International monetary transmission to the Euro area: Evidence from the U.S., Japan and China

Vespignani, Joaquin L. and Ratti, Ronald A.

University of Tasmania, University of Western Sydney

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Joaquin L. Vespignani[a*] and Ronald A. Ratti[b**]

[a]University of Tasmania, School of Economics and Finance, Australia
[b]University of Western Sydney, School of Business, Australia

Abstract

There are marked differences in the effect of increases in monetary aggregates in China, Japan and the U.S. on Euro area economic and financial variables over 1999-2012. Increases in monetary aggregates in China are associated with significant increases in the world price of commodities and with increases in Euro area inflation, industrial production and exports. Results are consistent with shocks to China's M2 facilitating domestic growth with expansionary consequences for the Euro area economy. In contrast, increases in monetary aggregates in Japan are associated with significant appreciation of the Euro and decreases in Euro area industrial production and exports. Production of goods highly competitive with European goods in Japan and expenditure switching in Japan are consistent with the results. U.S. monetary expansion has relatively small effects on the Euro area over this period compared to results reported in the literature for earlier sample periods.

Keywords: International monetary transmission, China's monetary aggregates, Euro area Commodity prices

JEL Codes: E52, E58, F31, F42

[*]Corresponding author: Joaquin L. Vespignani; University of Tasmania, School of Economics and Finance, Australia; Tel. No: +61 3 62262825; E-mail address: Joaquin.Vespignani@utas.edu.au

[**]Ronald A. Ratti; University of Western Sydney, School of Business, Australia; Tel. No: +61 2 9685 9346; E-mail address: r.ratti@uws.edu.au

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1. Introduction

This paper examines the influence of monetary aggregates shocks in U.S., China and Japan on the Euro area over 1999-2012. The topic is of interest given the rise in global monetary aggregates in recent years and the growing importance of China in the world economy. In 2011 China's M2 surpassed that in Japan, the U.S. and in the Euro area for the first time. The growing importance of China's money supply and unprecedented monetary expansion in the largest economies is illustrated in Figure 1. Given these developments, does a monetary expansion outside the Euro area have positive or negative effects in the Euro area? Does it matter where the monetary expansion originates? Does a monetary expansion in China, Japan or U.S. have the same consequences in improving or in worsening production in the Euro area and the Euro area trade balance?

The major finding of the paper is that over 1999-2012 China's monetary expansion has significant effects on the Euro area that are quite different from those of the U.S. and Japan.[1] China operates a dollar peg and has extensive capital controls in place. How then would China's monetary policy influence the Euro area? The influence on the Euro area is through an increase in demand for imports and given the sheer scale of China's growth through effects on world commodity prices. The rise in commodity prices is reflected in significantly higher inflation in the Euro area. China's monetary expansion is also associated with significant increases in Euro area industrial production and income absorption in China is reflected in greater Euro area exports.

[1] Sun (2009) argues that China operated an independent monetary policy during the fixed exchange rate period 1998 to 2005. Goodfriend and Prasad (2007) note that capital controls provide room for monetary policy independence in China even though the central bank manages the exchange rate. In the Mundell–Fleming model with imperfect capital mobility, sterilization actions under a fixed exchange rate permit an independent monetary policy. Up until 2005 the Renminbi was pegged to the U.S. dollar. Since 2005 the Renminbi has been allowed to float in a narrow margin around a fixed base rate determined with reference to a basket of major currencies.

Increases in monetary aggregates in Japan lead to significant appreciation of the Euro and are associated with significant decreases in Euro area industrial production and exports. Japanese production of goods highly competitive with European goods and expenditure switching in Japan are consistent with the results. U.S. monetary expansion has relatively small effects on the Euro area over 1999-2012. This contrasts with work on earlier time periods finding that U.S. expansionary monetary policy causes boom in other countries (for example, Kim (2001a)).

In this investigation we developed a novel approach to test the impact of foreign monetary aggregates shocks on the domestic Euro area economy.[2] The international monetary variables are assumed to be contemporaneously exogenous in a structural vector autoregression (SVAR) model. The effects of exogenous monetary policy shocks in China, Japan and the U.S. on Euro area output, inflation, monetary aggregates, interest rate, exchange rate and trade are then examined. Examination of the effect of changes in international monetary aggregates on the Euro area economy is important since these variables capture quantitative easing, something that interest rates, already at low levels, are unable to do.

In section 2 background studies on the effect of foreign monetary policy shocks on other economies are discussed. In section 3 the methodology for the study of international monetary transmission to the Euro area is presented. Data and variables are discussed in Section 4. The empirical results are presented in Section 5. Section 6 concludes.

2. Background studies

A number of papers have examined the effect of foreign monetary policy shocks on other economies. Intertemporal models by Svensson and Van Wijnbergen (1989) and

[2] Use of a SVAR to examine the impact of monetary aggregate shocks on economic variables is in line with a large number of VAR models showing the importance of monetary shocks for the real variable. Examples include Canova and De Nicolo (2002), Leeper and Roush (2003), and Favara and Giordani (2009)).

Obstfeld and Rogoff (1995) suggest that monetary expansion in a large open economy such as the U.S. will decrease world real interest rates and stimulate global aggregate demand in the U.S. and non-U.S. countries. Kim (2001a) finds that over 1974-1996 monetary expansion in the U.S. causes economic expansion in the non-U.S. G-6 by lowering interest rates across these economies. Holman and Neumann (2002) find that U.S. monetary expansion has positive effects on real activity in Canada. Canova (2005) reports a similar finding with regard to the effect of U.S. monetary policy on Latin American countries. Miniane and Rogers (2007) find that capital controls do not manage to insulate countries from U.S. monetary shocks. Shambaugh (2004) finds significant differences between how the domestic interest rates of exchange rate fixers and floaters respond to changes in foreign interest rates. Di Giovanni and Shambaugh (2008) show that high interest rates in a major country have a contractionary effect on the domestic economy of a country that fixed its exchange rate to that of the major country. The empirical work in these studies employs a SVAR framework.

Dedola and Lippi (2005) construct a SVAR for each of five OECD countries based on Christiano et al.'s (1999) five variable SVAR model for the U.S. which includes industrial production, the consumer price index, a commodity price index, a short-term interest rate and a monetary aggregate. Dedola and Lippi (2005) introduce sector output and the exchange rate into the Christiano et al. (1999) model. Kim and Roubini (2000) include the world price of oil in their SVAR model in their examination of exchange rate anomalies so as to capture negative and inflationary supply shocks. For non-U.S. G-6 Kim and Roubini (2000) find that the exchange rate has a transitory appreciation following a domestic monetary policy contraction and find no indication of open economy anomalies. Building on the Kim and Roubini (2000) model, Kim (2001a) examines the impact of U.S. monetary policy shocks on the non-U.S. G-6 and introduces bilateral trade balances into the model.

The predictions of the Mundell–Flemming–Dornbusch framework are ambiguous as to the effects of a monetary expansion in a foreign country on the domestic economy. A monetary expansion in a foreign country leads to an appreciation of the domestic real exchange rate which deteriorates domestic real trade balance as imports became cheaper and exports relatively more expensive for the domestic economy (switching-expenditure). Nevertheless, monetary expansions in a foreign country also improves income in this country, which could overtime lead to an increase in imports from other countries generating a positive effect on trade partner's net trade balance (income-absorption).

Kim (2001b) finds that for France, Italy and the U.K. (for approximately twenty year periods for each country ending in 1996) the exchange rate has a temporary appreciation following a domestic monetary policy contraction. Koray and McMillin (1999) report a similar result for the U.S. over 1973-1993. Kim (2001b) finds that the expenditure substitution effect of a devaluation dominates the income absorption effect of a domestic monetary expansion and the trade balance for these countries improves and that there is little evidence of a J-curve effect. Koray and McMillin (1999) report that for the U.S. there is evidence of a J-curve effect.

Grilli and Roubini (1996) survey work on liquidity models in open economies and argue the non-neutrality of money derives from a separation of goods and asset markets. Building on Kim (1999), Sousa and Zaghini (2008) find that increases in foreign liquidity increase the Euro area monetary aggregate and price level and temporarily increase Euro area output and real effective exchange rate. Dees et al. (2007) find that the short-term US interest rate does not significantly affect Euro area variables in a global VAR model.

Fan et al. (2011) finds that the growth rate in money supply (M2) play a crucial role in fine-tuning China's economy, while official interest rates played a very passive role. Johansson (2012) notes that starting in 1998 the central bank of China began open market operations for the first time and that this was one of the most significant changes in China's monetary system. Koz´luk and Mehrotra (2009) find that China's monetary expansion significantly impacts real activity in East and Southeast Asian countries by increasing in demand for imports. Johansson (2012) finds that China's monetary policy also influences equity markets in Southeast Asia. Koz´luk and Mehrotra (2009) and Johansson (2012) use M2 as the measure of China's monetary policy.

3. The Methodology

The goal of the paper is to assess whether shocks to the monetary aggregates of the U.S., China, and Japan are transmitted into Euro area activity. The paper estimates two SVARs on U.S., Chinese, Japanese, and Euro Zone M2 growth rates, Euro area industrial production growth, inflation, the return on the Euro trade weighted exchange rate, the European Central Bank's (ECB's) policy rate, and commodity or oil price inflation. Estimation of two SVAR models will allow assessment of the robustness of results obtained.

In construction of the model it is important to realize that the sample period for analysis, 1999:1 to 2012:12, is determined by the availability of monthly M2 data for the Euro area with the creation of the European Central Bank and by the observation that the People's Bank of China started concentrating on balance sheet adjustment for the conduct of monetary policy in 1998 (Johansson (2012)). Given the relatively short period of the sample it is necessary to work with data at monthly frequency. M2 is chosen as measure of monetary aggregate since it is the broadest monetary aggregate available for these four largest economies for the full period 1999:1 to 2012:12. M3 is not available for china over this period at monthly frequency. The monetary aggregates over the period of analysis capture quantitative easing, whereas official interest rates do not. It is also recognized that official interest rates do not show great variation over the period, particularly in Japan, and that the official interest rate in China is not the policy instrument. Finally, note that both monetary aggregates and official short-term interest rates appear in the empirical analysis.[3]

Our work is informed by a number of contributions to the literature on the effects of monetary policy on international economies. The first SVAR model we propose is an extension of the popular models of Christiano, Eichenbaum and Evans (1999) and Dedola and Lippi (2005) and the second SVAR model we propose is an extension of Kim and Roubini (2000). The first SVAR employs a standard Taylor rule identification, but the ECB policy rate does respond to the commodity price inflation shock at impact. The second SVAR follows Sims and Zha (1995) in that the monetary policy feedback rule is based on the recognition of information delays that do not allow the monetary policy to respond within the month to price level and output events. In the second SVAR model, the ECB sets the interest rate after observing the current value of money, the exchange rate and the world price of oil but not the current values of output, and the price level.[4]

3.1. The SVAR model 1

We construct a SVAR for the Euro area in which the monetary variables are U.S. M2 ($US\, M2_t$), China M2 ($China\, M2_t$), the Euro area M2 ($EU\, M2_t$), and Japan M2 ($Japan\, M2_t$). The monetary variables are in U.S. dollars. The other endogenous variables in the model are: the Euro area industrial production (IP_t), the Euro area consumer price index (CPI_t), the global commodity price index in U.S. dollars (COM_t), the short term Euro area interest rate (IR_t), the real effective trade-weighted Euro currency exchange rate (TWI_t).

The SVAR model 1 can expressed as:

[3] Canova and Menz (2011) criticize empirical work on monetary policy that focuses on interest rate as the exclusive indicator of monetary policy and sometimes leaving money aggregates out of the analysis entirely.

[4] Kim and Roubini (2000) note that official monthly data on consumer prices and industrial production are available with a one month lag, but that financial data are observed on a daily basis and information on monetary aggregates are available within the month.

$$B_0 X_t = \beta + \sum_{i=1}^{j} B_i X_{t-i} + \sum_{i=1}^{j} \rho_i Z_{t-i} + \varepsilon_t \quad , \qquad (1)$$

where j is the optimal lag length, determined by the Akaike Information Criterion (AIC), three lags in this case, X_t is vector of endogenous variables, Z_t is a vectors of country-specific exogenous variables, and ε_t denotes the vector of serially and mutually uncorrelated structural innovations. For the exogenous variable in Z_t we use the industrial production and the interest rate of China, of the U.S. and of the Euro area. The exogenous variables are including to isolate the effect of foreign monetary shocks from real activity and to distinguish between foreign money supply and demand.[5]

The vector X_t can be expressed as (Δ is the first difference operator):

$$X_t = \begin{bmatrix} \Delta\log(US\ M2_t), \Delta\log(China\ M2_t), \Delta\log(Japan\ M2_t),\ \Delta\log(IP)_t, \Delta\log(CPI_t), \\ \Delta\log(COM_t), IR_t, \Delta\log(EUM2_t), \Delta\log(TWI_t) \end{bmatrix} \qquad (2)$$

In the SVAR Model 1 in equation (1) restrictions are based on Christiano et al. (1999) and Dedola and Lippi (2005) to the extent possible given the introduction of international monetary variables. In our model the international monetary variables are assumed to be contemporaneously exogenous.[6] We assume that international monetary aggregates depend upon foreign economies with a delay of one month and affect Euro area variables after one month.[7] These additional restrictions are supported by the data, the log likelihood ratio (LR) for over-identified restrictions shows a higher chi-square coefficient when these restrictions are introduced.

The B_0^{-1} has a recursive structure such that the reduced-form errors e_t can be decomposed as $e_t = B_0^{-1}\varepsilon_t$.

[5] Sheehan (1983) and Stam and Delorme (1991) show that money stock in large economies such as the U.S. and Germany influence both domestic and foreign output (when taken as an exogenous variable). Consequently, we introduce in our model as exogenous variables industrial production and interest rates of each of the countries the U.S, China and Japan (represented by the vector Z_t in equation (1)) to isolate the country specific income effect from monetary aggregates.

[6] Substantiation of contemporaneous restrictions can be found in Dedola and Lippi (2005), page 1546.

[7] In analysis of the effects of global liquidity, Brana et al. (2012) argue that the monetary variable is ordered first in a VAR as it is expected to be more exogenous with respect to the other variables in the short run.

$$e_t \equiv \begin{pmatrix} e_t^{\Delta\log(US\,M2)} \\ e_t^{\Delta\log(China\,M2)} \\ e_{ct}^{\Delta\log(Japan\,M2)} \\ e_t^{\Delta\log(IP)} \\ e_t^{\Delta\log(CPI)} \\ e_t^{\Delta\log(COM)} \\ e_t^{IR} \\ e_t^{\Delta\log(EUM2)} \\ e_t^{\Delta\log(TWI)} \end{pmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & a_{43} & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & a_{53} & a_{54} & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & a_{63} & a_{64} & a_{65} & 1 & 0 & 0 \\ 0 & 0 & 0 & a_{73} & a_{74} & a_{75} & a_{76} & 1 & 0 \\ a_{80} & a_{81} & a_{82} & a_{83} & a_{84} & a_{85} & a_{86} & a_{87} & 1 \end{bmatrix} \begin{pmatrix} \varepsilon^{US\,M2\,Shock} \\ \varepsilon^{Chinese\,M2\,Shock} \\ \varepsilon^{Japanese\,M2\,shock} \\ \varepsilon^{aggre.\,demand\,shock} \\ \varepsilon^{Inflation\,shock} \\ \varepsilon^{commodity\,shock} \\ \varepsilon^{monetary\,policy\,shock} \\ \varepsilon^{EU\,M2\,Shock} \\ \varepsilon^{currency\,shock} \end{pmatrix} \quad (3)$$

In equation (3), following the three international monetary aggregates, the variables that appear are Euro area industrial production, Euro area consumer price index, global commodity price index, Euro area short-term interest rate and monetary aggregate, and the real effective trade-weighted Euro currency exchange rate.

To evaluate the impact of foreign monetary aggregates on Euro area trade variables, we follow Kim (2001a) and add one variable at the time to the model in equation (3). This exercise requires additional contemporaneous restrictions for the new variables. Given that trade variables are supposed to be affected contemporaneously by exchange rate fluctuation, we incorporate trade variables at the end of our system (equations (1) to (3)), consequently this variable is contemporaneously affected by all other variables and international monetary aggregates.[8] The variables added are Euro area real trade balance, nominal trade balance, real exports and nominal exports.

The statistics on trade between the Euro area and the U.S., Japan and China in Figures 2 and 3 illustrate the enormous shifts taking place in the relative roles of the interactions between China and the G3 economies over the last thirteen years. Figure 2 shows Euro area exports to the U.S., China and Japan as per cent of total Euro area exports over 1999-2011. Euro area exports to China relative to exports overall have increased by over 250% and Euro

[8] We also tried different orders in our Cholesky-type system, such as placing trade variables before trade weighted index, before Euro area M2 and before Euro area interest rate and results have been shown to be insensitive to order of these variables.

area exports to the U.S. and the Japan relative to exports overall have declined by about one third over the period.

Figure 3 reports data on Euro area imports from the U.S., China and Japan as per cent of total Euro area imports. In 2011 imports from China to the Euro area far exceed imports from the U.S. and from Japan. Over 1999-2011 imports from China to the Euro area increased by over 200% as a fraction of total Euro area imports and imports from the U.S. and from Japan fell by about one half as a fraction of total Euro area imports.

3.3. SVAR model 2

The robustness of results obtained with the SVAR model 1 will be examined with a SVAR model 2 based on Kim and Roubini (2000). Kim and Roubini (2000) developed a SVAR model using monthly data for developed economies that differs in several ways from the model in Equation (3). In the Kim and Roubini (2000) model, the short term interest rate and M2 are placed ahead of the CPI and industrial production (the order of these two variables is also switched).

Other differences between the two basic SVAR models include the following. Oil price is contemporaneously exogenous in Kim and Roubini (2000), whereas in SVAR model 1 and in Dedola and Lippi (2005) commodity prices are influenced contemporaneously by industrial production. In Kim and Roubini (2000), industrial production is dependent on supply shocks (represented by oil prices), but industrial production is contemporaneously exogenous in SVAR model 1 and in Dedola and Lippi (2005). SVAR model 2 follows these restrictions.

Given Equation (1), Kim and Roubini (2000)'s model can be extended with the vector X_t in the SVAR model 2 expressed as:

$$X_t = \begin{bmatrix} \Delta\log(US\ M2_t)\,, \Delta\log(China\ M2_t), \Delta\log(Japan\ M2_t),\ IR_t, \Delta\log(EUM2_t)\,, \\ \Delta\log(CPI_t)\,, \Delta\log(IP)_t\,, \Delta\log(GOP_t)\,, \Delta\log\big(TWI_{t)}\big) \end{bmatrix}, \tag{4}$$

and the reduced-form errors given by:

$$e_t \equiv \begin{pmatrix} e_t^{\Delta \log(US\ M2)} \\ e_t^{\Delta \log(China\ M2)} \\ e_t^{\Delta \log(Japan\ M2)} \\ e_{ct}^{\Delta \log(\ IR)} \\ e_t^{\Delta \log(EU\ M2)} \\ e_t^{\Delta \log(CPI)} \\ e_t^{\Delta \log(IP)} \\ e_t^{\Delta \log(GOP)} \\ e_t^{\Delta \log(TWI)} \end{pmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & a_{34} & 0 & 0 & a_{37} & a_{38} \\ 0 & 0 & 0 & a_{43} & 1 & a_{45} & a_{46} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & a_{56} & a_{57} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & a_{67} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ a_{80} & a_{81} & a_{82} & a_{83} & a_{84} & a_{85} & a_{86} & a_{87} & 1 \end{bmatrix} \begin{pmatrix} \varepsilon^{US\ M2\ Shock} \\ \varepsilon^{Chinese\ M2\ Shock} \\ \varepsilon^{Japanese\ M2\ shock} \\ \varepsilon^{monetary\ policy\ shock} \\ \varepsilon^{EU\ M2\ Shock} \\ \varepsilon^{Inflation\ shock} \\ \varepsilon^{aggre.\ demand\ shock} \\ \varepsilon^{global\ oil\ prices\ shock} \\ \varepsilon^{currency\ shock} \end{pmatrix} \quad (5)$$

In this system, the variable global oil price (GOP_t) is introduced instead of commodity prices. Equation (5) shows a different identification restriction consistent with Kim and Roubini (2000).[9] Once again, we find that the data support restrictions that international monetary variables affect the Euro area variables after one month using LR for over-identified restrictions test.

In Kim and Roubini (2000) the central bank reaction function (the fourth equation in system 1, 4 and 5) only responds contemporaneously to domestic monetary aggregates and oil prices as information regarding other variables are not available within the period. In the money demand equation (fifth equation) restrictions are imposed such that the demand for real money depends on both real income and nominal interest rate.[10] Restrictions in both the inflation and output equations (sixth and seventh equation respectively) are standard in the economic literature assuming that oil or commodity prices affect these variables in the same period on the ground that most commodities (e.g. oil and gas) are crucial inputs for many sectors.[11]

Kim and Roubini (2000), Kim (1999) and Kim (2001a; 2001b) treat oil prices and/or commodity prices as contemporaneously exogenous. The exchange rate equation is affected

[9] Detailed restrictions in Equation (5) are well substantiated in Kim and Roubini (2000) and they can be found in page 568.
[10] These restrictions also have been used in Kim (1999 and 2001a).
[11] These restriction have been also been used by Gordon and Lepper (1994), Sims and Zha (2006), Chistiano *et al.* (1999) and Kim (1999 and 2001a).

contemporaneously by all other variables as international exchange rate operators may arbitrage daily with all available information.

4. The Data and Variables

The data are monthly over 1999:1 to 2011:12 dictated by the availability of relevant data on the Euro area and China. G4 monetary aggregates, consumer price indices and short-term interest rate (Federal Funds rate for the U.S. and discount rate for the other countries), and oil price (West Texas Intermediate crude oil price) data are from the Federal Reserve of St. Louis (FRED). Industrial production indexes are from FRED except for China's which is from the National Bureau of statistics of China. The all commodity price index (U.S. dollar index) is from the World Bank. Euro area trade balances, exports and Euro trade weighted exchange rate index are from Eurostat.

To summarize, the monetary variables in the SVAR model are log first differences of M2 U.S. dollar amounts for the U.S., China, the Euro area and Japan. Euro area industrial production, Euro area consumer price index, global commodity price index (in USD), the real effect trade-weighted Euro currency, and industrial production indexes are log first differences. The short term interest rates appear in the model in percentage (by construction).

Table 1 reports test results for unit roots in the variables over 1999:1-2011:12. The null hypothesis for the Augmented Dickey-Fuller (ADF) test is the variable has a unit root and the null hypothesis for the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test is the variable is stationary. The first difference of the series is indicated by Δ. The lag selection criteria for the ADF test is based on Schwarz information Criteria (SIC) and for the KPSS is the Newey-West Bandwidth with constant and linear trend. All variables (but the interest rate) are first difference stationary according to Augmented Dickey-Fuller, Phillip-Perron (not reported) and Kwiatkowski–Phillips–Schmidt–Shin tests.

5. Empirical results

5.1. The impulse response effects of the structural monetary shocks: SVAR model 1

Figure 4 shows the dynamic response or impulse response function of the Euro area variables in the SVAR in equation (3) to one-standard deviation structural innovations. The dashed lines represent a one standard error confidence band around the estimates of the coefficients of the impulse response functions.[12] The first, second, and third columns show the responses of Euro area variables to structural innovations in U.S. M2, China M2, and Japan M2, respectively.

In the first row in Figure 4, Euro area industrial production tends to decline with positive innovations in U.S. M2 and in Japan's M2. In contrast, an unanticipated positive increase in China's M2 has a positive effect on Euro area industrial production that is statistically significant after two months, builds up over eight months and then persists. In the second row in Figure 4, Euro area CPI is not significantly affected by innovations in U.S. M2 (after the second month) and in Japan's M2. A positive shock to China's M2 has a positive effect on Euro area CPI that is sharply increases in the second month and then persists and is statistically significant throughout.

The effects of shocks to U.S. M2, China's M2, and Japan's M2 on international commodity prices are shown in the third row in Figure 4. After the first month a shock in U.S. M2 does not have a statistically significant effect on commodity prices. A positive shock in Japan's M2 does have a positive but relatively small effect on commodity prices after seven months. A positive innovation in China's M2 has a statistically significant positive effect on commodity prices that builds up over seven or eight months and that then persists over 20 months. The positive effect of China on oil prices in recent years has been established in the literature. Hamilton (2013) notes that demand from emerging market

[12] The confidence bands are obtained using Monte Carlo integration as described by Sims (1980), where 5000 draws were used from the asymptotic distribution of the VAR coefficient.

countries, particularly China, is a leading influence on oil prices in recent years. Kilian and Hicks (2013) find that unexpected growth in emerging economies over 2003-2008 propelled real oil price over the period. Ratti and Vespignani (2013) find that increased global liquidity (including that in China) significantly raises real oil prices over 1996:1-2011:12.

In the fourth row in Figure 4, the short term Euro area interest rate does not respond significantly to innovations in U.S. M2 or in China's M2. The short term Euro area interest rate does decline significantly for ten months in response to a positive innovation in Japan's M2. This latter result is consistent with a defensive response by the Euro area to a stimulus by Japan that strengthens the Euro and makes Japanese goods more competitive in Europe. In the fifth row of Figure 4, Euro area M2 does not respond significantly to an innovation in U.S. M2. Euro area M2 increases significantly in response to positive innovations in China's M2 and in Japan's M2. Consistent with the significant decline in the Euro area short term interest rate to a positive innovation in Japan's M2, the response in Euro area M2 to Japan's M2 is larger than is the response to positive innovation in China's M2.

The response effects of the real trade-weighted Euro currency to shocks to U.S. M2, China's M2, and Japan's M2 are shown in the last row in Figure 4. The responses to shocks to U.S. M2 and China's M2 are small and not statistically significant after the first few months. However, a positive shock in Japan's M2 does have a statistically significant positive effect on the real trade-weighted Euro currency after two months that persists for twenty months.

The significant effect of shocks to China's M2 on the real trade-weighted Euro exchange rate requires further explanation. A rise in China's M2 facilitates domestic growth and demand for imports. The currencies of the countries supplying imports to China experience upward pressure. To stabilize the pegged exchange rate, China must intervene in the foreign exchange market and sell foreign currency. The net effect of these actions on the real trade-weighted Euro exchange rate depends on the mix of imports and the mix of foreign currencies sold in the foreign exchange market.[13]

5.2. Responses of Euro area exports and trade balance to monetary shocks

Following a procedure in Kim (2001a) the Euro area real trade balance, nominal trade balance, real exports and nominal exports are now added one variable at a time as an additional variable (in last place) in the SVAR system in SVAR model 1 in Equation (3).[14] The impulse response functions of the Euro area trade variables to the international monetary aggregates shocks are shown in Figure 5. Each row of results is for a different SVAR. The first, second, and third columns show the responses of Euro area trade variables to structural innovations in U.S. M2, China M2, and Japan M2, respectively.

The third and fourth rows of Figure 5 show that a positive shock to Japan's M2 is associated with decreases in real and nominal Euro area exports. This result together with the findings of an appreciation in the Euro, a decline in Euro area industrial production and a decrease the Euro area short term interest rate in response to an expansionary monetary shock in Japan, is consistent with a highly competitive Japan. A monetary stimulus by Japan that strengthens the Euro and makes Japanese goods more competitive in Europe calls forth a defensive response in the Euro area. Expenditure substitution in Japan is reflected in lower Euro area exports. Japan's M2 shocks are consistent with a decline in the Euro area real and nominal trade balance, although the effects are not statistically significant in the first and second rows of Figure 5.

An unanticipated rise in China's M2 raises Euro area nominal exports as illustrated in the fourth row of the second column in Figure 5. The effects of China's M2 on real exports

[13] Prior to 2005, with the Renminbi pegged to the U.S. dollar, the consequence of an increase in China's M2 would be a devaluation of the U.S. dollar relative to other countries. Since 2005, with the Renminbi tied to band around a basket of world currencies, this consequence of an increase in China's M2 might be less marked.

[14] We also tried different orders in our Cholesky-type system, such as placing trade variables before trade weighted index, before Euro area M2 and before Euro area interest rate and results have shown to be insensitive to these orders.

and real and nominal trade balances for the Euro area are only marginal statistically significant at the beginning in Figure 5. Increases in monetary aggregates in China drive an increase in the world price of commodities, an increase in the Euro area CPI, and are associated with significant increases in Euro area industrial production and exports. Income absorption in China is reflected in greater Euro area exports.

In contrast, U.S. M2 has relatively small effects on Euro area output, inflation, and trade variables and on commodity prices. These results for the US are different from Kim's (2001a) result for monetary expansion in the U.S. that causes a boom in major European countries in earlier decades. This reflects the great change in the international economy in recent years with the rise of China as a major economic force.

5.3. The impulse response effects of the structural monetary shocks: SVAR model 2

Impulse response results from estimation of the model in Equations (4) and (5) are summarised in Figure 6. The first, second, and third columns show the responses of Euro area variables to structural innovations in U.S. M2, China M2, and Japan M2, respectively. The major difference from results reported in Figure 4 is that positive shocks to China's M2 now significantly increase the Euro area short term interest rate. This is consistent with European Central Bank efforts to reduce inflation and output in the Euro area as Chinese M2 shocks expand inflation, industrial production, oil prices and trade balance in this economy. With regard to real activity in the Euro area, Japan's monetary expansion has negative consequences, China's monetary expansion has positive consequences, and U.S. monetary expansion is inconsequential.

Results in this section are also in line with income absorption in China as Chinese monetary aggregates expansion lead an increase in Chinese imports from Euro area (reflected by improvements in Euro area inflation, industrial production and trade balance). In contrast, increases in monetary aggregates in Japan are associated with decline in Euro area industrial production. This is consistent with Japan's goods becoming more competitively priced relative to European goods on world markets and with expenditure switching in Japan.

5.4. Robustness checks

5.4.1. MO and M1 aggregates and lag length

An alternative specification of our models uses different monetary aggregates as monetary indicators. We explore the use of both international and Euro area M0 and M1 instead of M2.[15] This exercise reveals very similar results to those observed in Sections 5.1., 5.2. and 5.3. (These results are available upon request).

In our SVAR model 1 we follow Dedola and Lippi (2005) in determining the lag structure of the SVAR using AIC criteria. However, other studies such as Kim (1999), Kim and Roubini (2000) and Kim (2001b), and our SVAR model 2 use a standard six lags. We find that results are similar to those presented in Figures 4 and 5 when six lags are used in SVAR model 1, although there is a decline in efficiency because the standard errors in general are larger with use of six lags.

5.4.2. FAVAR Approach

Bernanke et al. (2005) propose a factor augmented VAR (FAVAR) to identify monetary policy shocks.[16] We estimate a FAVAR model to check the robustness of our results. To construct a FAVAR model we develop a principal component vector by including the variables: interest rate, consumer price index, industrial production, nominal trade weighted index for each of the three largest economies external to the Euro area (China, the U.S. and Japan). This vector is included as an endogenous variable and placed as the first

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[15] Monetary aggregates M3 is excluded because it is not available for China.

[16] A different approach considered in the literature is use of a global VAR (GVAR) by Dees et al. (2007). The GVAR combines separate models for each of the many economies linking core variables within each economy with foreign variables using quarterly data. The foreign variables external to a domestic economy are trade-weighted. In our study we do not pursue a GVAR because with monthly data the proxy variable for aggregate activity, industrial production, is an index. A more general observation concerns the unavailability on a monthly basis of broader measures (than merchandise trade) linking the economies such as current account data.

variable in augmented system (1), (2), and (3).[17] Results on the effects of the international monetary shocks on the Euro area (available under request) are remarkably similar to those obtained in Figure 4, showing the robustness of our model. The results for China's monetary expansion are unchanged. China's monetary expansion increases world price of commodities and global oil price and increases Euro area inflation and industrial production.

6. Conclusion

The major finding of the paper is that China's monetary expansion has a spill over effect on the Euro area through the effects on world commodity markets and through income absorption. Increases in monetary aggregates in China drive the increase in the world price of commodities, the increase in the Euro area CPI, and significant increases in Euro area industrial production and exports. These findings are robust to a number of model specifications including different assumptions about whether commodity/oil prices are contemporaneously exogenous. We feel that inclusion of the China variables in analysis of the international transmission of monetary shocks is the correct specification given the tremendous impact of China on the global economy in recent years.

Increases in monetary aggregates in Japan are linked with significant appreciation of the Euro, decreases in Euro area industrial production and exports, and with monetary expansion in the Euro area (indicated by a decline in the Euro area short term interest rate). U.S. monetary aggregates increases have relatively small effects on Euro area output, inflation, and trade variables and on commodity prices over 1999-2011, in sharp contrast to findings in the literature on the positive effect of U.S. monetary expansion on major Western countries in earlier decades.

[17] We allow this variable to interact contemporaneously with other variables in the system as indicated by the over identify log likelihood ratio test. The FAVAR approach in Bernanke et al. (2005) uses a two-step procedure suggested by Stock and Watson (2002). Factors are estimated by principal components before estimation of the factor-augmented VAR. The number of unobservable factors used for policy analysis may be selected on statistical grounds. We choose one factor and two lags to retain parsimony in the FAVAR approach.

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Table 1: Test for unit roots 1999:1-2011:12

Endogenous variables					
	ADF	KPSS		ADF	KPSS
$\log(US\ M2_t)$	0.896	1.515***	$\Delta\log(U.S.M2_t)$	0.076*	0.062
$\log(China\ M2_t)$	0.999	1.377***	$\Delta\log(China\ M2_t)$	0.080*	0.305
$\log(Japan\ M2_t)$	0.986	1.259***	$\Delta\log(Japan\ M2_t)$	0.000***	0.196
EU IR_t	0.642	0.570*	ΔEU IR_t	0.000***	0.083
$\log(EU\ M2_t)$	0.894	1.456***	$\Delta\log(EU\ M2_t)$	0.000***	0.178
$\log(EU\ CPI_t)$	0.988	1.414***	$\Delta\log(EU\ CPI_t)$	0.000***	0.212
$\log(EU\ IP_t)$	0.110	0.371*	$\Delta\log(EU\ IP_t)$	0.062***	0.090
$\log(COM_t)$	0.582	1.427***	$\Delta\log(COM_t)$	0.000***	0.036
$\log(EU\ TWI_t)$	0.568	0.882***	$\Delta\log(EU\ TWI_t)$	0.000***	0.184
$\log(GOP_t)$	0.191	1.388***	$\log(GOP_t)$	0.000***	0.077
Exogenous (control) variables					
$\log(US\ IP_t)$	0.110	0.352*	$\Delta\log(US\ IP_t)$	0.042*	0.078
$\log(China\ IP_t)$	-	-	$\Delta\log(China\ IP_t)$	0.011***	0.530*
$\log(Japan\ IP_t)$	0.200	0.420***	$\Delta\log(Japan\ IP_t)$	0.000***	0.010

Notes: The variables are U.S. M2, China M2, Euro area M2 (EU M2), Japan M2, Euro area industrial production (EU IP), Euro area consumer price index (EU CPI), global commodity price index (COM), short term Euro area interest rate (EU IR), real effective trade-weighted Euro currency foreign exchange rate (EU TWI), global oil prices (GOP), U.S. industrial production (US IP), China industrial production (China IP), and Japan industrial production (Japan IP). China industrial production is reported in percentage change by the National Bureau of statistics of China. The null hypothesis for the Augmented Dickey-Fuller (ADF) test is the variable has a unit root and the null hypothesis for the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test is the variable is stationary. The first difference of the series is indicated by Δ.The lag selection criteria for the ADF is based on Schwarz information Criteria (SIC) and for the KPSS is the Newey-West Bandwidth with constant and linear trend. *, **, *** indicates rejection of the null hypothesis at 1%, 5% and 10%, levels of significance.

Figure 1: Monetary aggregate M2 in billions of USD for largest economies

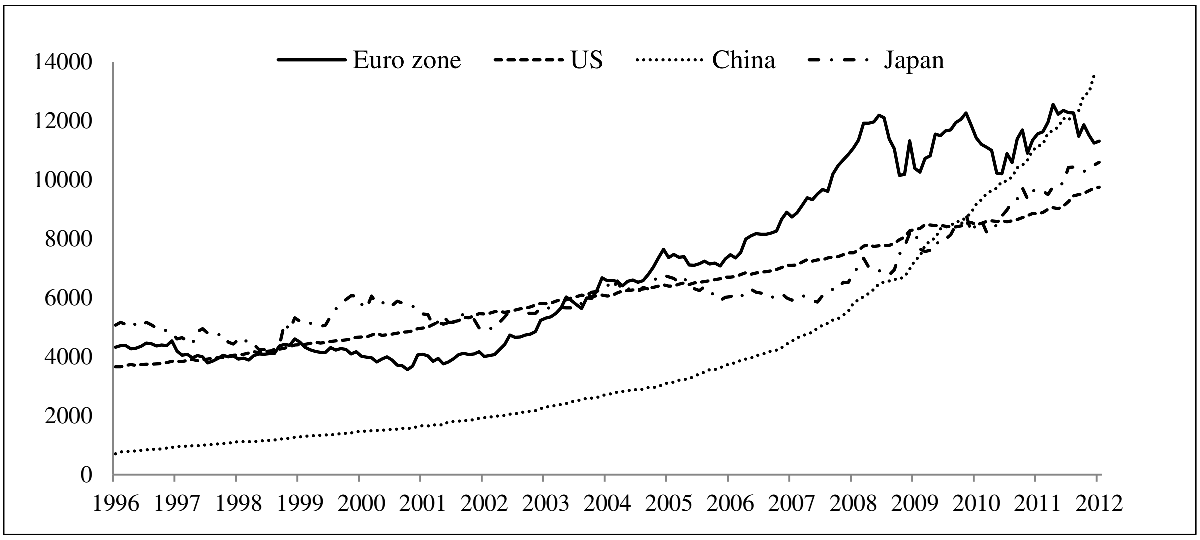


Figure 2: Euro area exports to the U.S., China and Japan as % of total Euro area exports

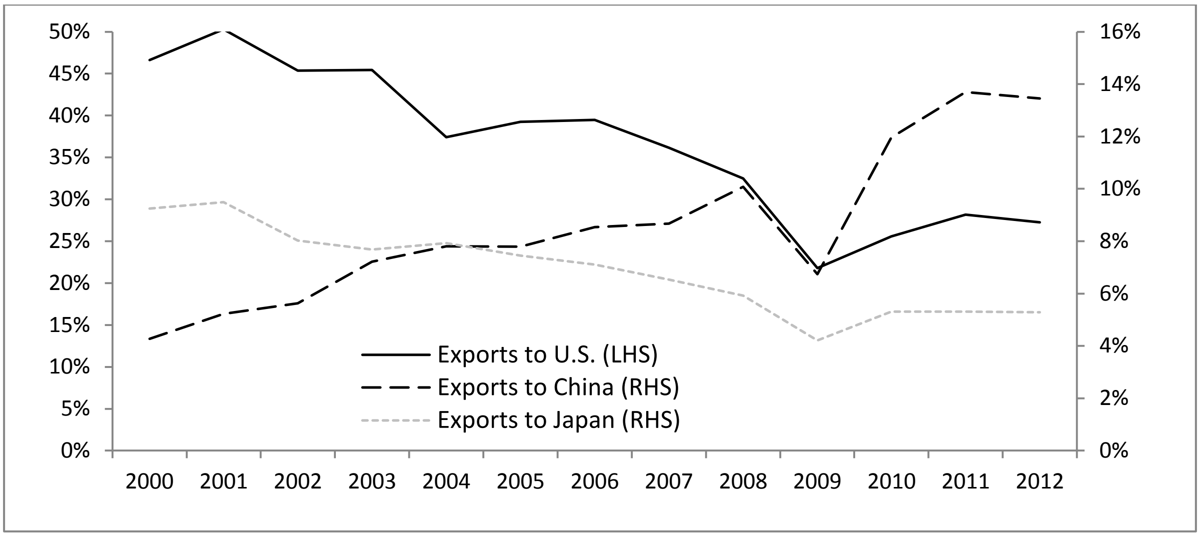


Figure 3: Euro area imports from the U.S., China and Japan as % of total Euro area imports

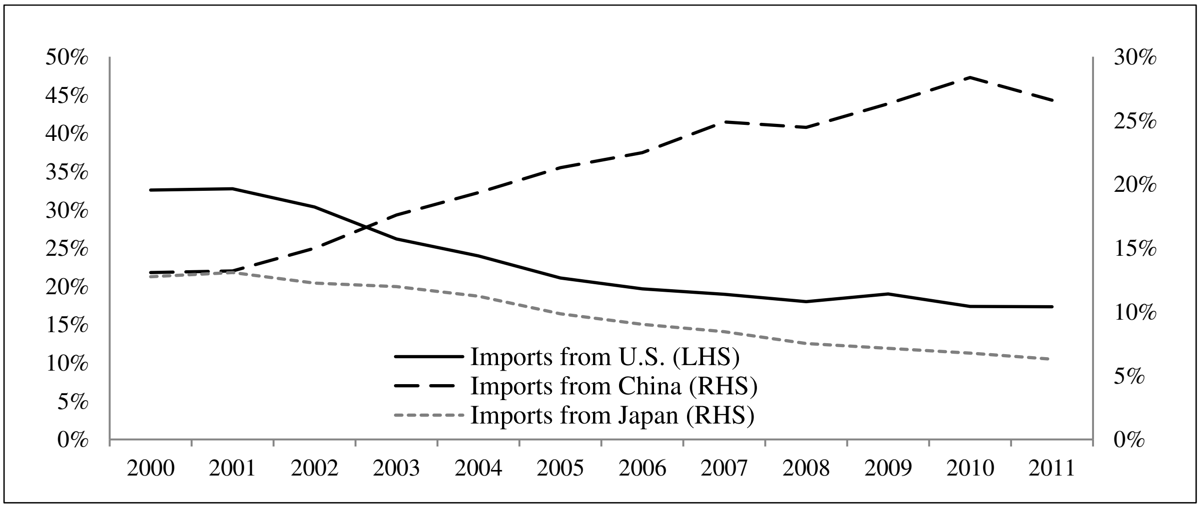
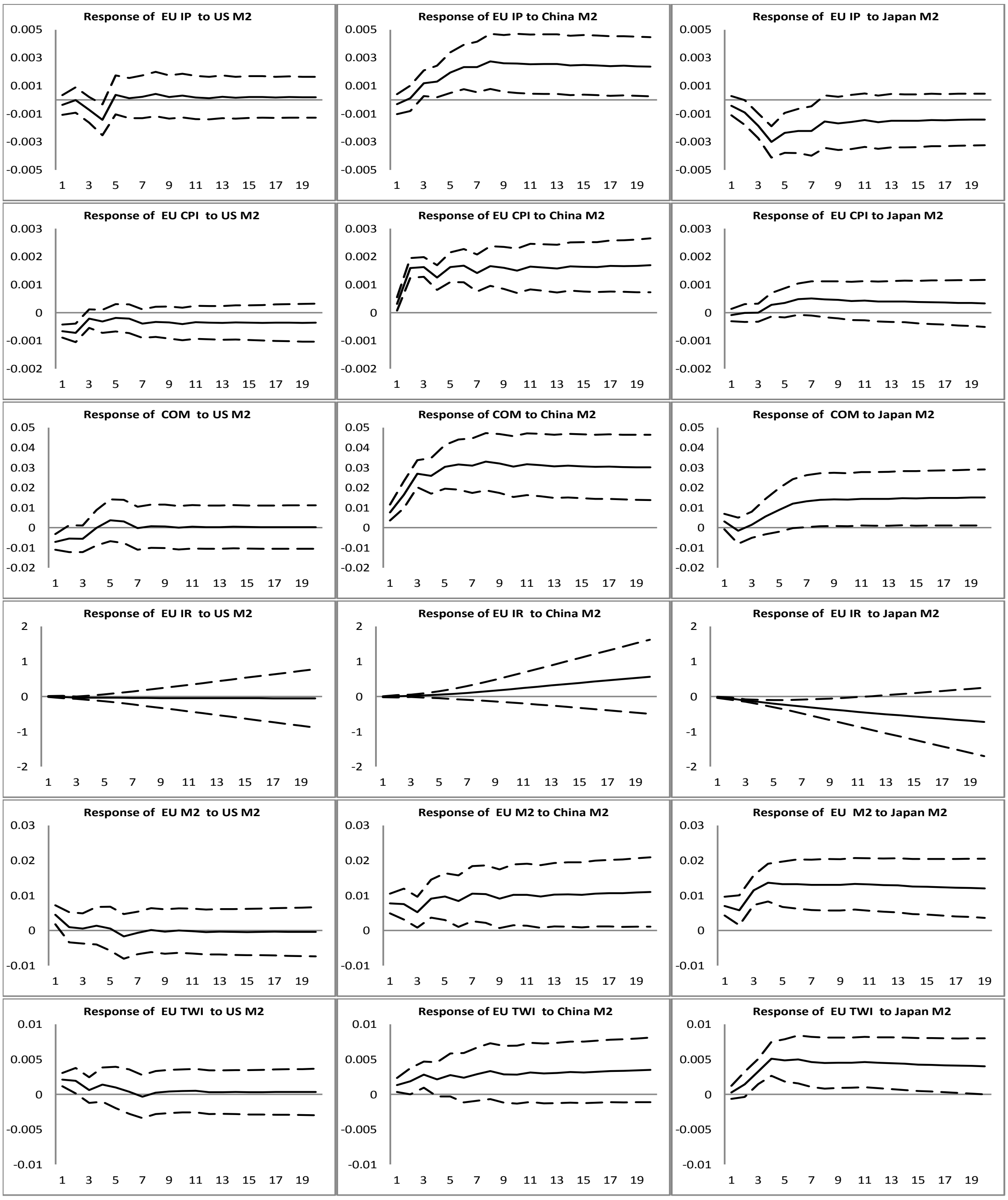
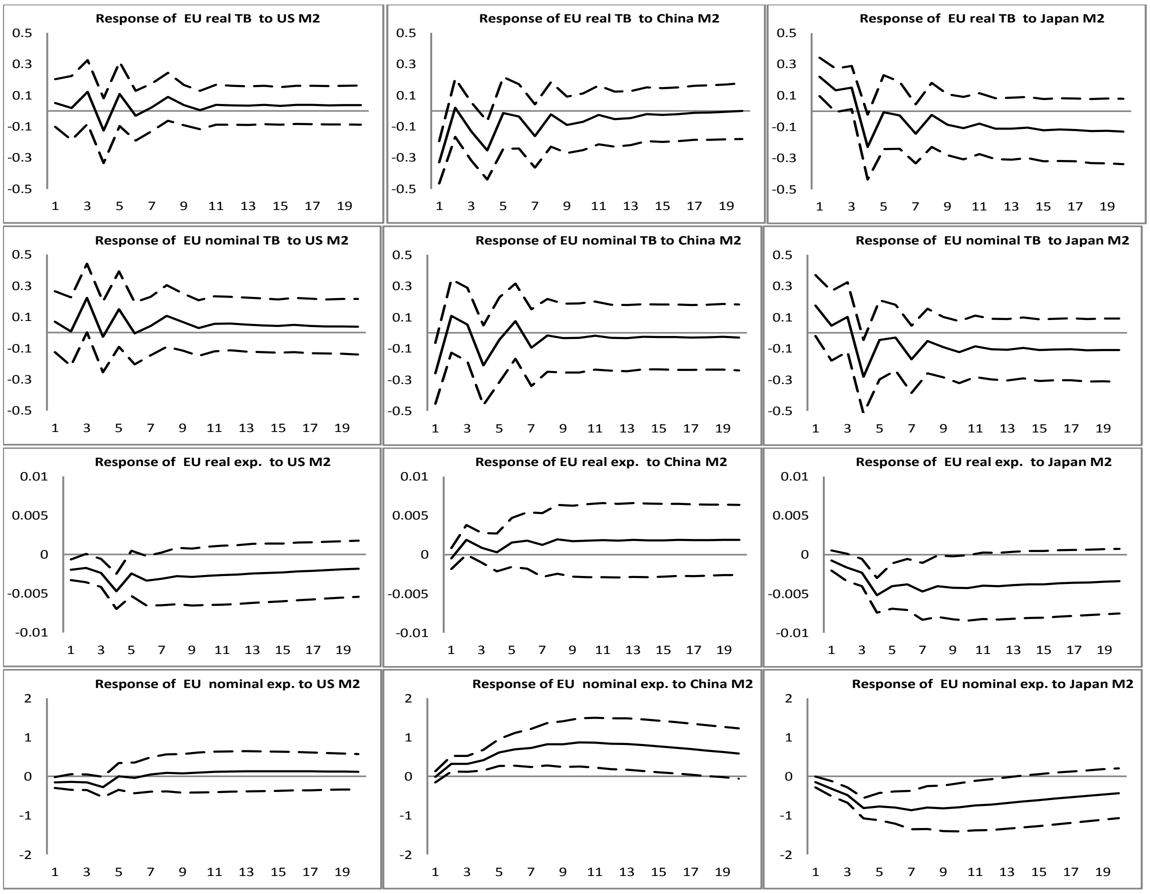


Figure 4: Response of Euro area economy to one standard deviation generalised innovations U.S. M2, China M2 and Japan M2 shocks: SVAR model 1



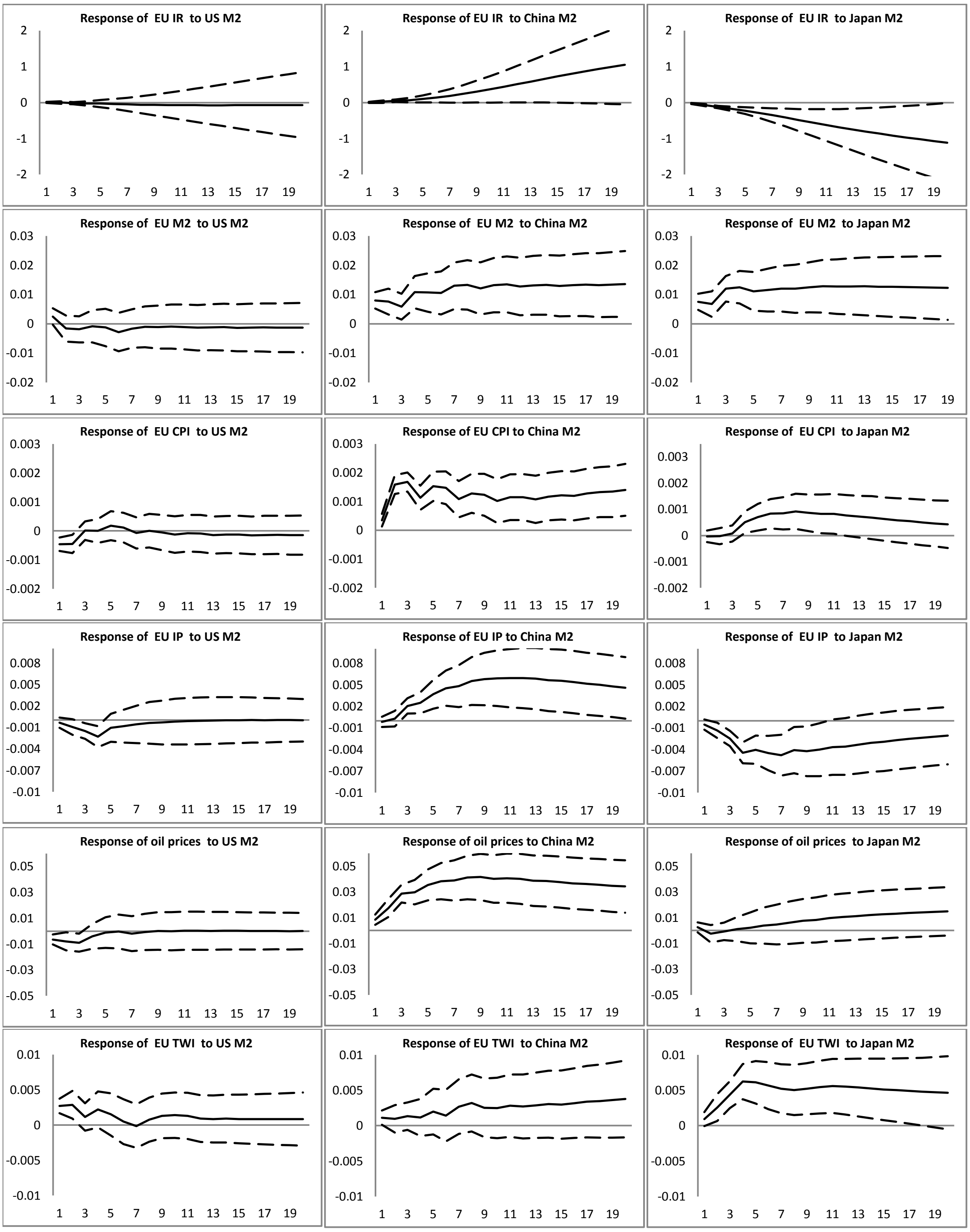
Notes: Figure 4 shows the dynamic response or impulse response function of the Euro area variables in the SVAR model 1 in equation (3). The confidence bands are obtained using Monte Carlo integration as described by Sims (1980), where 5000 draws were used from the asymptotic distribution of the VAR coefficient. The variables are U.S. M2, China M2, Euro area M2 (EU M2), Japan M2, Euro area industrial production (EU IP), Euro area consumer price index (EU CPI), global commodity price index in U.S. dollars (COM), short term Euro area interest rate (EU IR), the real effective trade-weighted Euro currency foreign exchange rate (EU TWI).

Figure 5: Response of Japanese real and nominal trade balance and exports to variables to a one standard deviation generalised innovations of U.S. M2, China M2 and Japan M2 shocks



Notes: Figure 5 shows the dynamic response or impulse response function of the Euro area real trade balance (EU real TB), nominal trade balance (EU nominal TB), and Euro area real exports and nominal exports (to the U.S., China and Japan) are added one variable at a time as an additional variable (in last place) in the SVAR model 1 in Equation (3). Each row of results is for a different SVAR. The first, second, and third columns show the responses of Euro area trade variables to structural innovations in U.S. M2, China M2, and Japan M2, respectively. The confidence bands are obtained using Monte Carlo integration as described by Sims (1980), where 5000 draws were used from the asymptotic distribution of the VAR coefficient.

Figure 6: Response of Euro area variables to U.S. M2, China M2 and Japan M2 shocks: SVAR model 2



Notes: Figure 6 shows the dynamic response or impulse response function of the Euro area variables in the SVAR model 2 in equation (5). The confidence bands are obtained using Monte Carlo integration as described by Sims (1980), where 5000 draws were used from the asymptotic distribution of the VAR coefficient. The variables are U.S. M2, China M2, Euro area M2 (EU M2), Japan M2, Euro area industrial production (EU IP), Euro area consumer price index (EU CPI), global oil prices, short term Euro area interest rate (EU IR), the real effective trade-weighted Euro currency foreign exchange rate (EU TWI), and Euro area real trade balance (EU real TB).