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Kang, Wensheng and Ratti, Ronald A. and Vespignani, Joaquin L.

Kent State University, University of Western Sydney, University of Tasmania

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Wensheng Kang[a], Ronald A. Ratti[bd], Joaquin L. Vespignani[cd]

[a]Kent State University, Department of Economics, US
[b]University of Western Sydney, School of Business, Australia
[c]University of Tasmania, Tasmanian School of Business and Economics, Australia
[d]CAMA, Australian National University, Australia

Abstract

This paper investigates the influence of liquidity shocks in China on the U.S. economy over 1996-2012. The influence on the U.S. is through China's influence on demand for imports, particularly that of commodities. In all models estimated a positive innovation in China's liquidity is associated with: 1) a positive and statistically significant effect on oil and commodity prices that builds up rapidly over three months and then persists for twenty months; 2) a positive and statistically significant effect on U.S. CPI inflation that builds up over about six months or so and then persists; 3) a statistically significant depreciation of the real trade-weighted U.S. currency after about two or three months that achieves maximum absolute value after five to eight months and that then persists.

Keywords: China's liquidity, oil price, trade-weighted U.S. dollar

JEL Codes: E52, F41, F42

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1. Introduction

This paper examines the influence of liquidity shocks in China on the U.S. economy. The topic is of interest given the growing importance of China in the world economy. The impact of large increases in global liquidity on world commodity prices and on goods and assets prices in particular countries has been well documented. Increases in liquidity are associated with a rise in aggregate demand that will increase the price of most assets including commodity prices. Global liquidity has been shown to have an impact on commodity prices by Kim (2001), Darius and Radde (2010) and Belke et al. (2013) and on oil prices by Ratti and Vespignani (2013), and D'Agostino and Surico (2009) demonstrate that global liquidity has predictive power for the US inflation rate.

The growing importance of China as a contributor to global liquidity has been marked. China's M2 (in U.S. dollars) accounts for 75% of the increase in global M2 (indicated by the M2 of the G3 - U.S., Euro area and Japan – and China) since 1996. In 2009 when China conducted expansionary monetary policy to offset the effects of the global financial crisis, China's M2 measured in U.S. dollars surpassed that in the U.S. for the first time, and by the end of 2012 exceeded that in the U.S. by 50%.[1] In China the monetary authority the People's Bank of China (PBoC) has had little difficulty in the liquidity enhancement by selling bonds to five largest state-owned commercial banks [2] with extremely low costs (see Koz´luk and Mehrotra (2009) and Johansson (2012)). The five top state-owned commercial banks in China then mostly lend to state-owned enterprises (sometimes because of the obligation) shown in Chen (2014). The importance of China's liquidity is illustrated in

[1] China's nominal M2 (in USD) increased on average by 19.5% per year from 1996 to 2011. The behaviour of China's nominal GDP is also strongly upward. From 1996 to 2011 China's nominal GDP (in USD) increased on average by 15% per year. China's real M2 also has a strong upward trend. Based on an index of 100 in 1996, by 2011:12 China's real M2 index (the deflator is the U.S. PPI index for commodities) is 340.
[2] In China the five largest banks are Industrial & Commercial Bank of China Ltd., Agricultural Bank of China Ltd., China Construction Bank Corp., Bank of China Ltd. and Bank of Communications Co.

Figure 1 and is expected to grow as the PBoC injects additional Chinese yuan into five major state-owned banks to bolster loan growth and shore up the economy started in September 2014 (Bloomberg).

How can China's liquidity influence the U.S. economy given that China has extensive capital controls in place? The influence on the U.S. is through the sheer scale of China's growth through effects in demand for imports, particularly that of commodities.[3] China's growth influences world commodity prices and this is reflected in significantly higher inflation in the U.S. Expansion in China's liquidity is also associated with significant decreases in the trade weighted value of the U.S. dollar. With an increase in liquidity and an increase in imports, China intervenes in the foreign exchange market to stabilize the exchange rate. Pre-2005 with the Renminbi pegged to the U.S. dollar, the effect of a monetary expansion in China is stabilized by the net sale of U.S. dollars. Recent empirical studies by Cai et al. (2012) and Fang et al. (2012) show that post 2005, consideration of the parity of the exchange rate of the renminbi against the U.S. dollar dominates the influence of the other currencies in determining the overall value of the renminbi with reference to a basket of major currencies. We find that increased liquidity in China is associated with a statistically significant decline in the real trade-weighted U.S. dollar exchange rate.

The following results are found to be robust across a number of model specifications. A positive innovation in China's M2 is associated with a positive, significant and persistent effect on oil price (and on commodity prices); a positive, significant and persistent effect on U.S. CPI inflation; a significant and persistent depreciation of the real trade-weighted U.S.

[3] China has a 6% annual growth rate in petroleum consumption since 1998. Hamilton (2011) notes that the newly industrialized economies, among which China has a leading role, have absorbed over two-thirds of the increase in world oil consumption since 1998. Radetzki (2006) notes that between 2000 and 2005 China's share of global demand growth for petroleum was 28%, for aluminium was more than 50%, for steel was more than 84%, and for copper was 95%. Radetzki (2006) surmises that in developing Asian countries a dollar added to the GDP uses more than twice the quantity of commodities as does a dollar added to the GDP in OECD countries. China's oil intake is forecast to be 17.5 million barrels per day by 2030, overtaking the United States as the world's largest oil consumer (World Energy Outlook 2012). World Energy Outlook to be found at: http://iea.org/publications/freepublications/publication/English.pdf.

currency; a significant and persistent depreciation of the U.S. terms of trade; positive, significant and persistent increases in price deflators for U.S. exports and imports; positive, significant and persistent increases in U.S. exports, imports; reduction in real U.S. trade deficit. Shocks to China's M2 have stronger impact on U.S. variables since about 2005. This is consistent with the growth of China's economy. The cumulative contribution of China M2 shocks on the U.S. consumer price index and on oil price are much larger in the last half of sample. The increase in import prices (attendant on a decline in the trade-weighted U.S. dollar exchange rate) together with the increase in oil prices account for the association of innovations to China's M2 with increases in U.S. consumer price inflation.

In this investigation we use a number of structural vector autoregressive models to examine the effects of liquidity shocks in China on U.S. output, inflation, monetary aggregates, interest rate, exchange rate, terms of trade and trade variables. The model is discussed in section 2, empirical results are presented in section 3 and section 4 concludes.

2. The Methodology

Using monthly macroeconomic variables for the U.S. economy, we introduce the effect of China's liquidity by constructing a structural vector autoregressive model (SVAR). Given that the impact of China's expansion of liquidity on the U.S. is being considered, liquidity measures for the U.S., the Euro area and for Japan are also included in the model along with standard economic variables for the U.S. China's liquidity and the U.S. variables are: China's M2 ($China\ M2_t$) in U.S. dollars, the short term U.S. interest rate ($US\ IR_t$), U.S. M2 ($US\ M2_t$), the U.S. consumer price index ($US\ CPI_t$), the U.S. industrial production ($US\ IP_t$), oil prices in U.S. dollars (OP_t) (or global commodity price index in U.S. dollars), the real effective trade-weighted U.S. dollar exchange rate ($US\ TWI_t$).

The exchange rate policy of China is of crucial importance in assessing the impact of China's monetary expansion on the U.S. economy. A rise in China's liquidity facilitates domestic growth and increases demand for imports including commodities. 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.[4] 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 July 21, 2005 the value of renminbi has been determined with regard to a basket of currencies among which the dollar has been pre-eminent. Indeed, over an extended period from 2008 to 2010 the renminbi/dollar rate did not vary from 6.8. This is illustrated in Figure 2. In Figure 2 with a tendency for a fall in the China/U.S. exchange rate since 2005 as the U.S. dollar weakened against other currencies. It is hypothesized that positive innovations in China's liquidity will depress the real trade-weighted U.S. dollar exchange rate.

The SVAR model is expressed in matrix form as (for simplicity the constant term is omitted):

$$B_0 X_t = \sum_{i=1}^{j} B_i X_{t-i} + \sum_{i=1}^{j} \varphi EIP_{cej,t-i} + \sum_{i=1}^{j} \gamma EM2_{ej,t-i} + \varepsilon_t, \tag{1}$$

where

$$X_t = \begin{bmatrix} \Delta\log(China\ M2_t), US\ IR_t, \Delta\log(US\ M2_t), \Delta\log(US\ CPI_t), \\ \Delta\log(US\ IP_t), \Delta\log(OP_t), \Delta\log(US\ TWI_t) \end{bmatrix}, \tag{2}$$

where j is the optimal lag length, determined by the Akaike information criterion (AIC) (two lags in this case), X_t is vector of endogenous variables, EIP_{cej} are the individual vectors of country-individual industrial production of China , Euro area and Japan (cej) and $EM2_{ej}$ are vectors of the country-individual M2 for Euro area and Japan (ej). Those exogenous vectors

[4] The net effect of these actions on the real trade-weighted U.S. dollar exchange rate depends on the countries of origin of imports to China, the foreign currencies sold by China in the foreign exchange market, and the weights assigned to currencies in the reference basket of major currencies (dominated by the U.S. dollar, Euro, Japanese yen and South Korean won) to which the renminbi is allowed to float within a narrow margin.

are introduced to the model to tackle the possible problem of omitted variables bias as U.S. industrial production may be correlated with largest economies such as China, Euro area and Japan industrial production and both China and U.S. M2 may be correlated with Euro area and Japan's M2. Equation (2) is shown with oil price representing commodity prices. Results are not affected if a global commodity price index replaces oil price in the SVAR.[5] Finally, ε_t is an error term vector, which is serially and mutually independent.

2.1. Identification strategy

In line with Bernanke (1986), Sims and Zha (1995), Kim and Roubini (2000) and Kim (2001a; 2001b) non-recursive identify restrictions are proposed in the contemporaneous structure. In their surveys of identifying monetary policy shocks, Sims and Zha (2006) and Kilian (2013) show that the non-recursive identification strategy has been proven to be robust in generating sensible impulse responses across variables and across countries. The contemporaneous matrix B_0X_t can be express as:

$$B_0X_t = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & a_{12} & 0 & a_{14} & 0 & a_{16} \\ 0 & a_{21} & 1 & a_{24} & a_{25} & 0 & 0 \\ 0 & 0 & 0 & 1 & a_{34} & a_{35} & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{bmatrix} \begin{pmatrix} \Delta log(China\ M2_t) \\ US\ IR_t \\ \Delta log(US\ M2_t) \\ \Delta log(US\ CPI_t) \\ \Delta log(US\ IP_t) \\ \Delta log(OP_t) \\ \Delta log(US\ TWI_t) \end{pmatrix}. \quad (3)$$

The restrictions in Equation (3) are essentially those in Kim and Roubini (2000) but with China's M2 entered as contemporaneously exogenous to the other variables based on the fact that the People's Bank of China sets its money supply, the increase of which will not affect largest economies' (such as U.S., Euro area and Japan) money supply immediately, but with a delay of at least a month, vice versa. Fan et al. (2011) observe that the central bank of China maintains that the money supply is the main monetary tool in China. Fan et al. (2011)

[5] In SVAR models Christiano et al.'s (1999) (for the U.S.) and Dedola and Lippi (2005) (for five OECD countries) utilize a global commodity price index as a variable and Kim and Roubini (2000) (for industrial economies) utilize oil price.

confirm that the growth rate in money supply (M2) plays a crucial role in fine-tuning China's economy, while official interest rates played a very passive role. Koz´luk and Mehrotra (2009) and Johansson (2012) use M2 as the measure of China's monetary policy in studies on the influence of China on East and Southeast Asian economies. In the robustness check section, we also assume that the People's Bank of China sets its money supply observing and reacting to the current value of the world price of oil following Koz´luk and Mehrotra (2009) and/or taking into account the contemporaneous values of the other U.S. variables.[6]

Kim and Roubini (2000) assume real output and oil prices (in the fifth and sixth equations respectively) are contemporaneously exogenous to all variables in the model due to information delay. The delay in the transition of the Chinese M2 and oil prices are substantiated by the fact that these variables are exogenous to the U.S. economy. However, previous studies have restricted real output in two different ways: Kim and Roubini (2000) and Kim (2001b) allows real output to depend contemporaneously on oil prices while Bagliano and Favero (1998) treat real output as contemporaneously exogenous of all variables.[7] Using a log likelihood ratio test for over-identification restrictions, results for our data support restrictions in favour of real output to be contemporaneously exogenous.[8]

Consistent with Sims and Zha's (1995) dynamic stochastic general equilibrium model, the U.S. 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. The monetary policy rule only responds contemporaneously to U.S. M2, oil prices and the real effective trade-weighted U.S. exchange rate. Following the literature, the

[6] The conduct of monetary policy in China has received considerable attention in recent years. In B-SVAR and sign restriction SVAR analyses of monetary policy in major emerging economies, including China, Mallick and Sousa (2012; 2013) find that domestic output falls significantly in response to own-country monetary tightening. Jawadi et al. (2014) show that liquidity in China mainly responds to domestic growth, interest rate and commodity prices over 1990:1 to 2008:4. Fernald et al. (2014) utilize a FAVAR model to examine the impact on the domestic economy of monetary policy in China, and find that changes in bank reserve requirements and central-bank interest rates are most consequential.

[7] Note that Bagliano and Favero (1998) use commodity prices instead of oil prices.

[8] The Chi-square value for treating real output as contemporaneously exogenous is 10.5, while the Chi-square value for assuming real output depends contemporaneously on oil prices is 9.98.

U.S. M2 monetary aggregate responds contemporaneously to the domestic interest rate, inflation and industrial production implying that real demand for money depends on the interest rate and real income.

In line with Kim and Roubini (2000) and Kim (2001a; 2001b) inflation is affected contemporaneously by real output and oil prices consistent with the notion of contemporaneous demand pull and cost push inflation forces. The real effective trade-weighted U.S. exchange rate responds contemporaneously to all variables but Chinese M2 given its forward-looking properties and the fact that exchange rates operate daily looking at current data and economic activity.[9] Alternative identification strategies are explored in examination of the robustness of results.

2.2. The Data and unit root test

The data are monthly from 1996:1 to 2012:12. The starting date is dictated by the first monthly observation of Chinese M2 reported by People's Bank of China. Monetary aggregates, industrial production indexes, U.S. CPI, interest rate, oil prices (West Texas Intermediate crude oil) and commodity price data are from the Federal Reserve of St. Louis (FRED), while Chinese M2 is from People's Bank of China. The U.S. trade prices and variables are from the U.S. Bureau of Labor Statistics. Up until 2005 China's renminbi was pegged to the U.S. dollar.

To avoid spurious regression problem, we test the data for unit root process. Table 1 reports test results for unit roots in the variables over 1996:1-2012:12. The null hypothesis for the Augmented Dickey-Fuller (ADF) test is that the variable has a unit root and the null hypothesis for the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test is that 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-

[9] See for example Bagliano and Favero (1998), Kim and Roubini (2000) and Kim (2001a; 2001b).

West Bandwidth with constant and linear trend. In Table 1, the Augmented Dickey Fuller test (ADF) unit root tests reveals that the logs of all endogenous variables in the model are only first difference stationary. These results are confirmed by Kwiatkowski-Phillips-Schmidt-Shin (KPSS), where the inverse null hypothesis is tested.[10] Consequently, and following the literature using monthly data the model is estimated in first difference.

3. Empirical Results

3.1. The impulse response results

Figure 3 shows the dynamic response or impulse response function of the U.S. variables in the SVAR in equation (3) to a one per cent change in China liquidity shocks. The dashed lines represent a one standard error confidence band around the estimates of the coefficients of the impulse response functions.[11]

In the first row in Figure 3, the short term U.S. interest rate does not respond significantly to innovations in China's M2. An unanticipated positive increase in China's M2 has a negative effect on U.S. M2 that is statistically significant. This latter result is consistent with a defensive response by the U.S. to a stimulus by China, which boosts U.S. CPI inflation and industrial production and weakens the U.S. dollar as discuss later. A positive innovation in China's M2 has statistically significant positive effect on the U.S. CPI. The effect builds up over five months and then persists. In the second row in Figure 3, U.S. industrial production is positively affected by positive innovations in China's M2, but the effect is not statistically significant.

A positive shock in China's M2 has a positive and statistically significant effect on oil price that builds up rapidly over three months and then persists for twenty months in the

[10] Results are also supported by the Dickey Fuller GLS (DF-GLS) and the Phillip-Perron (PP) which are available upon request. In addition, all exogenous variables in the model are also first different stationary (data available upon request).

[11] 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.

second row in Figure 3. The effect of China's growth on real oil price has been documented in the literature. Hamilton (2011) notes that rapid growth in oil consumption in China and in other emerging countries is the most important factor influencing oil prices in recent years. Kilian and Hicks (2012) associate the rise in real oil price over 2003-2008 with unexpected growth in emerging economies (primarily China and India). Ratti and Vespignani (2013) find a large cumulative impact of China's real M2 on the real price of crude oil over the last fifteen years. In results not shown, if a global commodity price variable replaces the oil price variable in the SVAR in equation (2) results are similar. A positive innovation in China's M2 has a positive and statistically significant effect on commodity price that rises sharply over three months, peaks at about five months, and then persists for twenty months.

The response effects of the real trade-weighted U.S. dollar to shocks to China's M2, is shown in the last diagram in Figure 4. A rise in China's M2 is associated with a statistically significant negative effect on the real trade-weighted U.S. currency after two months that persists for twenty months. The effect of an increase in China's M2 might be expected to be less marked on the real trade-weighted U.S. dollar exchange rate since 2005 (with the renminbi tied to a band around a basket of world currencies rather than being pegged to the dollar). However, it should be noted that the scale of China's influence on the global economy in the last half of the sample is much greater than in the first half of the sample and that considerable weight has been given to the U.S. dollar in the basket of major currencies around which central parity the value of renminbi is allowed to vary since 2005. In results not reported, it is found that when the sample is broken in July 2005, a positive innovation in China's M2 is associated with a statistically significant negative effect on the real trade-weighted U.S. foreign exchange rate post July 2005.

3.2. Responses of U.S. trade variables to China Liquidity shocks

Given the finding that a positive shock to China's liquidity leads to a statistically significant and persistent depreciation of the real trade-weighted value of U.S. currency, the impact of shocks to China's M2 on U.S. trade and trade price variables will be examined.

Following a procedure in Kim (2001a) the price deflator for U.S. exports, price deflator for U.S. imports, and U.S. terms of trade variable (U.S. export price/U.S. import price) are now added one variable at a time as an additional variable in the SVAR system (Equations 2 and 3). The impulse response functions of the U.S. trade price variables to a one per cent change in China M2 shocks are shown in Figure 4. An unanticipated rise in China's M2 significantly raises the price deflator for U.S. exports and the price deflator for U.S. imports. The rise in both price deflators is completed after five months and then persists over the twenty months shown. The rise in the price deflator for U.S. exports is consistent with the finding that a positive innovation in China's M2 has a positive and statistically significant effect on U.S. CPI inflation that builds up over several months and then persists. The rise in the U.S. price deflator for U.S. imports in response to a positive innovation in China's M2 ties in with the statistically significant depreciation of the real trade-weighted value of U.S. exchange rate. A positive shock in China's M2 results in a rise in the U.S. dollar price of imports for U.S. consumers.

The impulse response of the U.S. terms of trade to a positive shock in China's M2 is shown in the third diagram in Figure 4. The U.S. terms of trade decline following a positive shock to China's M2. The decline in the terms of trade is statistically significant after three months, achieves maximum effect at four months, and then persists almost unchanged. Although a positive shock in China's M2 significantly raises export prices, the effect on import prices is so much greater that the terms of trade significantly decline. This is an important result since changes to the terms of trade affect consumption decisions, the composition of output across industries and welfare, and channel international shocks.

In figure 5 the impulse response function of Chinese M2 shocks on the U.S. trade variables: nominal exports, imports and trade balance and real exports, imports and trade balance are reported. These results are obtained from SVAR models in which these variables are added one variable at a time as an additional variable in the SVAR model in Equations (2) and (3).

In Figure 5 a positive shock to China's M2 significantly expands both U.S. nominal and real exports. Foreign demand for U.S. goods is stimulated by the fall in the U.S. dollar. The effect of a shock to China's M2 on real U.S. exports is statistically significant after three months, with the rise in real exports completed after six months after which the effect persists. A positive innovation in China's M2 has a negative effect on real U.S. imports that (with the exception of a significant effect at three months) is not statistically significant. U.S. demand for foreign goods is relatively price inelastic with the result that the nominal dollar value of U.S. imports is significantly increased. The net consequences of these effects on exports and imports are that a positive shock to China's M2 does not significantly impact the U.S. nominal trade balance, but does significantly improve the U.S. trade balance in real terms.[12] In Figure 5 a positive shock to China's M2 has a significant effect on the U.S. trade balance in real terms from three months onwards. The effect is highly persistent.

An interesting issue that arises is whether the effects of shocks to China's M2 on U.S. trade variables are driven by bilateral China/U.S. trade effects or non-China/U.S. trade effects or both. In Figure 6 it is shown that except in the second month, a positive shock to China's M2 does not significantly impact U.S. nominal exports to China or U.S. nominal imports from China. The significant rise in U.S. nominal exports in response to a positive shock to China's M2 is driven by a significant rise in U.S. exports to countries other than China. The impulse response results for the effect of a positive shock to China's M2 on U.S. nominal

[12] As in Kim (2001b) real exports (export volume) minus real imports (import volume) is used as a proxy for the U.S. trade balance in real terms.

exports excluding exports to China are shown in Table 6. U.S. dollar exports to the rest of the world (exclusive of China) rise significantly after three months and the effect persists. In response to a positive shock to China's M2, U.S. dollar imports from the rest of the world (exclusive of China) also rise significantly after three months and the effect persists. However, the rise in U.S. dollar exports is significantly greater than the rise in U.S. dollar imports with respect to the world exclusive of China as shown in Figure 6.

3.3. Historical decomposition of the effects of China's Liquidity

The cumulative contribution of the structural shocks to China's M2 to the U.S. consumer price index, oil prices, the real effective trade-weighted U.S. dollar exchange rate, the U.S. terms of trade, real trade balance variables and short term U.S. interest rate are shown in Figure 7. These results are obtained from estimating the SVAR model in Equation (3), with the exception of those for the real trade balance and the terms of trade. Results for the latter variables are obtained from modifying the model in Equation (3) by adding the real trade balance and the terms of trade variables once at the time to this system. The cumulative contributions of structural shocks to the variables reported in Figure 7 are annual averages of the monthly data (the moving average of the last 12 months) to improve the readability of the plot. The data are not annualized.

Striking facts from Figure 7 are that the cumulative contribution of China's M2 to the U.S. variables shown appears to differ in the second half of the sample from the first half of the sample. Consistent with the growth of China's economy, shocks to China's M2 have stronger impact of China on U.S. variables since about 2005. The cumulative contribution of China M2 shocks on the consumer price index and on oil price are much larger (more positive) in the last half of sample. The rapid increase in oil price leading to a peak in June 2008 is associated with a positive contribution from China's M2. The cumulative impact of China's M2 on the price of oil is also positive in the strong recovery of oil price since 2009.

China's monetary expansion has a positive cumulative contribution to the U.S. consumer price index since 2005 in contrast to a largely negative cumulative contribution to the U.S. consumer price index before 2005. In 2005 the annualized contribution of China's M2 to US CPI is up to 0.3%.

The cumulative effect of China M2 shocks on the real effective trade-weighted U.S. dollar exchange rate is largely negative since 2005. In the last half of the sample China's M2 shocks have tended to contribute to a decline in the trade-weighted U.S. dollar. The effect of China M2 shocks on worsening the terms of trade for the U.S. in the latter half of the sample is also quite marked in Figure 7. In Figure 7 the cumulative effect of China M2 shocks on the U.S. trade balance in real terms is largely negative over 2005 to 2011, i.e. China M2 shocks tended to result in an improved U.S. trade balance in real terms over these years. This outcome is consistent with the movements in the terms of trade. The increase in import prices (attendant on a decline in the trade-weighted U.S. dollar exchange rate) together with the increase in oil prices account for the association of innovations to China's M2 with increases in U.S. consumer price inflation.

The contribution of China's M2 to U.S. short-term interest rate in Figure 7 show large positive contributions that overlap with the U.S. recession periods March 2001 to November 2001 and December 2007 to June 2009. During these times global demand was also weak, but China's economy and M2 continues to expand. For this reason we observe the pattern of positive contributions by innovations to China's M2 to U.S. short-term interest rate in the two periods indicated.[13]

3.4. Robustness and alternative identification strategies

[13] In 2001 period there is the collapse of the speculative dot-com bubble and fall in business outlays and investments, and in the 2007-2009 period there is the subprime mortgage crisis and collapse of the U.S. real estate bubble. Global demand was weak during these periods in that both U.S. real export volume and U.S. real import volume decline sharply during 2001-2002 and 2008-2009.

We now investigate the robustness of the results using alternative specifications to the SVAR reported in Equation (3). We investigate four alternative non-recursive identification restrictions in the contemporaneous matrix restriction to that shown for B_0X_t in equation (3). The alternative identification schemes based on Equations (1) and (2) are the following:

$$B_0X_t = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{10} & 1 & a_{12} & 0 & a_{14} & 0 & a_{16} \\ a_{20} & a_{21} & 1 & a_{24} & a_{25} & 0 & 0 \\ a_{30} & 0 & 0 & 1 & a_{34} & a_{35} & 0 \\ a_{40} & 0 & 0 & 0 & 1 & 0 & 0 \\ a_{50} & 0 & 0 & 0 & 0 & 1 & 0 \\ a_{60} & a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{bmatrix} \begin{pmatrix} \Delta log(China\,M2_t) \\ US\,IR_t \\ \Delta log(US\,M2_t) \\ \Delta log(US\,CPI_t) \\ \Delta log(US\,IP_t) \\ \Delta log(OP_t) \\ \Delta log(US\,TWI_t) \end{pmatrix}, \quad (4)$$

$$B_0X_t = \begin{bmatrix} 1 & a_{01} & 0 & a_{03} & a_{04} & 0 & 0 \\ 0 & 1 & a_{12} & 0 & a_{14} & 0 & a_{16} \\ 0 & a_{21} & 1 & a_{24} & a_{25} & 0 & 0 \\ 0 & 0 & 0 & 1 & a_{34} & a_{35} & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{bmatrix} \begin{pmatrix} \Delta log(China\,M2_t) \\ US\,IR_t \\ \Delta log(US\,M2_t) \\ \Delta log(US\,CPI_t) \\ \Delta log(US\,IP_t) \\ \Delta log(OP_t) \\ \Delta log(US\,TWI_t) \end{pmatrix}, \quad (5)$$

$$B_0X_t = \begin{bmatrix} 1 & a_{01} & a_{02} & a_{03} & a_{04} & a_{05} & a_{06} \\ 0 & 1 & a_{12} & 0 & a_{14} & 0 & a_{16} \\ 0 & a_{21} & 1 & a_{24} & a_{25} & 0 & 0 \\ 0 & 0 & 0 & 1 & a_{34} & a_{35} & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{bmatrix} \begin{pmatrix} \Delta log(China\,M2_t) \\ US\,IR_t \\ \Delta log(US\,M2_t) \\ \Delta log(US\,CPI_t) \\ \Delta log(US\,IP_t) \\ \Delta log(OP_t) \\ \Delta log(US\,TWI_t) \end{pmatrix}, \quad (6)$$

$$B_0X_t = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & a_{12} & 0 & a_{14} & 0 & a_{16} \\ 0 & a_{21} & 1 & a_{24} & a_{25} & 0 & 0 \\ 0 & 0 & 0 & 1 & a_{34} & a_{35} & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ a_{60} & a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{bmatrix} \begin{pmatrix} \Delta log(China\,M2_t) \\ US\,IR_t \\ \Delta log(US\,M2_t) \\ \Delta log(US\,CPI_t) \\ \Delta log(US\,IP_t) \\ \Delta log(OP_t) \\ \Delta log(US\,TWI_t) \end{pmatrix}. \quad (7)$$

In system (4), the U.S. variables respond contemporaneously to China's M2. In system (5), China's M2 responds to U.S. domestic variables in the same way that U.S. M2 does. In system (6), China's M2 responds contemporaneously to all U.S. domestic variables. Finally, in system (7) the real trade-weighted U.S. dollar responds contemporaneously to China's M2.

The estimation of the SVAR models outlined in Equations (4), (5), (6) and (7) results in impulse response of the U.S. economic variables to positive shocks to China's liquidity that are very similar to those shown in Figure 3. In all models a positive innovation in China's liquidity is associated with:

1. a positive and statistically significant effect on oil price (or on commodity prices) that builds up rapidly over three months and then persists for twenty months;
2. a positive and statistically significant effect on U.S. CPI inflation that builds up over about six months or so and then persists;
3. a statistically significant depreciation of the real trade-weighted U.S. currency after about two or three months that achieves maximum absolute value after five to eight months and that then persists.

In Table 2, the log likelihood ratio for over-identification test Chi-square values are reported for each of the five models shown in Equations (3) – (7). The highest value for over-identification test restriction is for our model of choice in Equation (3), indicating that the restriction cannot be rejected at a higher significance level than for the other models.

4. Conclusion and discussion

The major finding of the paper is that China's liquidity expansion has a spill over effect on the U.S. through the effects on world commodity markets and through the exchange rate regime followed by China. Increases in liquidity in China significantly increase the world prices of oil and commodities, significantly increases U.S. CPI inflation, and significantly decreases the real trade-weighted value of the U.S. dollar and the terms of trade for the U.S. In response to a shock to China's M2 the increase in the price deflator for U.S. imports is significantly greater than the increase in the price deflator for U.S. exports. The increase in import prices due to decline in the trade-weighted U.S. dollar and the increase in oil (and commodity) prices account for the association of innovations to China's M2 with increases in U.S. consumer price inflation. These findings are robust to a number of model specifications including different assumptions about whether commodity or oil prices appear in the model, when U.S. variables respond contemporaneously to Chinese M2, when China's M2 may respond to all U.S. domestic variables, and when the real trade-weighted value of the U.S. dollar responds contemporaneously to China's M2.

The inclusion of China variables in analysis of the international transmission of liquidity shocks is an appropriate specification given the tremendous impact of China on the global economy in recent years. It is now clear that China's economy has achieved a scale such that China's liquidity has influence on the U.S. economy. China's growth influences world commodity/oil prices and this is reflected in significantly higher inflation in the U.S. China's liquidity expansion is also associated with significant decreases in the real trade weighted value of the U.S. dollar that is due to the operation of a pegged currency. To maintain the value of its currency at a time of liquidity expansion, China in effect takes steps that result in a devaluation of real trade-weighted value of the U.S. dollar.

References

Bagliano, F. C., Favero, C. A., 1998. Measuring monetary policy with VAR models: An evaluation. European Economic Review 42(6), 1069-1112.

Belke, A., Bordon, I.G., Volz, U., 2013. Effects of global liquidity on commodity and food prices. World Development 44, 31-43.

Bernanke, B., 1986. Alternative explanations of the money-income correlation. Carnegie-Rochester series on Public Policy 25, 49-99.

Cai, Z., Chen, L. and Fang, Y., 2012. A new forecasting model for USD/CNY exchange rate", Studies in Nonlinear Dynamics & Econometrics, 16(2), forthcoming.

Chen, G., 2014. A growth perspective on foreign reserve accumulation. Macroeconomic Dynamics, 1-22.

Christiano, L.J., Eichenbaum, M., Evans, C., 1999. Monetary policy shocks: What have we learned and to what end? In: Taylor, J.B., Woodford, M. (Eds.), Handbook of Macroeconomics, Vol. 1A. North-Holland, Amsterdam, 65–148.

D'Agostino, A., Surico, P., 2009. Does global liquidity help to forecast US inflation? Journal of Money, Credit and Banking 41, 479-489.

Darius, R., Radde, S., 2010. Can global liquidity forecast asset prices? IMF Working Paper 10/196, International Monetary Fund, Washington, D.C.

Dedola, L., Lippi, F., 2005. The monetary transmission mechanism: Evidence from the industries of five OECD countries. European Economic Review 49(6), 1543-1569.

Fan, L., Yu, Y., Zhang, C., 2011. An empirical evaluation of China's monetary policies. Journal of Macroeconomics 33 (2), 358–371.

Fang, Y., Huang, S., Niu, L., 2012. De facto currency baskets of China and East Asian economies: The rising weights. Bank of Finland BOFIT Discussion Papers, 2-2012.

Fernald, J.G., Spiegel, M.M., Swanson, E.T., (2014). Monetary policy effectiveness in China: Evidence from a FAVAR model. Journal of International Money and Finance, Article in Press. DOI: 10.1016/j.jimonfin.2014.05.007

Hamilton, J.D. (2011), "Historical Oil Shocks," NBER Working Paper No. 16790. Forthcoming in The Routledge Handbook of Major Events in Economic History, Randall E. Parker (Author, Editor), Robert M. Whaples (Editor), Routledge, 2013.

Jawadi, F., Mallick, S.K., Sousa, R.M., 2014. Nonlinear monetary policy reaction functions in large emerging economies: The case of Brazil and China. Applied Economics 46 (9), 973-984.

Johansson, A.C., 2012. China's Growing Influence in Southeast Asia – Monetary Policy and Equity Markets. The World Economy 35(7), 816-837.

Kilian, L., (2013). Structural vector autoregressions. In: N. Hashimzade and M.A. Thornton (eds.), Handbook of Research Methods and Applications in Empirical Macroeconomics, Cheltenham, UK: Edward Elgar, 515-554.

Kilian, L., and B. Hicks (2012), "Did Unexpectedly Strong Economic Growth Cause the Oil Price Shock of 2003-2008?" Journal of Forecasting, forthcoming.

Kim, S., Roubini, N., 2000. Exchange rate anomalies in the industrial countries: a solution with a structural VAR approach. Journal of Monetary Economics 45, 561–586.

Kim, S., 2001a. International transmission of US Monetary policy shocks: evidence from VARs. Journal of Monetary Economics 48, 339–372.

Kim, S., 2001b. Effects of monetary policy shocks on the trade balance in small open European countries, Economics Letters 71(2), 197-203.

Kim, Y.S., 2001. Liquidity, Prices, Seigniorage, and the transition from barter to fiat money. Macroeconomic Dynamics 5, 353-379.

Koz´luk, T., Mehrotra, A., 2009. The Impact of Chinese Monetary Policy Shocks on East and South-East Asia. Economics of Transition 17 (1), 121–45.

Mallick, S.K., Sousa, R.M., 2012. Real effects of monetary policy in large emerging economies. Macroeconomic Dynamics 16 (SUPPL. 2), 190-212.

Mallick, S.K., Sousa, R.M., 2013. Commodity prices, inflationary pressures, and monetary policy: evidence from BRICS economies. Open Economies Review 24 (4), 677-694.

Radetzki, M., 2006. The anatomy of three commodity booms. Resources Policy 31, 56–64.

Ratti, R.A., Vespignani, J.L., 2013. Liquidity and Crude Oil Prices: China's Influence Over 1997-2011. Economic Modelling 33, 517-525.

Sims, C.A., 1980. Macroeconomics and Reality. Econometrica 48, 1-48.

Sims, C.A., Zha, T., 1995. Does monetary policy generate recessions?: Using less aggregate price data to identify monetary policy. Working paper, Yale University, CT.

Sims, C.A., Zha, T., 2006. Does Monetary Policy Generate Recessions? Macroeconomic Dynamics 10 (2), 231-272.

Sun, H., 2009. Autonomy and Effectiveness of Chinese Monetary Policy under the De Facto Fixed Exchange Rate System. China and World Economy 17 (3), 23-38.

Table 1: Test for unit roots 1996:1-2012:12:

Endogenous variables					
Variables	ADF	KPSS	PP	ADF	KPSS
$\log(China\ M2_t)$	0.999	1.793***	$\Delta\log(China\ M2_t)$	0.0399***	0.312
$\mathrm{U.S.IR}_t$	0.733	1.022***	$\mathrm{U.S.IR}_t$	0.000***	0.068
$\log(U.S.M2_t)$	0.975	1.796***	$\Delta\log(U.S.M2_t)$	0.000***	0.077
$\log(U.S.CPI_t)$	0.892	1.805***	$\Delta\log(U.S.CPI_t)$	0.000***	0.062
$\log(U.S.IP_t)$	0.119	0.946***	$\Delta\log(U.S.IP_t)$	0.011***	0.234
$\log(OP_t)$	0.650	1.639***	$\Delta\log(OP_t)$	0.000***	0.036
$\log(U.S.TWI_t)$	0.786	1.343***	$\Delta\log(U.S.TWI_t)$	0.000***	0.194

Notes: The variables are China M2, short term U.S. interest rate (U.S. IR), U.S. M2, U.S. consumer price index (U.S. CPI), U.S. industrial production (U.S. IP), global oil price (OP), and real effective trade-weighted U.S. foreign exchange rate (U.S. TWI). 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. ***, **, * indicates rejection of the null hypothesis at 1%, 5% and 10%, levels of significance.

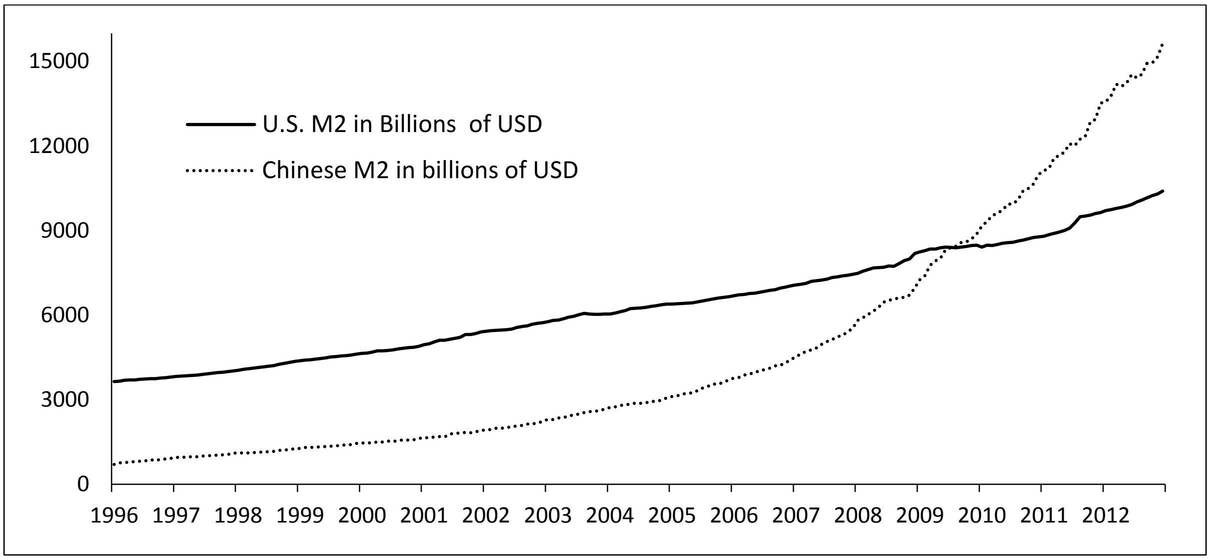
Table 2: Log likelihood ratio test for over-identification restrictions

Null Hypothesis : Restrictions are valid

Model restrictions	3	4	5	6	7
Chi-square value	10.5	8.16	4.49	6.89	9.01

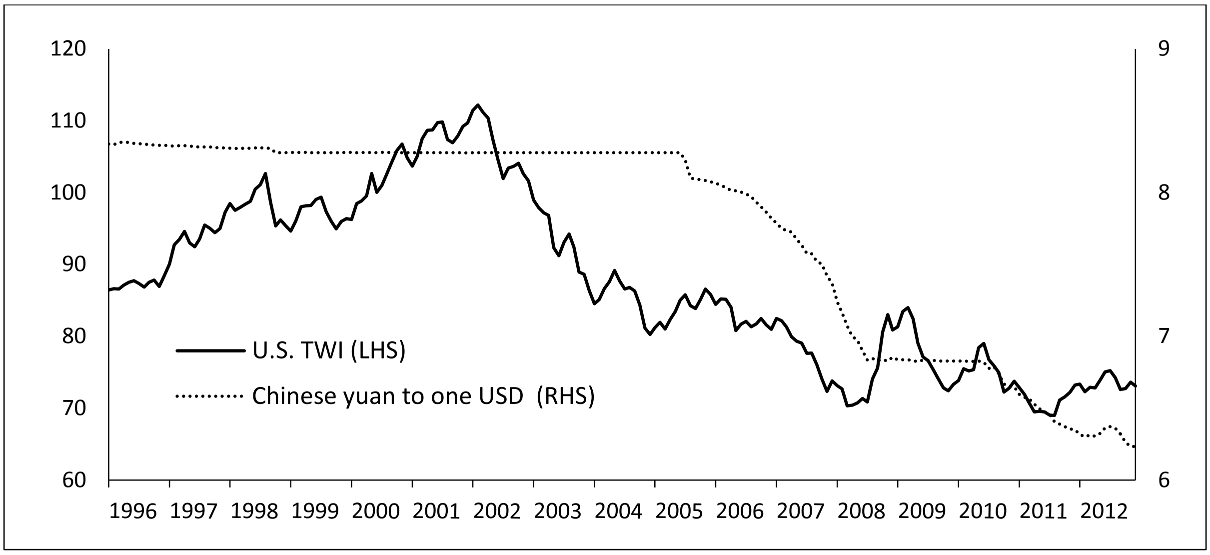
Notes: Log likelihood ratio for over-identification test Chi-square values are reported for each of the five models shown in equations (3), (4), (5), (6) and (7). The test is for non-recursive identification restrictions in the contemporaneous matrix restrictions in equations (3), (4), (5), (6) and (7), based on equations (1) and (2). The highest value for over-identification test restriction is for model of choice in equation (3), indicating that the restriction cannot be rejected at higher significant level than for the other models.

Figure 1: Monetary aggregate M2 in billions of U.S. dollars for China and the U.S.



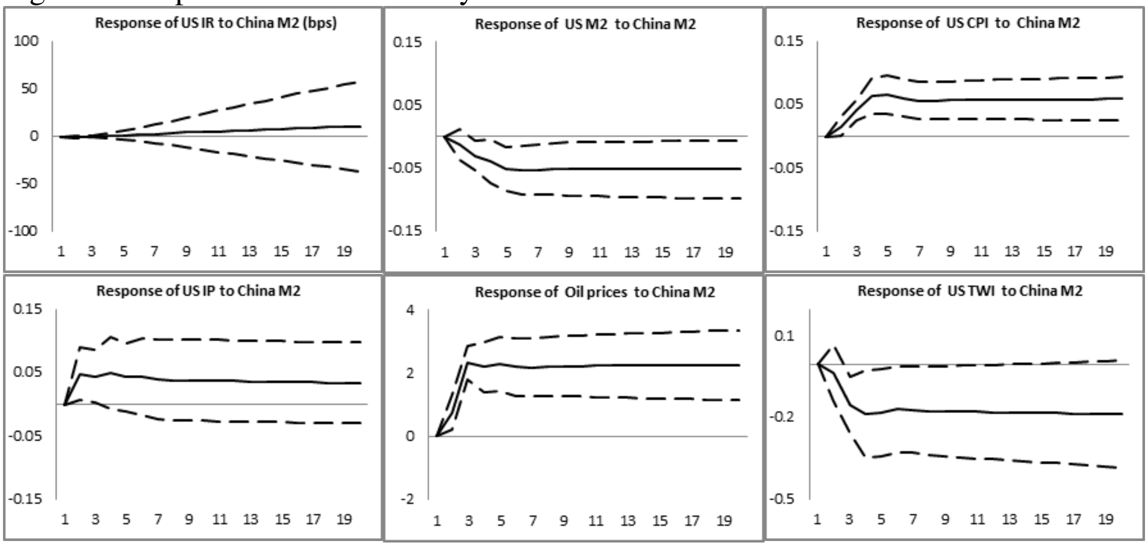
Notes: U.S. M2 data are from the Federal Reserve of St. Louis (FRED) and China M2 data are from People's Bank of China.

Figure 2: China/U.S. exchange rate and real effective trade-weighted U.S. dollar



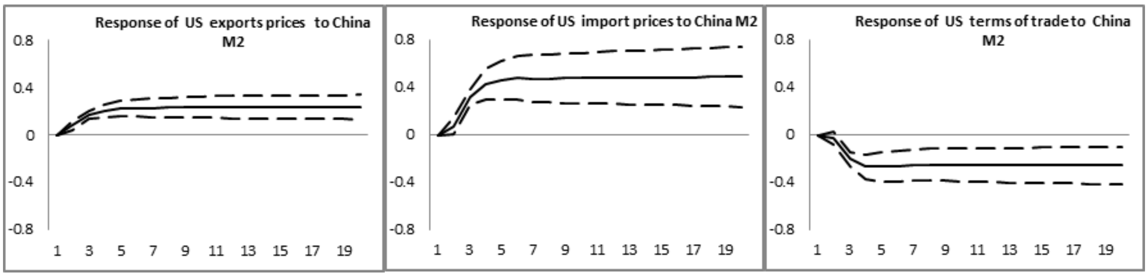
Notes: China/U.S. exchange rate and real effective trade-weighted U.S. dollar (U.S. TWI) from the Federal Reserve of St. Louis (FRED).

Figure 3: Response of U.S. economy to China M2 shocks: 1996:1-2012:12



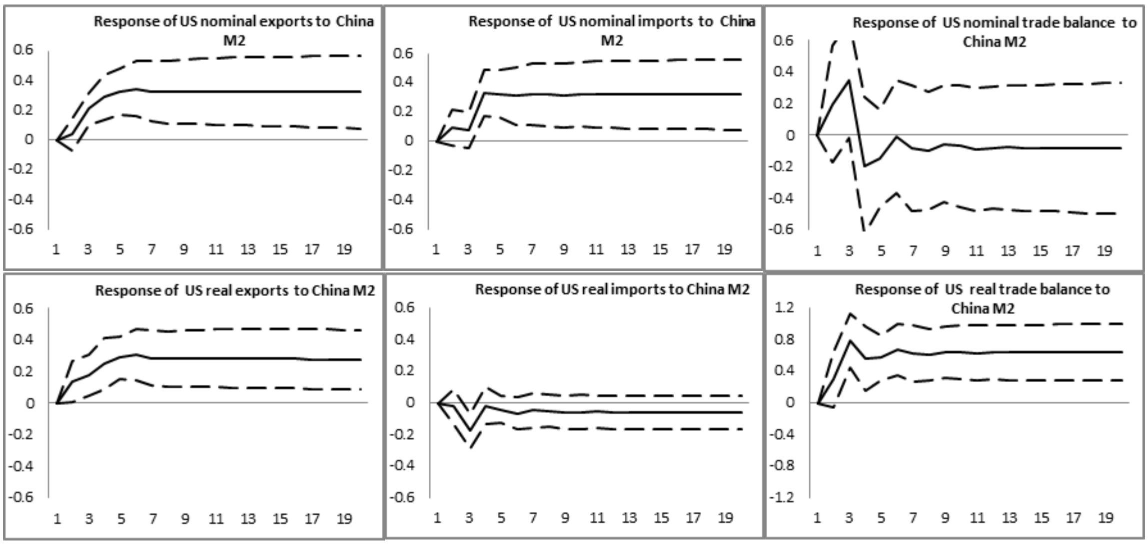
Notes: Figure 3 shows the dynamic response or impulse response function of the U.S. variables in the SVAR model equation (3) to positive China M2 shocks. The confidence bands are obtained using Monte Carlo integration as described by Sims (1980), where 5000 draws were used from the asymptotic distribution of the VAR coefficient. The variables are China M2, short term U.S. interest rate (USIR), U.S. M2 (USM2), U.S. consumer price index (US CPI), U.S. industrial production (US IP), global oil price (OP), and real effective trade-weighted U.S. dollar exchange rate (US TWI).

Figure 4: Response of U.S. trade prices to China M2 shocks: 1996:1-2012:12



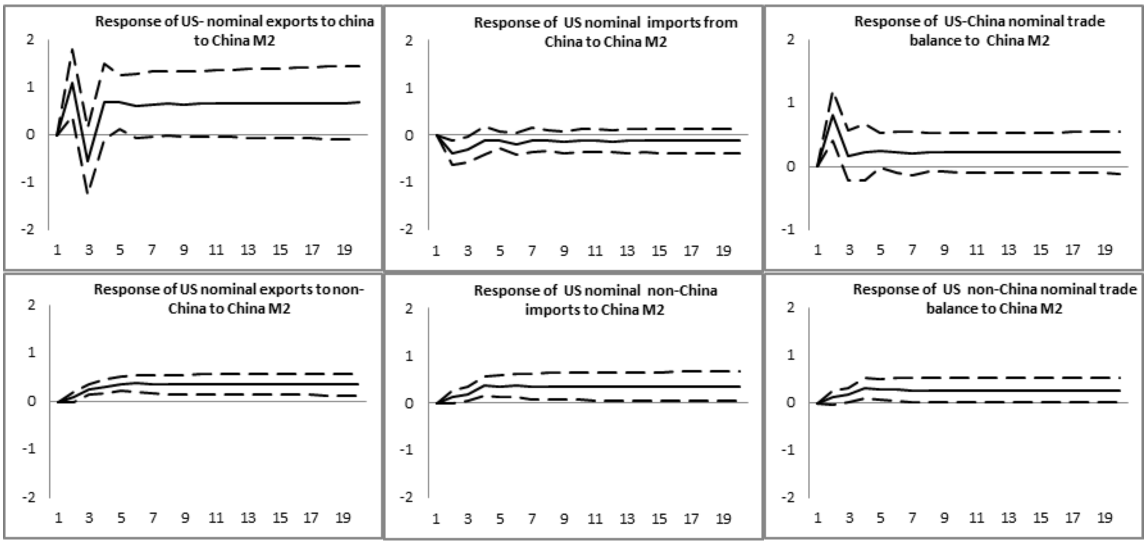
Notes: Figure 4 shows the dynamic response or impulse response function of the U.S. trade price variables from an SVAR model based on equation (3) to positive China M2 shocks. The variables in Figure 4 are China M2, the price deflator for U.S. exports, price deflator for U.S. imports, and U.S. terms of trade variable (U.S. export price/U.S. import price).

Figure 5: Response of U.S. trade variables to China M2 shocks: 1996:1-2012:12



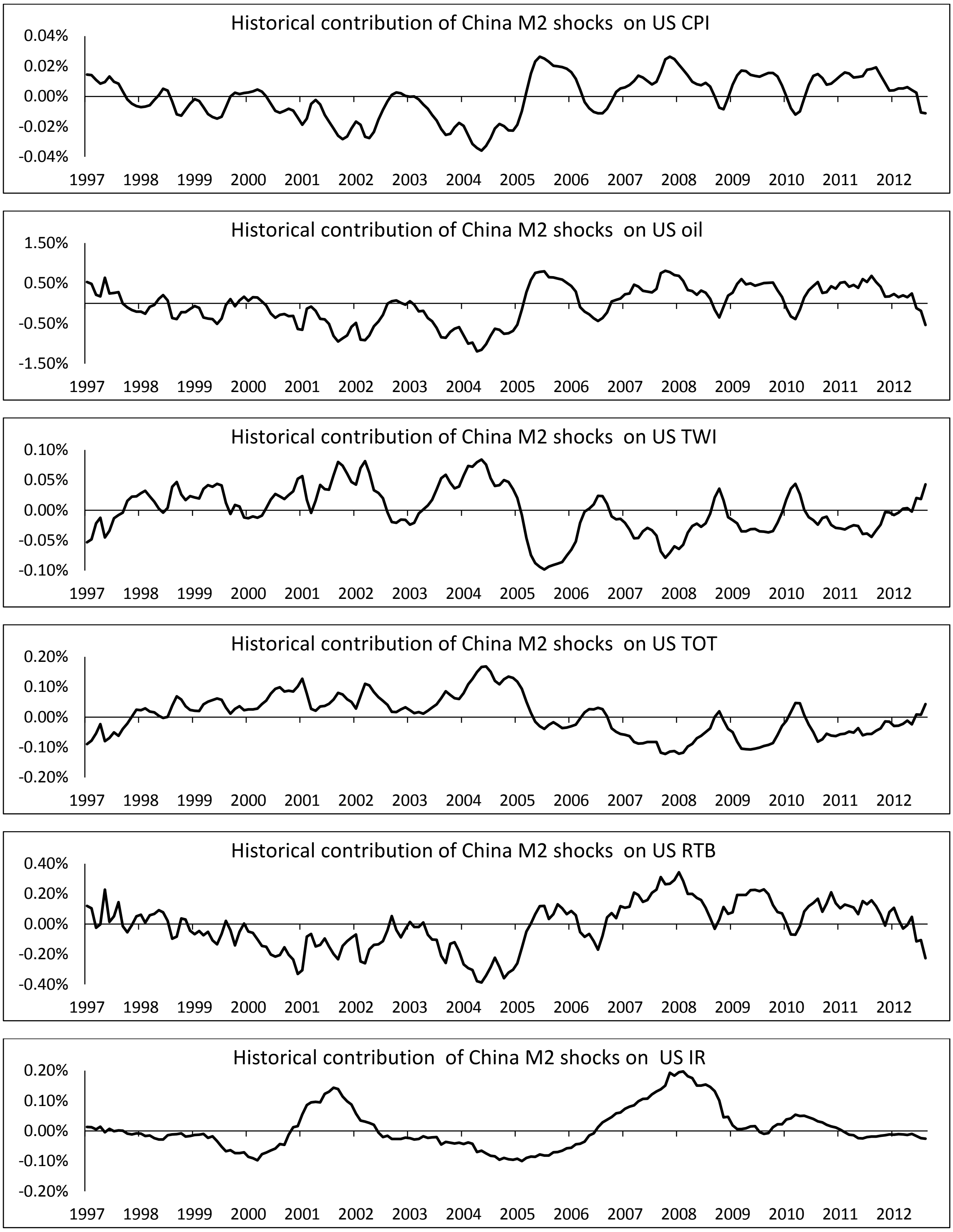
Notes: Figure 5 shows the dynamic response or impulse response function of the U.S. trade variables from a SVAR model based on equation (3) to positive China M2 shocks. The variables in Figure 5 are China M2, nominal U.S. exports, nominal U.S. imports, nominal U.S. trade balance, real U.S. exports, real U.S. imports, and real U.S. trade balance.

Figure 6: Response of bilateral U.S.-China and U.S.-non-China bilateral trade variables



Notes: Figure 6 shows the dynamic response or impulse response function of the U.S. variables from a SVAR model based on equation (3) to positive China M2 shocks. The variables in Figure 6 are China's M2, and variables given by bilateral exports, imports, and net nominal trade balance between either the U.S. and China or the U.S. and the world exclusive of China.

Figure 7: Historical decomposition on Chinese monetary shocks on U.S. economy: 1997:1 to 2012:12



Notes: Figure 7 shows the cumulative contribution of structural shocks to China's M2 to U.S. economic variables. The variables are short term U.S. interest rate (USIR), U.S. M2 (USM2), U.S. consumer price index (US CPI), U.S. industrial production (US IP), global oil price (OP), real effective trade-weighted U.S. dollar exchange rate (US TWI), the real trade balance (RTB) and the terms of trade (TOT). The cumulative contributions of structural shocks to the U.S. variables reported in Figure 7 are annual averages of the monthly data (the moving average of the last 12 months) to improve the readability of the plot. The data are not annualized.