted several exchange rates against USD. The black line presents the posterior median of responses while the red lines are the 32th and 68th percentiles.

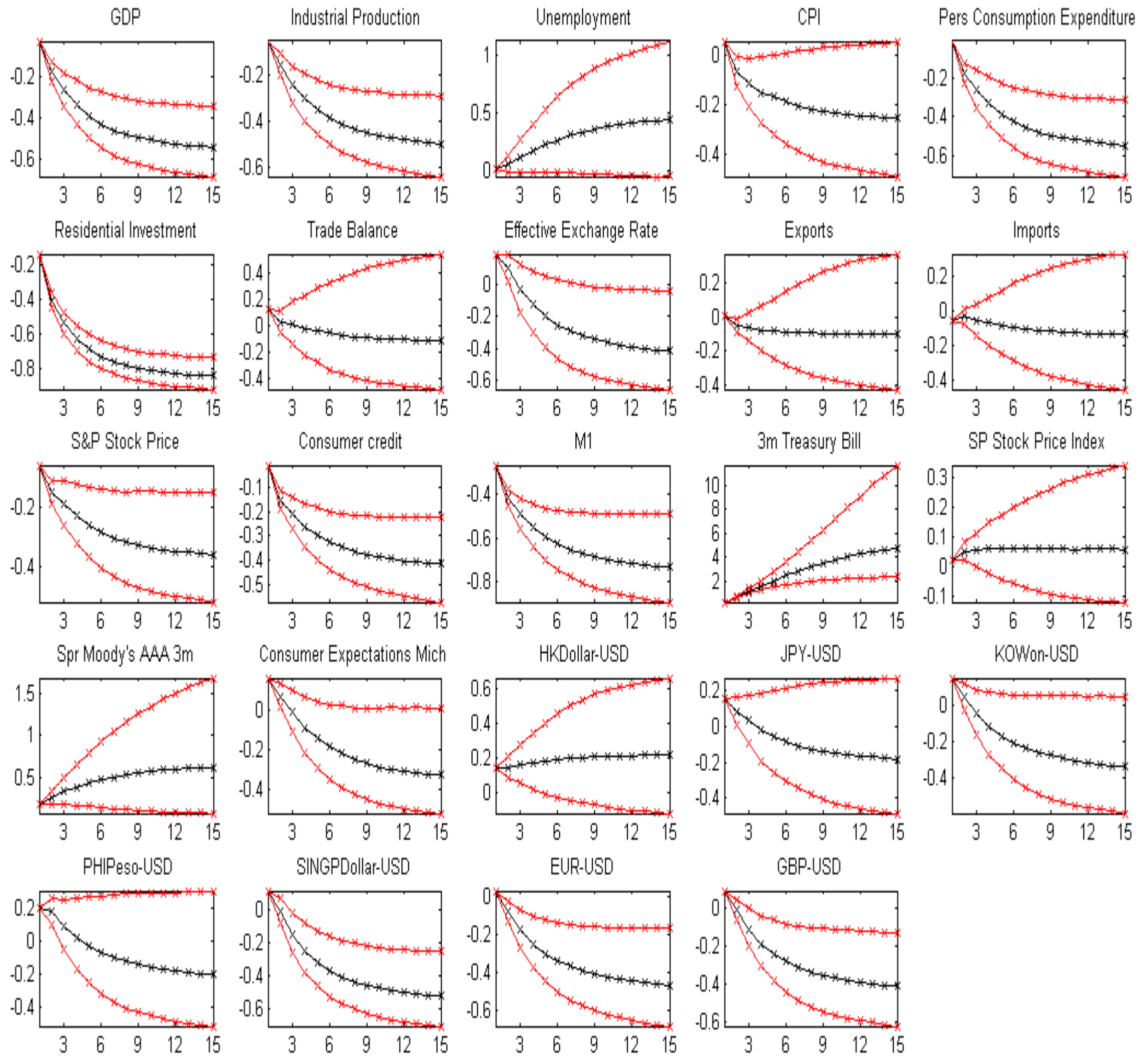

Figure 2: Responses of real activity and inflation variables for East Asian countries

Selected impulse responses of real activity and inflation variables for East Asian countries to a contractionary US monetary policy shock. The black line presents the posterior median of responses while the red lines are the 32th and 68th percentiles.

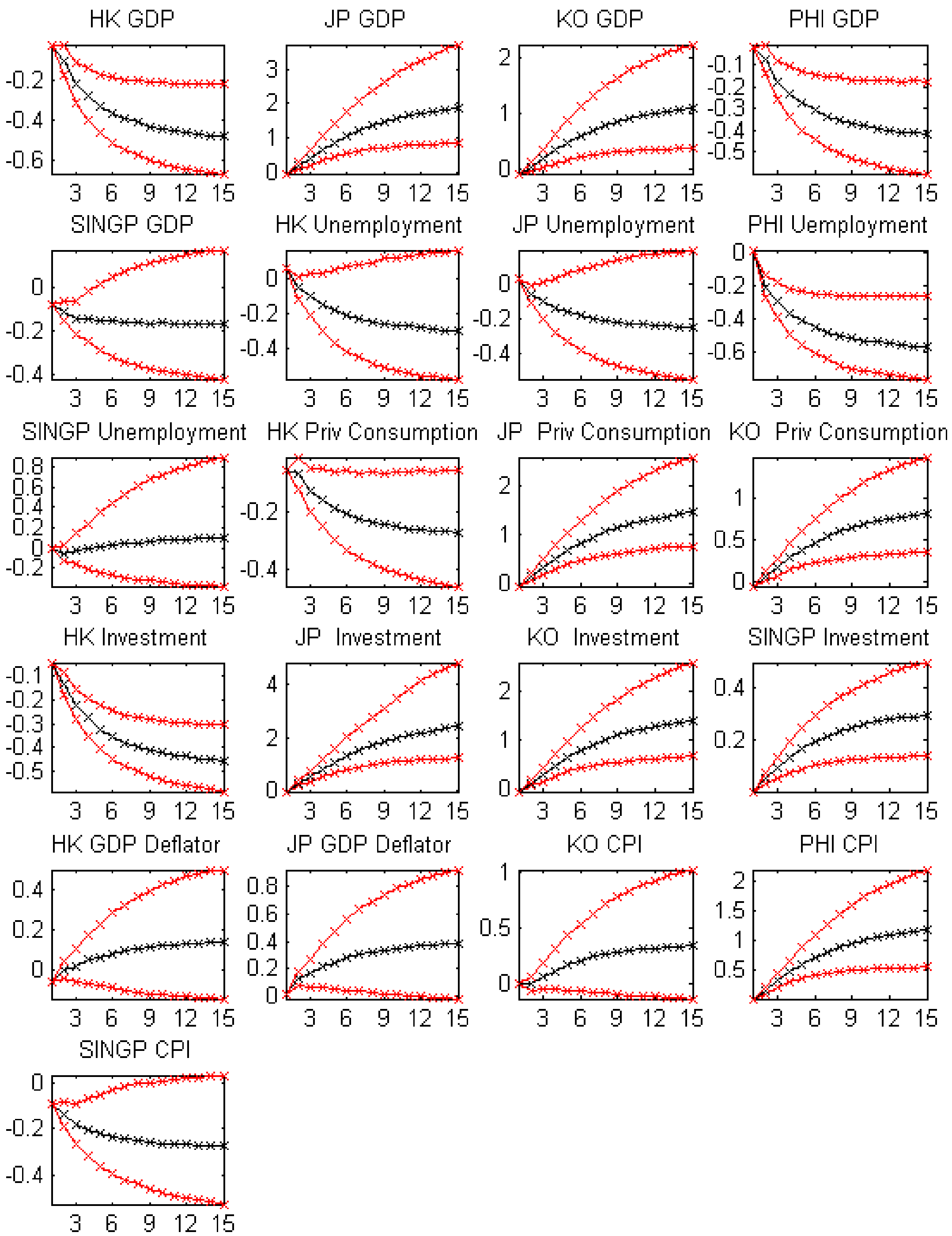

Figure 3: Responses of trade activity variables for East Asian countries

Selected impulse responses of trade activity variables for East Asian countries to a contractionary US monetary policy shock. The black line presents the posterior median of responses while the red lines are the 32th and 68th percentiles.

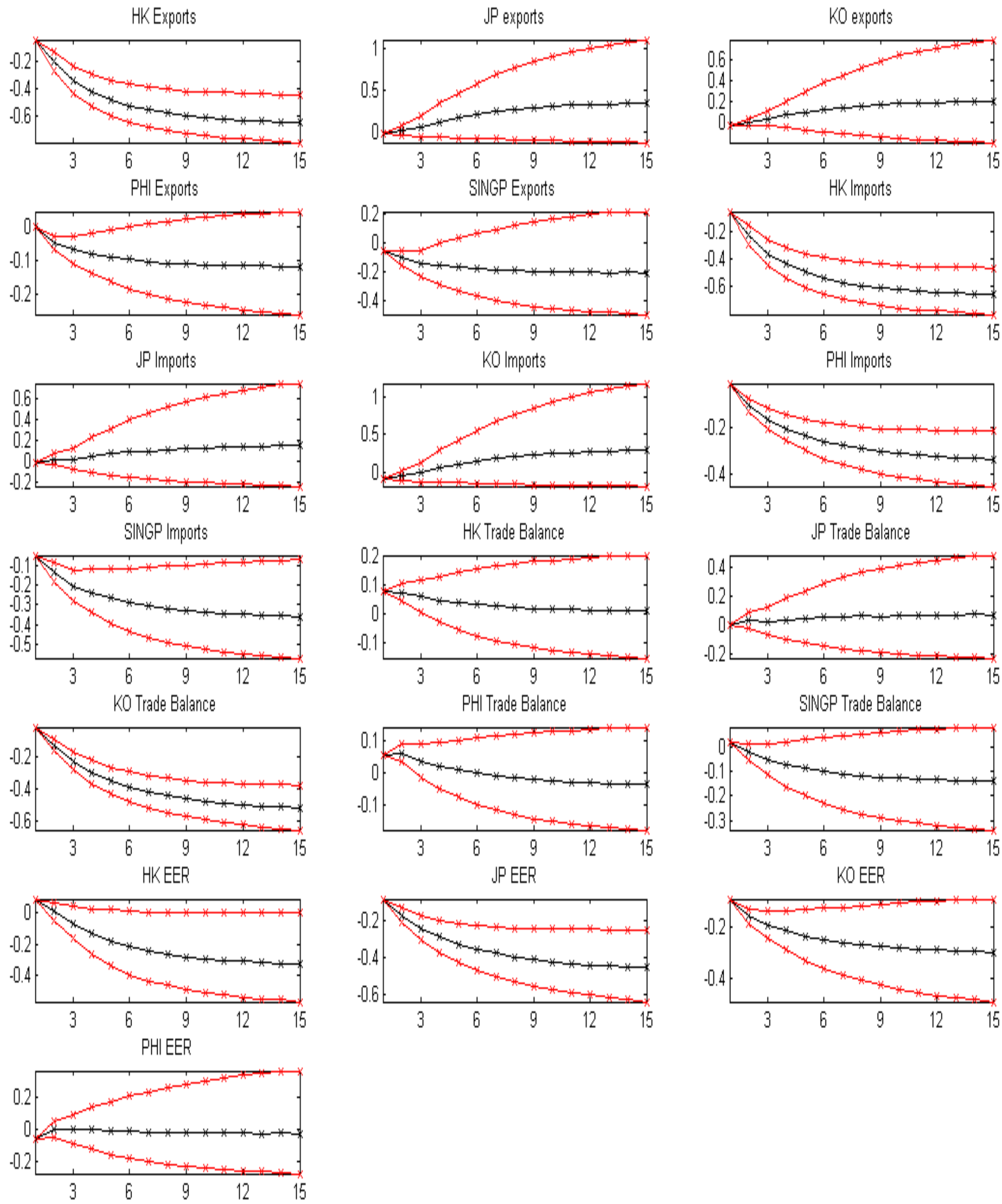

Figure 4: Responses of asset price variables for East Asian countries

Selected impulse responses of asset price variables for East Asian countries to a contractionary US monetary policy shock. The black line presents the posterior median of responses while the red lines are the 32th and 68th percentiles.

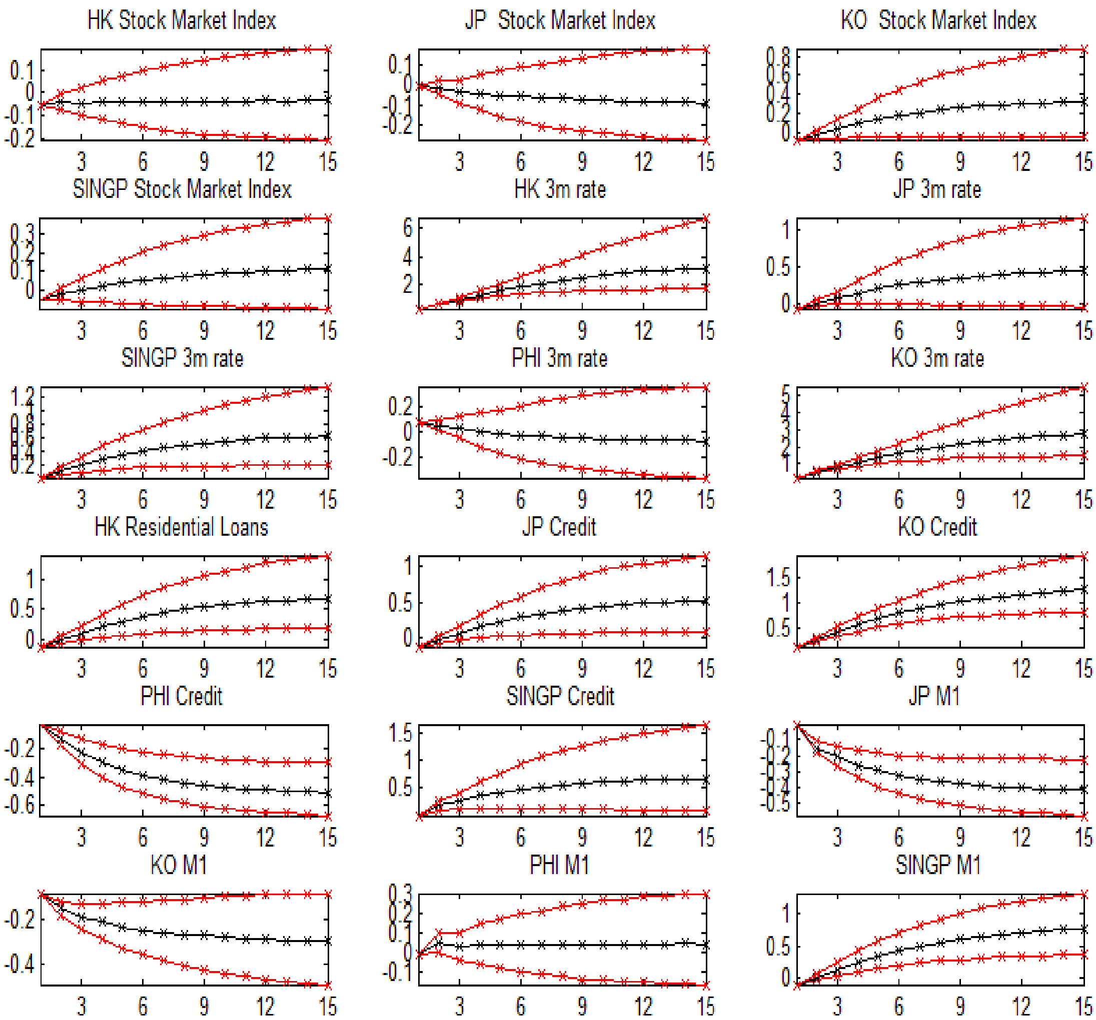

Figure 5: Responses of real activity and inflation variables for euro area countries

Selected impulse responses of real activity and inflation variables for euro area countries to a contractionary US monetary policy shock. The black line presents the posterior median of responses while the red lines are the 32th and 68th percentiles.

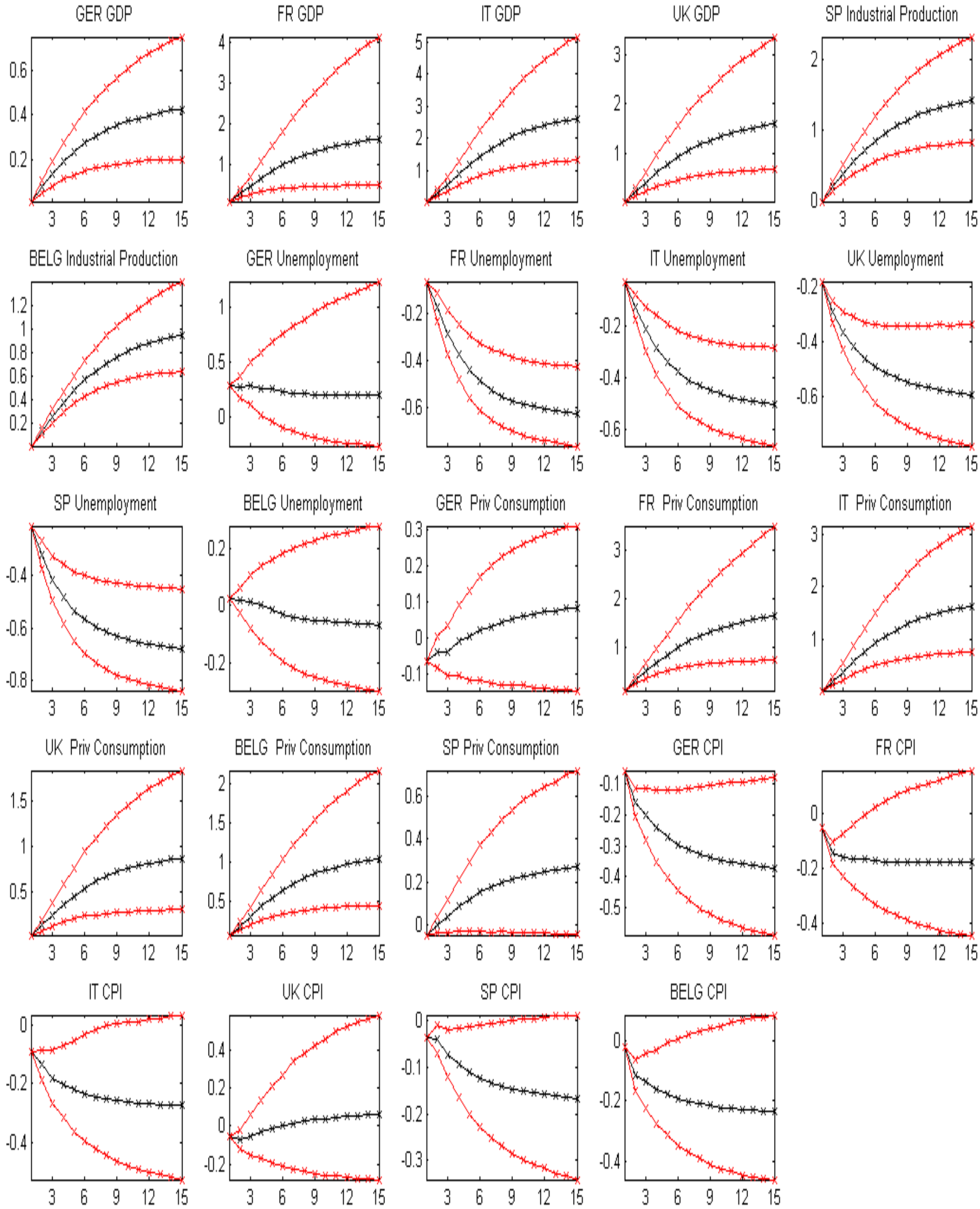

Figure 6: Responses of trade activity variables for euro area countries

Selected impulse responses of trade activity variables for euro area countries to a contractionary US monetary policy shock. The black line presents the posterior median of responses while the red lines are the 32th and 68th percentiles.

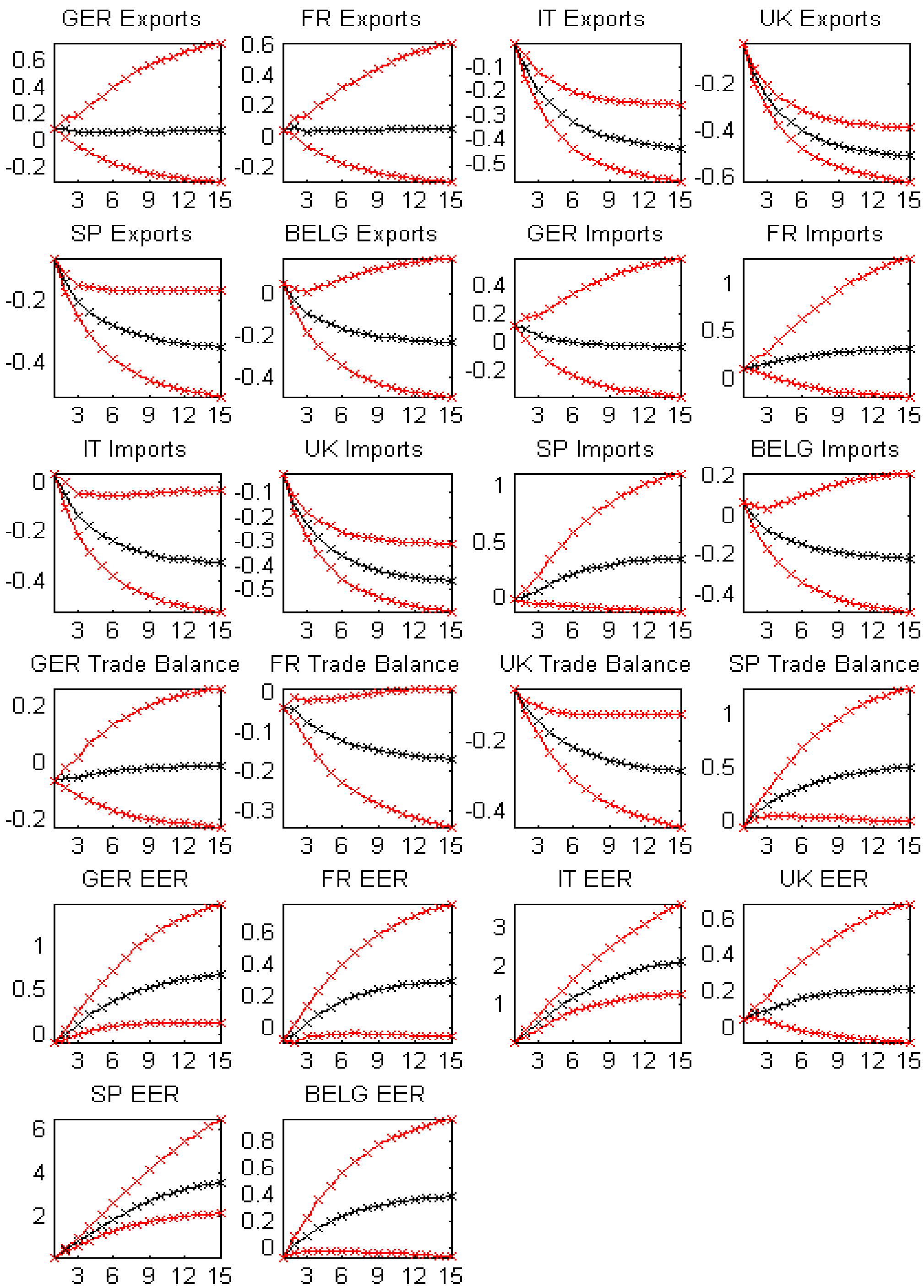

Figure 7: Responses of asset price variables for euro area

Selected impulse responses of asset price variables for euro area countries to a contractionary US monetary policy shock. The black line presents the posterior median of responses while the red lines are the 32th and 68th percentiles.

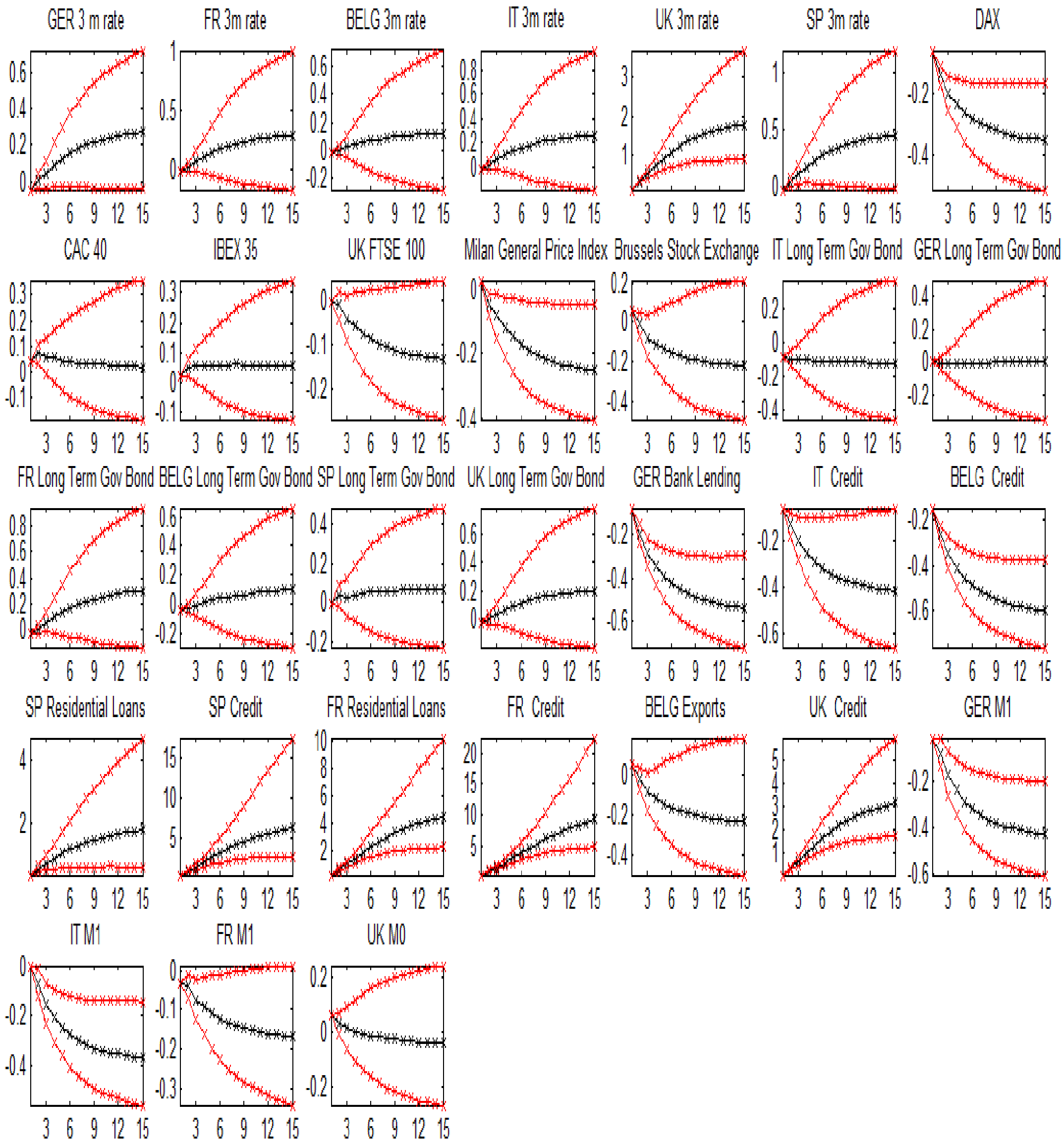

Table 1: Posterior medians of responses for US variables

Posterior medians of -one year after -impulse responses for selected US variables. The responses referred to four representative periods, 1987, 1999, 2007 and 2013. The year 1987 signs the beginning of global integration, 1999 is chosen to gauge the impacts of the gradual deepening of financial integration, 2007 represents the pre- crisis period while 2013 is indicative of the post crisis period.

US variables

	1987	1999	2007	2013
Real Activity Variables				
GDP	-0.09	-0.01	-0.37	-0.33
IP	0.01	0.03	-0.31	-0.31
Employment	0.35	0.43	0.32	0.25
Unemployment	0.00	-0.03	0.07	0.02
Pers. Cons.	-0.11	-0.03	-0.42	-0.29
Resid. Inv.	-0.47	-0.38	-0.65	-0.59
Gov. Cons.	0.63	0.40	0.17	0.30
Inflation Variables				
CPI	0.21	0.14	0.64	0.03
GDP Deflator	0.73	0.52	1.35	0.73
PPI Fin. Goods	0.11	0.04	0.51	0.03
Asset Prices and Monetary Variables				
S&P	-0.16	-0.18	-0.28	-0.25
DJ Ind. Index	-0.10	-0.16	-0.27	-0.21
House Price	0.59	0.65	0.21	0.44
Consumer Credit	0.30	0.42	0.30	0.35
3m Rate	0.29	0.26	0.30	0.17
12m Rate	-0.05	0.04	0.00	-0.05
10y Gov Bond	-0.02	-0.01	-0.04	-0.04
M0	-0.34	-0.39	-0.36	-0.18
M1	-0.48	-0.60	-0.63	-0.45
M2	0.43	0.21	0.26	0.81
Trade Activity Variables				
Trade balance	-0.06	-0.22	-0.40	-0.35
Terms of Trade	0.29	0.41	-0.21	0.05
REER	-0.04	0.68	0.33	-0.07
Imports	0.35	0.19	-0.10	-0.10
Exports	-0.32	-0.24	-0.03	0.00

	1987	1999	2007	2013
Exchange Rates (./USD)				
CHYuan	-0.05	0.29	0.35	0.04
HKDollar	0.33	0.47	0.28	0.13
JPY	0.10	0.47	0.21	0.02
KOWon	0.12	0.54	0.06	-0.04
PHIPeso	-0.07	0.58	0.56	0.13
MALAYRinggit	-0.21	0.04	0.05	-0.23
SINGPDollar	-0.10	0.40	0.10	-0.23
TWDollar	-0.23	0.19	0.17	-0.14
INDRupee	-0.03	-0.05	0.08	-0.14
EUR	-0.16	-0.02	-0.13	-0.38
GBP	-0.25	-0.13	-0.08	-0.31
Miscellaneous				
Consumer Expectations Mich.	-0.15	0.01	-0.03	-0.05
Expectation of CPI Inflation	0.14	0.07	0.06	0.02
Expectation of GDP Deflator	0.75	0.53	0.38	0.38
Spread: Moody's AAA-3m	-0.19	-0.24	-0.32	-0.21

Table 2: Posterior medians of responses for foreign real activity variables

Posterior medians of -one year after -impulse responses for selected real activity indicators. The responses referred to four representative periods, 1987,1999,2007 and 2013.

Real Activity variables

GDP

	1987	1999	2007	2013
HK	0.12	0.19	-0.23	-0.28
JP	1.94	0.38	0.14	0.63
KO	1.21	0.09	-0.05	0.24
PHI	0.08	0.18	-0.16	-0.21
SINGP	0.33	0.01	-0.28	-0.24
GER	0.33	0.16	0.17	0.17
FR	1.84	0.82	0.22	0.48
IT	1.82	0.43	0.34	0.74
UK	1.57	0.47	0.13	0.52

Unemployment

	1987	1999	2007	2013
HK	-0.11	-0.03	-0.13	-0.07
JP	-0.10	-0.05	-0.15	-0.06
PHI	-0.05	-0.03	-0.16	-0.13
SINGP	0.03	0.00	-0.11	-0.02
GER	-0.09	0.07	0.01	-0.01
FR	-0.08	-0.01	-0.11	-0.04
IT	-0.01	0.02	-0.10	-0.04
SP	-0.03	-0.08	-0.13	-0.05
BELG	0.04	0.06	-0.06	0.02
UK	0.03	-0.04	-0.09	-0.05

Industrial Production

	1987	1999	2007	2013
HK	-0.11	0.07	-0.28	-0.42
JP	0.87	0.24	-0.19	-0.09
KO	0.80	0.03	-0.29	0.03
SINGP	0.34	0.06	-0.33	-0.28
GER	1.11	0.46	0.06	0.07
FR	1.06	0.35	-0.12	-0.01
IT	0.23	0.07	-0.05	0.05
SP	1.01	0.53	0.00	0.16
BELG	0.69	0.30	0.02	0.01
UK	0.58	0.17	-0.31	-0.20

Private Consumption

	1987	1999	2007	2013
HK	0.13	0.08	-0.15	-0.12
JP	1.07	0.12	0.13	0.51
KO	0.73	0.09	0.04	0.15
SINGP	0.44	0.06	-0.12	0.03
GER	0.37	0.02	-0.07	-0.07
FR	1.23	0.67	0.30	0.65
IT	1.50	0.44	0.20	0.42
BELG	0.68	0.36	0.46	0.08
UK	0.98	0.33	0.09	0.26

Government Consumption

	1987	1999	2007	2013
HK	0.44	0.13	0.29	0.64
JP	0.17	0.01	-0.19	-0.09
KO	0.38	0.09	0.27	0.35
PHI	-0.23	-0.14	-0.03	-0.15
SINGP	0.20	0.21	0.34	0.27
FR	-0.10	-0.19	-0.18	-0.06
UK	-0.06	0.11	-0.03	-0.15

Investment

	1987	1999	2007	2013
HK	-0.13	-0.09	-0.19	-0.31
JP	1.41	0.36	0.38	0.86
KO	1.00	0.16	0.06	0.36
SINGP	0.24	0.10	0.12	0.07
FR	1.89	1.12	0.66	0.89
UK	0.52	0.23	0.08	0.34

Table 3: Posterior medians of responses for trade activity and inflation variables

Posterior medians of -one year after –impulse responses for selected trade activity and inflation variables.The responsesrefer to1987,1999, 2007 and 2013.

Trade Activity and Inflation variables

	1987	1999	2007	2013
Exports				
HK	-0.04	0.04	-0.37	-0.47
JP	0.56	0.18	-0.27	-0.31
KO	0.32	-0.06	-0.36	-0.18
PHI	0.01	0.00	-0.09	-0.18
SINGP	0.51	0.11	-0.30	-0.22
GER	0.46	0.48	0.12	-0.15
FR	0.74	0.50	0.00	-0.11
IT	0.03	0.13	-0.12	-0.39
SP	0.14	-0.01	-0.28	-0.32
BELG	0.15	0.25	-0.07	-0.35
UK	-0.20	-0.04	-0.19	-0.43
Imports				
HK	-0.07	-0.03	-0.38	-0.50
JP	0.83	0.33	-0.11	-0.08
KO	0.45	-0.05	-0.24	-0.09
PHI	-0.07	-0.05	-0.15	-0.29
SINGP	0.25	0.07	-0.28	-0.35
GER	0.33	0.54	0.23	-0.26
FR	0.68	0.61	0.18	-0.12
IT	0.17	0.30	-0.08	-0.38
SP	0.99	0.26	-0.20	0.13
BELG	0.15	0.30	-0.01	-0.35
UK	-0.05	0.00	-0.25	-0.39
Trade Balance				
HK	0.01	0.06	0.02	0.00
JP	0.15	0.09	-0.05	0.04
KO	-0.02	0.00	-0.08	-0.04
PHI	0.02	0.05	0.00	0.01
SINGP	0.04	0.04	-0.07	-0.02
GER	0.06	-0.01	-0.08	0.03
FR	0.03	0.01	-0.02	0.02
SP	-0.05	-0.06	0.11	0.09
UK	-0.04	-0.03	0.00	-0.03

	1987	1999	2007	2013
Effective Exchange Rate				
HK	-0.10	0.21	0.13	-0.10
JP	-0.06	-0.17	-0.33	-0.22
KO	0.03	-0.09	-0.16	-0.04
PHI	-0.15	-0.12	0.00	0.12
GER	-0.07	-0.25	0.03	0.36
FR	-0.21	-0.23	0.02	0.13
IT	0.63	0.18	0.33	0.83
SP	1.10	0.29	0.56	1.19
UK	0.34	0.19	0.00	0.06
Terms of Trade				
HK	-0.06	0.12	0.17	0.15
JP	0.34	-0.01	-0.16	0.56
SINGP	0.00	0.34	0.32	-0.02
GER	0.27	-0.10	-0.12	0.70
UK	-0.19	-0.22	-0.13	-0.15
SP	0.57	0.05	0.06	0.86
CPI/GDP deflator				
HK	-/0.17	-/-0.03	-/0.12	-/0.06
JP	0.01/0.43	-0.09/0.21	0.01/0.32	-0.26/0.4
KO	0.07/0.21	-0.16/-0.07	0.16/0.12	0.01/0.13
PHI	0.29/0.17	0.02/0.10	0.49/0.04	0.26/-0.07
SINGP	-0.2/0.19	-0.25/0.28	-0.05/0.19	-0.33/0.04
GER	-0.41/- -	-0.32/-	-0.03/-	-0.34/ -
FR	0.08/1.25	-0.22/0.35	-0.12/0.55	-0.35/0.76
IT	0.24/-	-0.12/-	0.11/-	-0.08/-
SP	-0.1/-	-0.09/-	0.12/-	-0.28/ -
BELG	-0.35/-	-0.27/ -	0.05/-	-0.36/-
UK	-0.13/1.14	-0.22/0.23	0.20/0.43	-0.26/0.73

Table 4: Posterior medians of responses for selected asset price variables

Posterior medians of one-year-after-impulse responses for selected asset price variables. The responses referred to four representative periods, 1987,1999, 2007 and 2013.

Asset Price variables

	1987	1999	2007	2013
3 month interest rate				
HK	0.24	0.22	0.24	0.14
JP	0.17	0.02	0.09	0.04
KO	0.01	0.03	0.06	-0.03
PHI	0.07	0.09	0.06	-0.01
SINGP	0.22	0.18	0.26	0.14
GER	0.04	0.02	0.10	-0.02
FR	0.11	0.03	0.11	0.02
IT	0.11	0.04	0.09	0.02
SP	0.16	0.05	0.09	0.04
BELG	0.11	0.04	0.11	0.01
UK	0.19	0.13	0.20	0.09
Stock Market Index				
HK	0.04	-0.04	-0.08	-0.07
JP	0.21	0.15	-0.12	-0.04
KO	0.35	-0.07	-0.21	0.07
SINGP	0.20	-0.01	-0.11	0.01
GER	0.10	0.21	0.20	0.11
FR	0.16	0.23	0.12	0.09
IT	-0.05	0.03	-0.16	-0.11
BELG	-0.02	0.09	0.13	0.09
SP	0.12	0.11	0.05	0.11
UK	0.08	0.08	-0.02	-0.03
Long Term Interest Rate				
JP	0.13	0.03	0.09	0.02
GER	0.10	0.06	0.07	-0.02
FR	0.16	0.06	0.08	0.01
IT	0.09	0.01	0.06	0.00
BELG	0.13	0.04	0.07	0.00
SP	0.11	0.03	0.03	0.01
UK	0.08	0.05	0.07	0.02

	1987	1999	2007	2013
Residential Loans/Consumer Credit				
HK	0.43/-	-0.16/-	0.06/-	0.13/ -
JP	-/0.23	-/-0.17	-/0.00	-/0.22
KO	-/0.56	-/0.40	-/0.46	-/0.45
PHI	- /-0.36	- /-0.14	-/0.01	-/-0.27
SINGP	-/0.12	/0.06	- /0.57	-/0.57
GER	-0.04/-0.16	-0.13/-0.11	-0.28/0.00	-0.34/-0.22
FR	1.25/2.16	0.88/1.12	1.25/1.86	1.02/1.91
IT	-/0.69	-/0.17	-/0.43	-/0.42
SP	0.96/1.62	1.23/1.44	1.01/1.76	0.53/1.44
BELG	-/-0.46	/-0.39	-/-0.29	-/-0.35
UK	-/1.21	-/0.53	-/0.60	-/0.76
M0/M1				
JP	0.64/-0.16	0.39/-0.12	0.24/-0.32	0.46/-0.28
KO	0.13/0.09	0.15/-0.09	-0.04/-0.33	-0.06/ -0.24
PHI	0.33/0.26	0.30/0.27	0.03/0.05	0.05 /0.06
SINGP	0.19/0.16	0.02/-0.17	0.08/0.01	0.14/0.26
GER	0.21/-0.13	0.31/0.07	0.14/-0.11	-0.04/-0.21
IT	-/0.08	-/0.20	-/-0.16	-/-0.21
FR	-/0.11	-/0.14	-/-0.19	-/-0.18
UK	0.22/-	0.24/-	-0.09/-	0.02/-

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