Hot Money and Quantitative Easing: The Spillover Effects of U.S. Monetary Policy on the Chinese Economy

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Abstract

We develop a factor-augmented vector autoregression model to estimate the effects of changes in U.S. monetary policy and economic policy uncertainty have on the Chinese housing, equity and loan markets. We find that the decline in the U.S. policy rate since the Great Recession has led to a significant increase in Chinese regulated interest rates and to a rise in Chinese housing investment. One possible reason for this effect is the substantial inflow of "hot money" into China. The responses of Chinese variables to U.S. shocks at the zero lower bound are different from those responses in normal times. Moreover, increased uncertainty regarding U.S. policy negatively impacts the Chinese stock and real estate markets during normal times but not at the zero lower bound.

JEL codes: F3, C3, E4

Keywords: international policy spillover, Chinese real estate market, U.S. monetary policy, policy uncertainty

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1. Introduction

Since the Great Recession, the federal funds rate, the primary tool of U.S. monetary policy, has hit the zero lower bound for extended periods, and researchers have been keenly interested in investigating how this unconventional U.S. monetary policy and its tapering affect emerging markets, particularly the Chinese market. Although China is the world's largest emerging economy, questions surround the existence and magnitude of the spillover effects since the Chinese capital account has not fully opened up and the Chinese exchange rates are not flexible. Is it true that U.S. monetary policy has little spillover effect on the Chinese economy? We investigate this question in this paper and we also study the manner in which the central bank of China, the People's Bank of China (PBOC), reacts to U.S. monetary policy shocks. Moreover, since the outbreak of the most recent financial crisis in the U.S., economists have wondered whether uncertainty regarding U.S. economic policy has detrimental effects on the U.S. economy. Thus, we will also study whether there are any spillover effects on the Chinese economy that may be attributable to U.S. economic policy uncertainty which is measured by the EPU index recently proposed by Baker et al. (2012).

In short, we use a broad set of Chinese economic indicators and run a factor-augmented vector autoregression (FA-VAR) model to estimate the effects that changes in both the U.S. policy rate and in U.S. policy uncertainty have on the Chinese economy. A similar methodology was used by Fernald et al. (2014) and He et al. (2013) to study the Chinese economy, although those studies focus on the effects of Chinese monetary policy shocks without addressing the impact of U.S. monetary policy and policy uncertainty shocks on the Chinese economy.

The advantage of the FA-VAR approach is that we are able to include a large number of data series, 175 series in our FA-VAR model, without being constrained by concerns about preserving the degree of freedom, as is the case with a standard vector autoregression (VAR) approach. One criticism of the standard VAR approach is that the small number of variables included does not represent the rich information set that the central bank and market participants actually use and that policy innovations may be contaminated as a result. Thus, Sims (1992) explains that imperfectly controlling for information about future inflation would result in the "price puzzle" phenomenon, i.e., the finding common to VAR models that a contractionary monetary policy shock is followed by increased, rather than decreased, price levels. The use of the FA-VAR approach also addresses potential endogeneity issues that arise from the notion that the Federal Reserve might adjust monetary policy in response to economic conditions in China. Endogeneity concerns are supported by historical precedents, such as when the Fed lowered short-term U.S. interest rates in light of the Russian default and Asian financial crisis in the late 1990s (Neely, 2004). Because we are using the FA-VAR model used by Bernanke et al. (2004), the effects of the impulse response due to an unforecasted innovation in U.S. monetary policy are measured, which controls for a rich information set of both Chinese and U.S. macroeconomic variables.

Our estimation results suggest that there are significant cross-country spillover effects. We find that Chinese benchmark interest rates significantly respond to a U.S. monetary policy shock, while the market interest rates, trade balance and exchange rate do not change significantly. This result suggests that U.S. monetary policy shocks do not affect the Chinese economy through the trade channel. This finding is consistent with Canova (2005)'s earlier finding that U.S. monetary shock has significant effects on Latin American countries during the 1980-2002 period and that the primary transmission channel for these effects is the interest rate, whereas the trade channel plays an insignificant role. Our results suggest that, in addition to the benchmark interest rates, the so-called "hot money" may also play an important role in the transmission mechanism, which resonates with Prasad and Wei (2007)'s finding that "hot money",rather than the trade surplus, is the most important component of reserve accumulation in China. We also find that the responses of the Chinese economy to U.S. monetary policy shock and policy uncertainty shock exhibit different dynamics in periods before and after the time when the zero lower bound is binding in the U.S. This result suggests the existence of structural changes in both the Chinese economy and in the transmission mechanism of U.S. monetary policy.

There are several papers investigating the international spillover effects of U.S. monetary policy that are closely related to this paper.

Maćkowiak (2007) use the structural VAR approach to study the effects of external shock on eight emerging economies (Hong Kong, Korea, Malaysia, Philippines, Singapore, Thailand, Chile and Mexico) that are assumed to be small open economies that have no influence on U.S interest rates, although U.S. interest rates may substantially affect them. However, this assumption does not apply to China. China is a large trading partner with the U.S., and according to World Bank (2014), China will soon become the largest economy in the world based on purchasing power parity; thus, the state of the Chinese economy is certainly on the mind of central bankers around the world, which may pose endogeneity challenges for this methodology. Maćkowiak (2007) finds that U.S. monetary shock affects the real output and price levels in emerging economies even more strongly than the real output and price levels in the U.S. Furthermore, a U.S. monetary shock can quickly affect short-term interest rates and exchange rates in emerging markets. In our FA-VAR approach, we find that the impact of a U.S. monetary shock on Chinese industrial production is rarely statistically significant and does not affect the RMB/USD exchange rate due to the managed floating of the PBOC, although it can have a substantial effect on Chinese benchmark interest rates.

The theoretical work by Haberis and Lipinska (2012) shows that the inability of foreign monetary policy to stabilize the foreign economy at the zero lower bound creates a spillover that affects how well the home policymaker is able to stabilize its own economy. Although China is not a small open economy, we find that the PBOC's responses in setting the required reserve ratio and benchmark interest rates are different during the zero lower bound period compared with those responses during non-zero lower bound periods.

Focusing on developed countries, Bauer and Neely (2014) studies the relative importance of signalling and portfolio balance channels for the effects Federal Reserves large scale asset purchases (LSAP) program have on the international bond yields.

Dedola et al. (2013) has studied the global implications of unconventional national policies. Their key finding is that, in general, a lack of cooperation will result in suboptimal credit policies. In our results, especially during those times when the zero lower bound is binding in the U.S., we find that the PBOC takes contractionary credit measures in response to expansionary monetary policy shock in the U.S. that are plausibly aimed at restricting the credit available to the Chinese economy as "hot money" flows into China; failing to respond in this manner might lead to higher than optimal credit availability in the Chinese economy.

The remainder of this paper is structured as follows: Section 2 illustrates the model and data we use. In Section 4, we present robustness checks. Section 3 shows the results and analysis, and Section 5 concludes.

2. FA-VAR Model and Data

2.1. Model

We use the FA-VAR model developed by Bernanke et al. (2004) to investigate the effects of both U.S. monetary policy and U.S. policy uncertainty on the Chinese economy. There are a large number of observed macroeconomic time series X_t ($N \times 1$ vector) that contain very rich information on economic conditions. We also have observed variables Y_t (we call them "policy indicators" in this paper), and we aim to investigate how the shock to Y_t affects X_t. In this paper, we focus on Y_t that includes two particular variables: the U.S. policy rate and U.S. policy uncertainty.

However, it is challenging to use all the series in X_t in a structural VAR analysis because there are hundreds of series, but the number of observations in each series is small. Fortunately, many studies have confirmed that a few factors can explain a large fraction of the variance in many macroeconomic series. Therefore, instead of directly using every macroeconomic series, the informational series are summarized using a small number of unobservable factors F_t ($K \times 1$ vector, where K is much smaller than N). Because the factors F_t are unobservable, they are constructed by means of a principal component analysis. The dynamics of F_t and Y_t are assumed to follow the following transition equation:

$$\left(F \right)_t Y_t = \Phi(L) \left(F \right)_{t-1} Y_{t-1} + \nu_t, \tag{1}$$

where $\Phi(L)$ is a polynomial of the lag operator and ν_t is the error term with zero mean and covariance matrix Σ. We assume that the error term can be represented as linear combinations of structural shocks: $\nu_t = P\epsilon_t$. The structural shocks (ϵ_t) we consider here include U.S. monetary policy shocks, ϵ_t^{MP}, U.S. policy uncertainty shocks, ϵ_t^{PU}, and other structural shocks that are not our focus and will not be identified in this paper. Among these structural shocks, we are particularly interested in the monetary policy shock and the policy uncertainty shock.

Following Bernanke et al. (2004), the macroeconomic series X_t are related to the factors F_t and the policy indicators Y_t by an observation equation as follows:

$$X_t = \Lambda^f F_t + \Lambda^y Y_t + e_t. \tag{2}$$

The procedures used to construct the factors are described in Appendix C.

2.2. Data

We include 175 monthly macroeconomic series in China, and the complete table of variables included is found in the supplementary material. The sample period runs from January 2000 to February 2014. We choose to begin with the year 2000 based on data availability. All series except for policy variables are adjusted for the Chinese New Year effect as described by Fernald et al. (2014) and then adjusted for seasonality by using the U.S. Census Bureau X-13 program. We address missing values through the EM algorithm introduced by Stock and Watson (2002).

The U.S. monetary policy measure we use is the shadow federal funds rate proposed by Wu and Xia (2014), who extended the effective federal funds rate with a latent measure that allows for a negative policy rate when the zero lower bound is binding, and this series is plotted in Figure 1. The measure of U.S. policy uncertainty that we use is the prominent news-based measure proposed by Baker et al. (2012), as shown in Figure 2.

2.3. Estimation

The estimation method follows Bernanke et al. (2004). We first extract the first three principal components of the observed macroeconomic series over our sample period and then separate out the part in the principal components that is orthogonal to Y_t as factors F_t. Next, we estimate the transition equation, Equation (1), and the observation equation, Equation (2), with OLS. The impulse response functions and variance decomposition of each macroeconomic series can be obtained by combining the estimation results of these two equations. Identification is achieved by the recursiveness assumption, which means that the error term in each regression is constructed to be uncorrelated with the error in the preceding equations. More specifically, the factors are constructed to not respond to monetary policy shocks and policy uncertainty shocks contemporaneously.

We separate the full sample period into two subsamples. The first period runs from 2000M1 to 2008M9, and the second runs from 2009M12 to 2014M2.

The second period corresponds to the period during which the federal funds rate stays at zero and several unconventional monetary policies have been implemented by the Federal Reserve. We get our main results from the estimation using the second subsample, and use the estimation with the first subsample as a robustness check.

3. Results

We choose stock market variables, bond market variables, policy rates, price variables, real estate variables, and real economic activity variables to investigate their dynamics in response to U.S. monetary policy shocks and U.S. policy uncertainty shocks at the zero lower bound period.

3.1. Impulse Responses

The figures report the impulse responses in standard deviation units. We standardize the monetary policy shock to correspond to a decrease in the effective federal funds rate of 25 basis points during normal times and to a decrease of the Wu-Xia shadow federal funds rate of 25 basis points when the zero lower bound is binding. The size of the U.S. policy uncertainty shock is standardized to 10% of its standard deviation. The top, bottom, and middle lines correspond to 90% bootstrap confidence intervals and bootstrap median, respectively.

3.1.1. Impulse Responses to U.S. Monetary Policy Shock at ZLB

Figure 3 demonstrates the effects of an expansionary U.S. monetary policy shock on Chinese industrial output, the purchasing managers index (PMI), Chinese monetary authority assets, CPI and retail sales. We see that there are no significant responses in these variables. In particular, the response in the Chinese GDP is consistent with the finding by Chinn (2013) that in contrast to Hong Kong, Singapore and Malaysia, China's GDP response is fairly small. Figure (4) also shows that expansionary U.S. monetary policy has not significantly affected the Chinese trade balance or Chinese exports to the U.S.

Figure (4) shows that the RMB exchange rate with respect to the U.S. Dollar and foreign direct investment does not respond significantly to U.S. monetary policy shock. However, the same figure shows that there is a significant increase in foreign "hot money" flowing into China in response to expansionary U.S. monetary policy shocks. "Hot money" is approximated by subtracting the trade surplus (or deficit) and net flow of foreign direct investment from the change in foreign reserves, as in Martin and Morrison (2008). Thus, we can infer from the IRFs that the channel through which U.S. monetary policy spills over into China is mainly the "hot money" channel rather than the trade channel or the exchange rate channel.

Figure (5) includes the changes in M2, loans, required reserve ratio, and interest rates. Because the required reserve ratio and bank lending and deposit rates are still regulated by the PBOC, the changes in nominal loan rates can be treated as the policy response of the PBOC to U.S. monetary policy. Using VAR models, Kim (2001) found that U.S. expansionary monetary policy shocks lead to booms in the non-U.S. G-6 countries and that a decrease in the world real interest rate might be an important transmission channel. However, there are significant differences between the economy of China and those of the non-U.S. G-6 countries. Because we are using the FA-

VAR approach, after controlling for a rich set of Chinese and U.S. variables, we find that the PBOC would raise regulated interest rates and increase the required reserve ratio to cool down the Chinese economy and curb inflationary pressures and over-investment in response to unanticipated expansionary innovations in U.S. monetary policy. The fall in M2 can also be attributed to the same motive of the PBOC to prevent the Chinese economy from overheating due to unforecasted expansionary U.S. monetary policy. Consistent with the findings of Gertler and Karadi (2014), monetary policy can typically produce modest movements in short rates that lead to large movements in the cost of credit. Although at its peak, the increase in the nominal lending rate is less than 7% of its standard deviation, but the decrease in loans is much more substantial, which indicates the success of the PBOC in curbing borrowing by increasing the required reserve ratio and lending rates. Different from the responses of government regulated benchmark interest rates, market determined interest rates, as illustrated by the 1-year SHIBOR, does not respond significantly to the U.S. monetary policy shock.

Figure (6) shows the responses of the Chinese stock market to U.S. monetary policy shocks. For example, an expansionary U.S. monetary policy shock does not have a significant impact on the Shanghai Stock Exchange Composite Index, but it causes a decline in the price/earning ratios in the medium run, although the effect is not significant in either the short run or long run. One reason for this decline is the PBOC's contractionary monetary policy in response to U.S. expansionary policy. Another reason for the decline is that an expansionary U.S. monetary policy makes the U.S. stock market a more attractive alternative for investors, which is compounded by the fact that the Chinese stock market operates in the absence of effective institutions and remains quite deficient in its market mechanisms (Chen, 2013). The same figure also displays the responses of the real estate market. Investment in real estate as well as floor space began to rise significantly from the beginning of the period, and this rise is quite persistent. Unlike the stock market, the Chinese real estate market becomes more attractive when the interest rate in the U.S. is low. The sticky demand for housing and the local government's revenue incentives provide security for the boom of the Chinese real estate market when the U.S. enters into quantitative easing. For foreign investors, instead of investing in the U.S. with a low return rate, investing in the Chinese real estate market might be a more attractive option. For Chinese investors, investing in real estate might be an effective hedge against concerns about imported inflation. When we divide the source of funding for Chinese real estate investment into four categories – domestic loans, foreign investment, self-raised and other – we do not find any particular category of real estate investment to be particularly significant despite the fact that aggregate real estate investment is significant.

Based on the figures discussed above, we can formulate the hypothesis that U.S. monetary policy has spillover effects on the Chinese real economy, but these effects are not transmitted to China purely through the interest rate channel. We find additional evidence from studying the impact of U.S. monetary policy on Chinese interest rates on government bonds using higher-frequency data and the methodology of identification through heteroskedasticity. Furthermore, as discussed above, Figure (4) shows that "hot money," whose magnitude of response is quite significant, seems to be the spillover channel.

3.1.2. Impulse Responses to U.S. Policy Uncertainty Shock at ZLB

Figure (7) shows that at the zero lower bound, a positive U.S. policy uncertainty shock has no significant effect on Chinese industrial output, monetary authority foreign assets, PMI, or retail sales. Figure (8) shows that there is also no significant effect on the Chinese trade balance, exchange rate, or hot money. Figure (9) shows that China raises its required reserve ratio and its benchmark interest rates, which can be interpreted as the PBOC's desire to caution against investment in an uncertain environment.

Figure (10) shows that higher U.S. policy uncertainty does not affect the Shanghai Stock Exchange Composite Index or price/earning ratios significantly. However, a U.S. policy uncertainty shock does increase new floor space started in China over the short run but not in the medium or long run.

Thus, the previous analysis shows that the effects of U.S. policy uncertainty on Chinese macroeconomic variables are short-lived, which is consistent with the finding in Bloom (2009) that the impact of uncertainty shocks on firms last only six months.

3.2. Variance Decomposition

A standard result of the VAR literature is that U.S. monetary policy shock accounts for small fraction of the forecast errors for U.S. real economic activity. Intuitively, U.S. monetary policy shocks should not play a very important role in accounting for the forecast errors of Chinese macro variables. Therefore, instead of looking at the absolute value of the variance decomposition, we are more interested in the relative importance of U.S. monetary policy shocks and policy uncertainty shocks to the Chinese economy.

The second column of Table (1) presents the ratios between the fraction of the 1-, 2-, 6-, and 12-month forecast errors caused by U.S. monetary policy shocks and those caused by U.S. policy uncertainty shocks for selected Chinese macroeconomic variables. Comparing the one-month-ahead variance decomposition ratios both before and during the zero lower bound period shows that U.S. monetary policy shocks are more important than policy uncertainty shocks for more variables during the zero lower bound period. As time passes, the importance of policy uncertainty shocks collapses quickly at the zero lower bound. The differences imply that U.S. policy uncertainty may only affect the Chinese economy for a short period of time, and the Chinese market in general pays more attention to current U.S. monetary policy instead of what that policy might be in the future.

It is notable that, although the stock market as a whole remains more sensitive to U.S. policy uncertainty shocks at the zero lower bound, the PE ratios of financial intermediaries and real estate companies have come to rely more on monetary policy than on policy uncertainty.

4. Robustness Checks

4.0.1. Before the Zero Lower Bound Period

Figure (11) to Figure (18) illustrate the impulse responses of variables to U.S. monetary policy shocks and U.S. policy uncertainty shocks before the federal funds rate hit the zero lower bound. Expansionary U.S. monetary policy shocks significantly increase U.S. policy uncertainty before period during which the zero lower bound is binding, whereas such shocks do not generate significant effects on U.S. policy uncertainty at the zero lower bound. The responses of certain Chinese variables are different from those at the zero lower bound. For example, with a negative U.S. monetary policy shock, the Chinese benchmark interest rates decrease rather than increase in the medium-run, which is more consistent with the results from Kim (2001)'s VAR exercise showing that non-U.S. G-6 countries would lower interest rates in response to an expansionary U.S. monetary policy shock. In addition, there is no significant contraction in Chinese M2 or in the total amount of loans during the period before the zero lower bound is binding. The results on the stock markets and on real estate investment are generally in the same direction. In addition to the differences in the responses to U.S. monetary shocks, the reaction to U.S. policy uncertainty shock is also different between these two periods. There are significant negative responses in the Chinese benchmark interest rates in the medium run before the zero lower bound is binding. However, at the zero lower bound, the responses of the Chinese benchmark interest rates are significantly positive. This result can be interpreted as an indication that, during the period before the zero lower bound is binding in the U.S., the PBOC may be concerned that increases in U.S. policy uncertainty might potentially widen the output gap in China and thus may be attempting to accommodate investments in China by lowering benchmark interest rates; however, in response to increases in U.S. policy uncertainty when the zero lower bound is binding in the U.S., the PBOC does not become accommodative, possibly due to the fear that China might face over-investment because of an inflow of cheap credit from overseas. In addition, the Shanghai Stock Exchange Composite Index, the price/earnings ratio of the Shanghai Stock Exchange, total real estate investment, real estate investment from domestic loans and self-raised sources, which do not have significant changes under the same shock at the zero lower bound, now decline significantly, suggesting that there are significant spillovers of U.S. policy uncertainty into the Chinese economy before the zero lower bound is binding in the U.S.

The third column of Table (1) presents the repative importance of U.S. monetary policy shocks and policy uncertainty shocks for Chinese economy before the zero lower bound is binding in the U.S.. Comparing with the second column in this table, we can find that the U.S. policy uncertainty shocks were relatively more important both in the short run and in the long run before the zero lower bound is binding.

The differences can be explained from two perspectives. The first is that the Chinese economy has undergone substantial changes in recent years. Both the interest rate and exchange rate systems changed significantly during the 2000s. Beginning in 2005, a managed floating exchange rate was implemented that is based on market supply and demand with a basket of currencies. The bond market has grown, although it remains too small to effectively transmit monetary policy. The liberalization process of the interest rate is still coming. All these changes cause changes in the response of macroeconomic variables to U.S. monetary policy shocks.

The second reason is that there is a structural change in the U.S. monetary policy transmission mechanism at the zero lower bound. This finding is supported by the responses of the Chinese benchmark interest rates. Before the zero lower bound period, the response of the Chinese benchmark interest rates to a monetary policy shock is hump-shaped, and this change is persistent. However, at the zero lower bound, there is no hump shape in the response. In other words, the response reaches its peak at the time the shock hits and then declines monotonically. Moreover, the effect of a monetary policy shock dies off more quickly at the zero lower bound. This finding is consistent with the results in Zhang (2014).

5. Conclusion

Contrary to the notion that U.S. monetary policy shocks have no significant impact on China, we find that such shocks do have significant spillover effects on the Chinese economy. Since the Great Recession, a decline in the U.S. policy rate would result in a significant rise in Chinese housing investment, possibly as a result of the substantial inflow of "hot money" into China. The PBOC's response is to increase the Chinese regulated interest rates in order to curb over-investment. The responses of variables to U.S. shocks during the period at the zero lower bound differ from those in normal times, which suggests structural change in both the Chinese economy and the U.S. monetary policy transmission mechanism. In addition, increases in U.S. policy uncertainty have negative effects on the Chinese real estate and stock markets during normal times, but not at the zero lower bound. The U.S. policy uncertainty shock has become less important than the U.S. monetary policy shock in recent years, which indicates that we now care more about the realized policy itself instead of the unknown possibilities of what economic policy actions might be undertaken in the future.

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Appendix A. Tables

Table 1: Variance Decomposition of Selected Variables

Variables	Variance Decomposition Ratio (MP/PU)[1]							
	At the ZLB				Before the ZLB			
	1m	6m	12m	24m	1m	6m	12m	24m
SSEI	1.45	0.21	1.01	5.00	0.81	0.32	0.34	0.46
PE ratio (SSE All)	2.42	0.22	1.05	5.07	0.43	0.31	0.34	0.47
PE ratio (SSE A)	2.71	0.22	1.05	5.07	0.68	0.32	0.32	0.41
PE ratio (SSE Fin)	2.17	0.33	1.13	4.99	0.08	0.27	0.31	0.41
PE ratio (SSE RE)	0.81	0.35	1.17	4.83	0.21	0.30	0.33	0.45
PE ratio (SSE Const)	0.57	0.44	1.11	3.74	0.59	0.30	0.33	0.46
PE ratio (SSE Manu)	1.65	0.25	1.03	4.92	6578.75	0.30	0.32	0.43
Loan	0.97	0.39	1.14	4.58	0.05	0.09	0.14	0.17
Loan Rate (1yr)	0.10	0.97	2.98	4.53	1.98	0.32	0.33	0.44
HH DR (1yr)	0.08	1.07	3.36	5.27	1.03	0.33	0.33	0.42
SHIBOR (1d)	240.34	1.92	5.53	10.57	0.32	0.41	0.23	0.18
Bond Index (Inter Bank ST)	0.37	0.28	0.73	2.94	0.05	0.18	0.16	0.22
CPI	1.20	0.33	1.00	4.49	0.10	0.16	0.18	0.34
InvestRE	4.93	3.47	3.25	3.82	581.50	0.50	0.19	0.12
NHS	0.184	0.524	2.181	56.772	4.615	3.149	60.259	62.506
Comm Bldg Sales	0.63	0.94	1.89	2.66	225.77	0.53	0.20	0.12
PMI Manufacturing	1.05	0.32	1.06	4.68	0.32	0.41	0.23	0.18
PMI new orders	9.55	0.53	1.20	5.05	0.32	0.41	0.23	0.18
Macro index	0.82	0.42	1.21	4.61	0.05	0.11	0.16	0.21

[1] "MP" and "PU" represent monetary policy shock and policy uncertainty shock, respectively. The "Variance Decomposition Ratio" represents the ratio between the percentage of 1-, 2-, 6-, and 12-month-ahead forecast variance that monetary policy shocks account for and that policy uncertainty shocks account for.

Appendix B. Figures

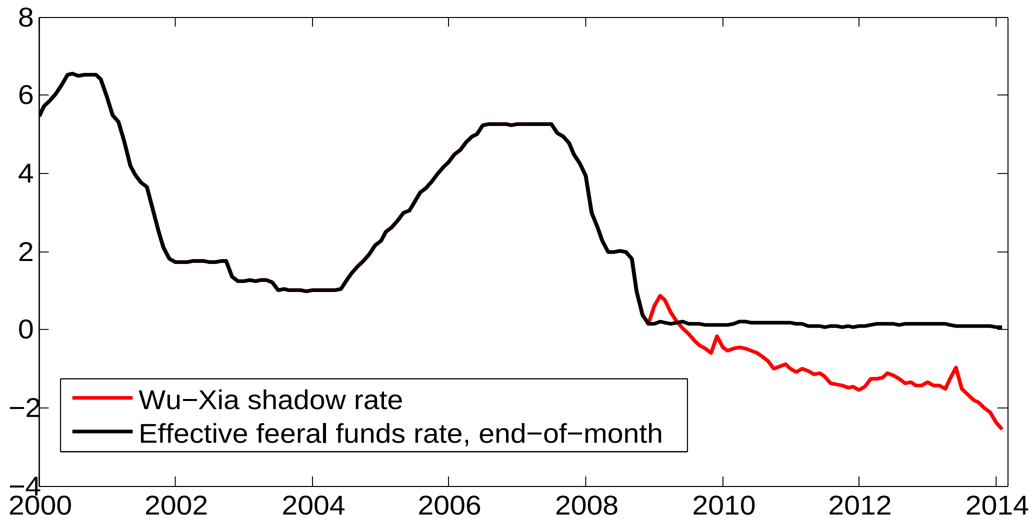

Figure 1: The Wu-Xia Shadow Federal Funds Rate compared with the effective federal funds rate.

NOTE: Board of Governors of the Federal Reserve System and Wu and Xia (2014)

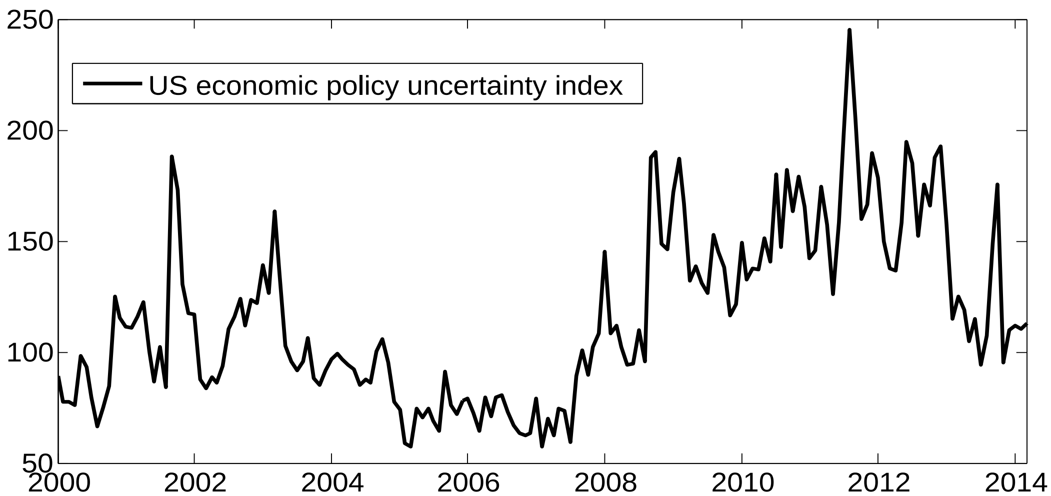

Figure 2: Monthly U.S. Economic Policy Uncertainty Index.

NOTE: Baker, Scott R., Nicholas Bloom, and Steven J. Davis. (2013)

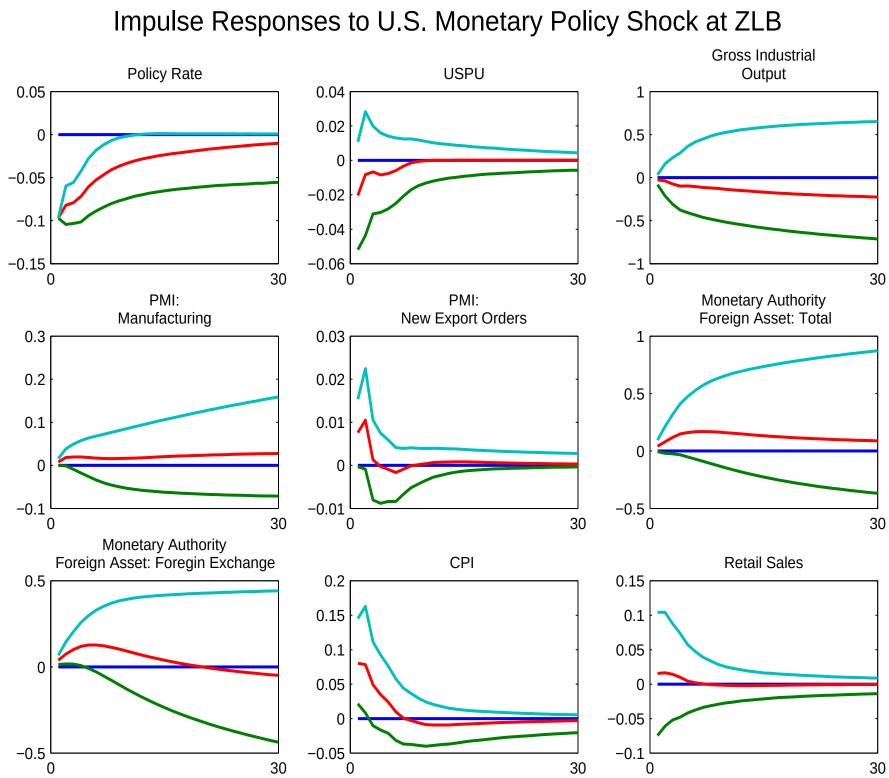

Figure 3: Impulse Responses to U.S. Monetary Policy Shock at the ZLB.

NOTE: Impulse responses to a monetary policy shock from 0 to 30 months at the zero lower bound, estimated using data from January 2009 to February 2014. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The monetary policy shock corresponds to a decrease in the Wu-Xia Shadow Federal Funds Rate of 25 basis points.

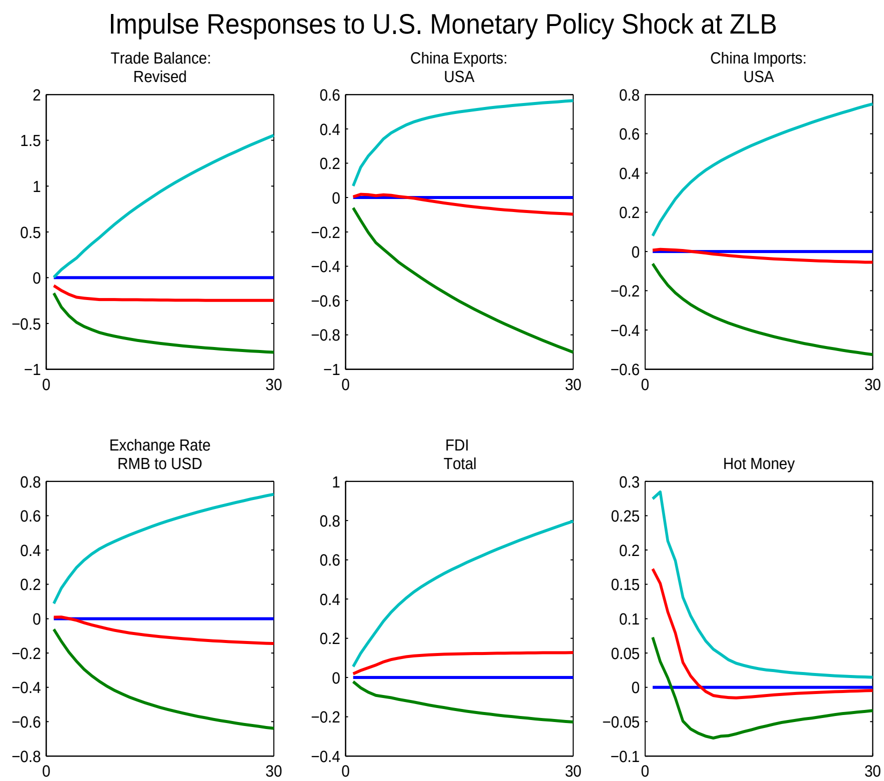

Figure 4: Impulse Responses to U.S. Monetary Policy Shock at the ZLB

NOTE: Impulse responses to a monetary policy shock from 0 to 30 months at the zero lower bound, estimated using data from January 2009 to February 2014. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The monetary policy shock corresponds to a decrease in the Wu-Xia Shadow Federal Funds Rate of 25 basis points.

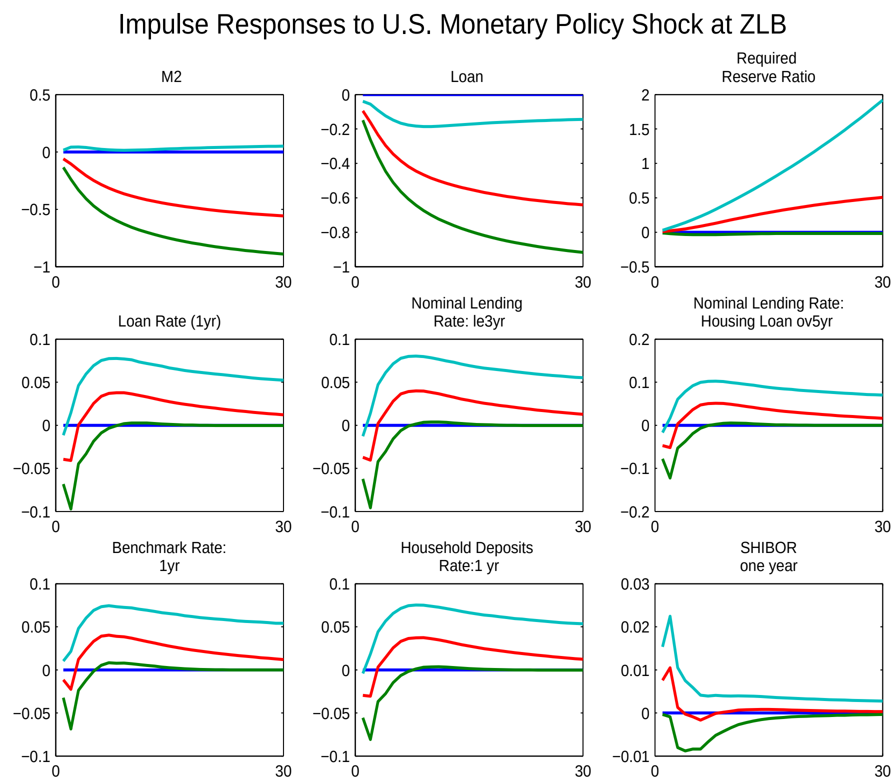

Figure 5: Impulse Responses to U.S. Monetary Policy Shock at the ZLB

NOTE: Impulse responses to a monetary policy shock from 0 to 30 months at the zero lower bound, estimated using data from January 2009 to February 2014. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The monetary policy shock corresponds to a decrease in the Wu-Xia Shadow Federal Funds Rate of 25 basis points.

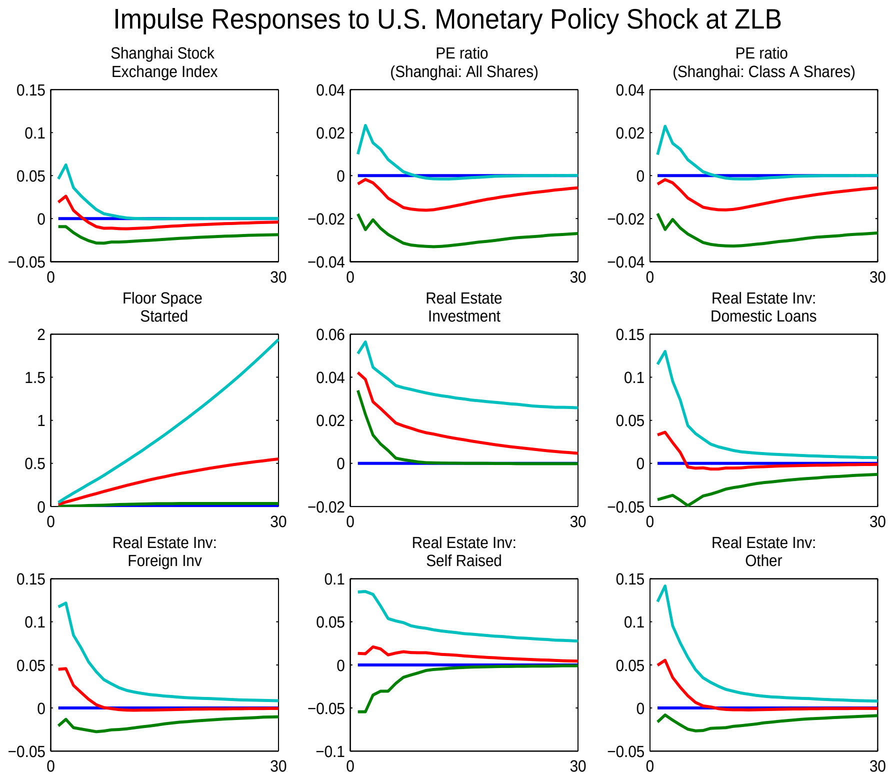

Figure 6: Impulse Responses to U.S. Monetary Policy Shock at the ZLB
NOTE: Impulse responses to a monetary policy shock from 0 to 30 months at the zero lower bound, estimated using data from January 2009 to February 2014. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The monetary policy shock corresponds to a decrease in the Wu-Xia Shadow Federal Funds Rate of 25 basis points.

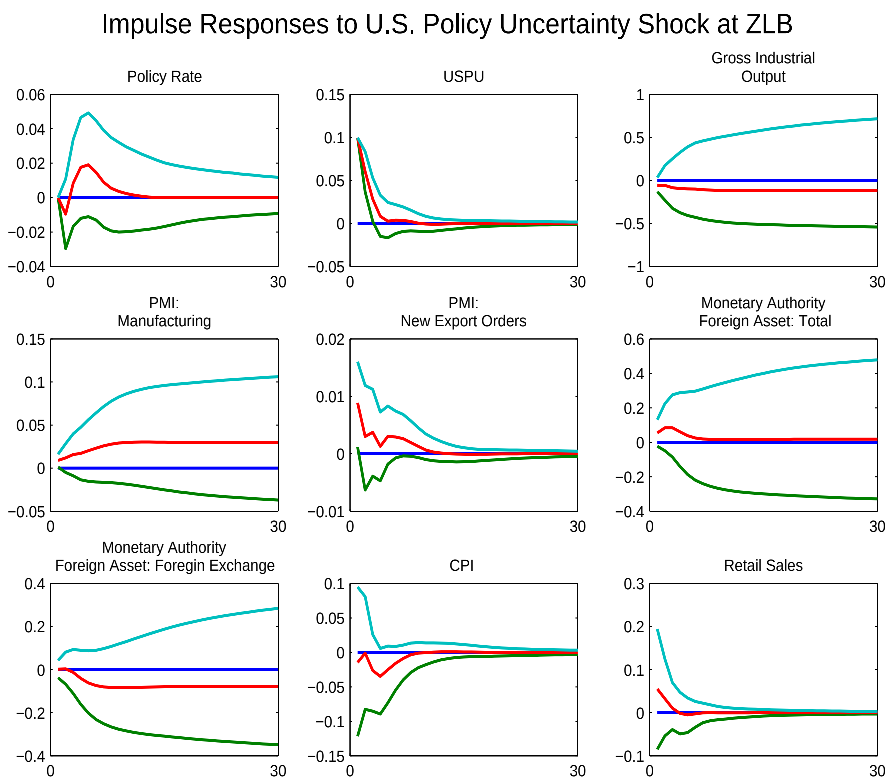

Figure 7: Impulse Responses to U.S. Policy Uncertainty Shock at the ZLB

NOTE: Impulse responses to a policy uncertainty shock from 0 to 30 months at the zero lower bound, estimated using data from January 2009 to February 2014. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The policy uncertainty shock corresponds to an increase in the U.S. policy uncertainty Index of 10% of the standard deviation.

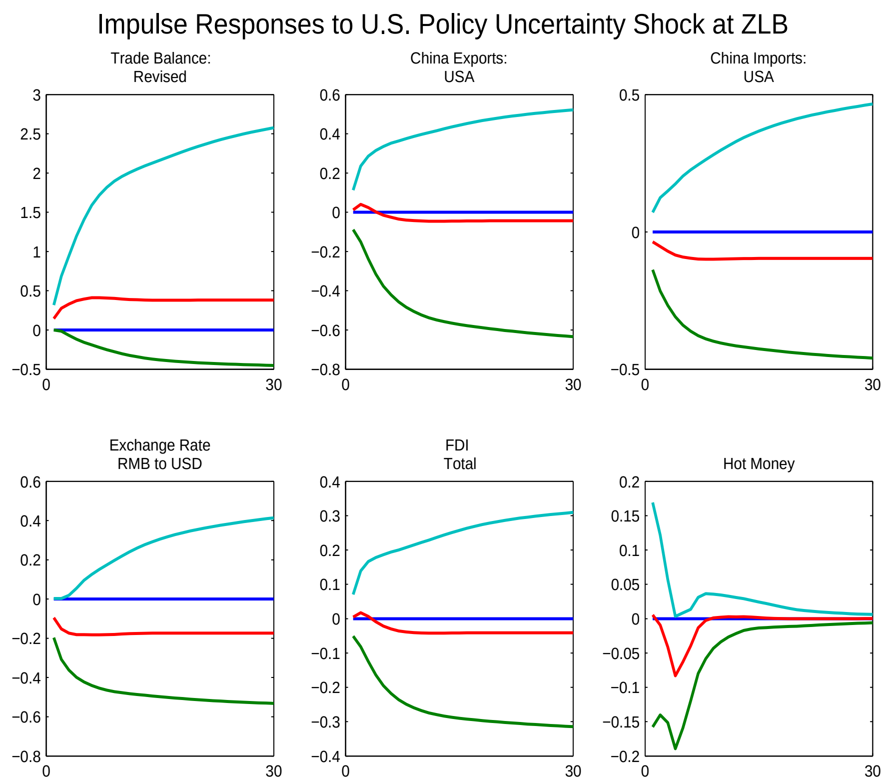

Figure 8: Impulse Responses to U.S. Policy Uncertainty Shock at the ZLB
NOTE: Impulse responses to a policy uncertainty shock from 0 to 30 months at the zero lower bound, estimated using data from January 2009 to February 2014. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The policy uncertainty shock corresponds to an increase in the U.S. policy uncertainty Index of 10% of the standard deviation.

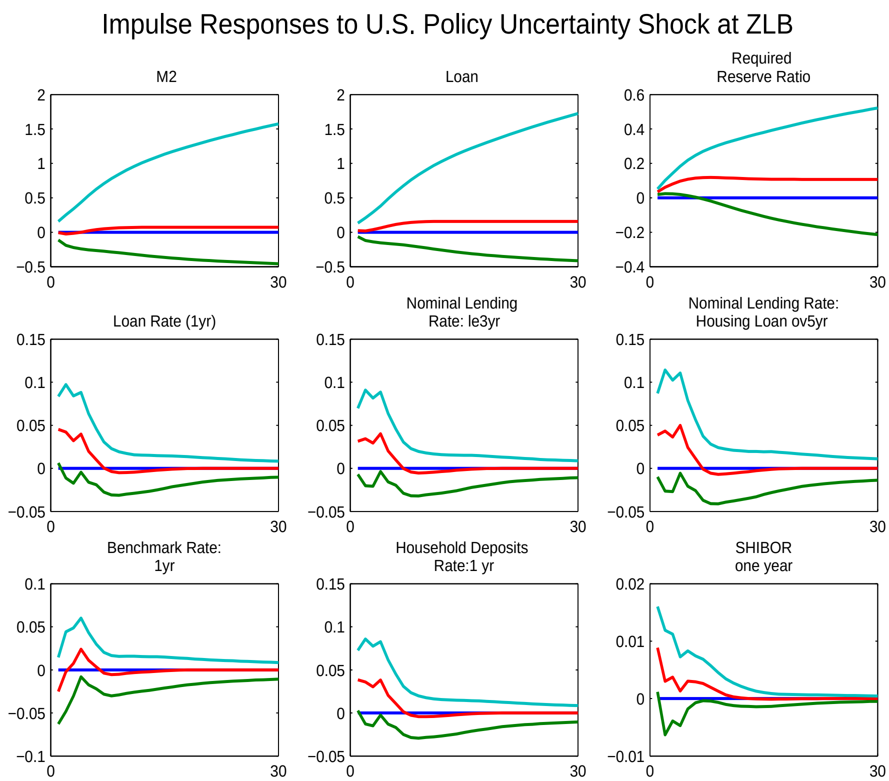

Figure 9: Impulse Responses to U.S. Policy Uncertainty Shock at the ZLB
NOTE: Impulse responses to a policy uncertainty shock from 0 to 30 months at the zero lower bound, estimated using data from January 2009 to February 2014. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The policy uncertainty shock corresponds to an increase in the U.S. policy uncertainty Index of 10% of the standard deviation.

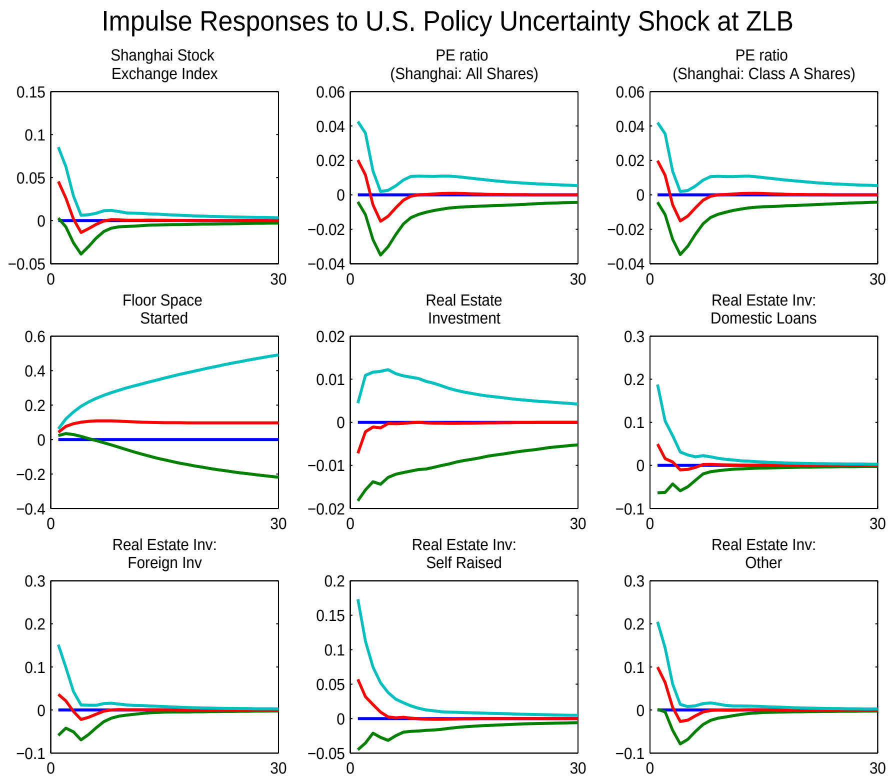

Figure 10: Impulse Responses to U.S. Policy Uncertainty Shock at the ZLB

NOTE: Impulse responses to a policy uncertainty shock from 0 to 30 months at the zero lower bound, estimated using data from January 2009 to February 2014. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The policy uncertainty shock corresponds to an increase in the U.S. policy uncertainty Index of 10% of the standard deviation.

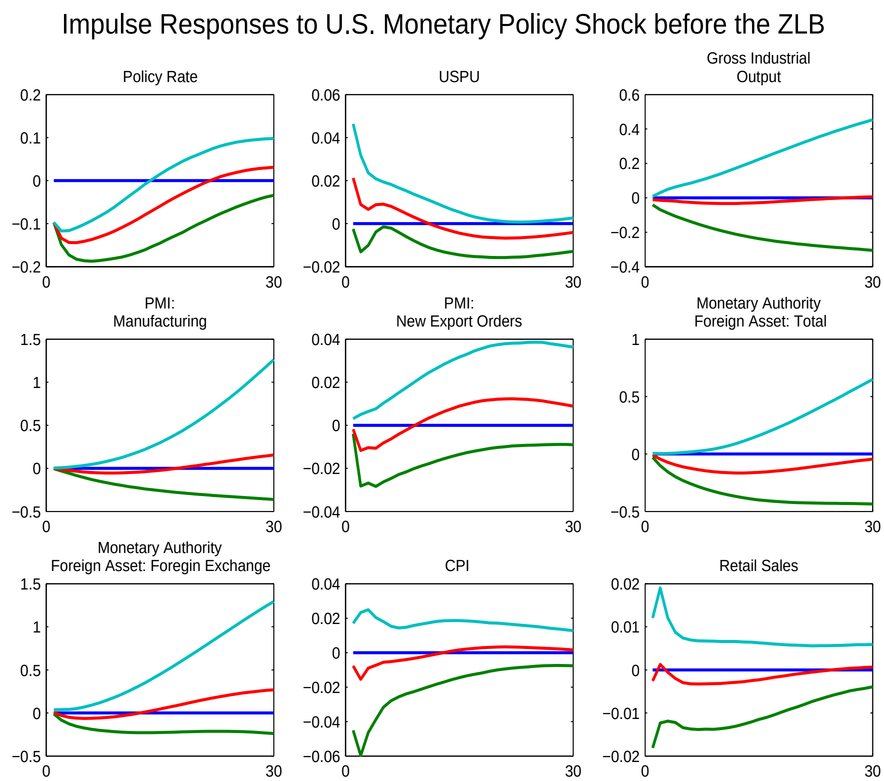

Figure 11: Impulse Responses to U.S. Monetary Policy Shock before the zero lower bound NOTE: Impulse responses to a monetary policy shock from 0 to 30 months before the zero lower bound is binding, estimated using data from January 2000 to December 2008. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The monetary policy shock corresponds to a decrease in the Effective Federal Funds Rate of 25 basis points.

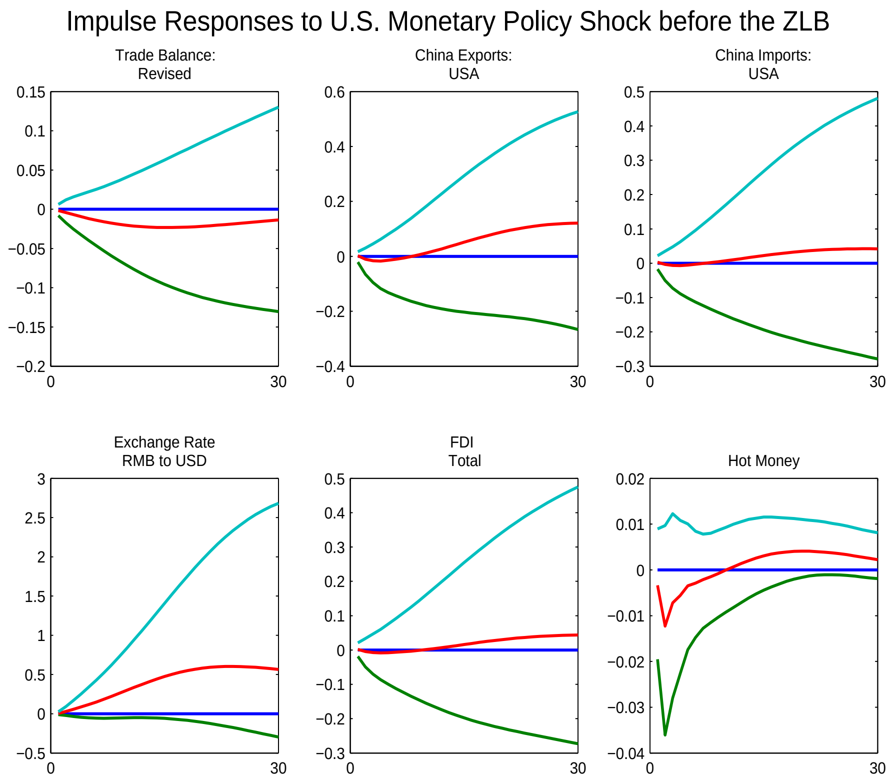

Figure 12: Impulse Responses to U.S. Monetary Policy Shock before the zero lower bound
NOTE: Impulse responses to a monetary policy shock from 0 to 30 months before the zero lower bound is binding, estimated using data from January 2000 to December 2008. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The monetary policy shock corresponds to a decrease in the Effective Federal Funds Rate of 25 basis points.

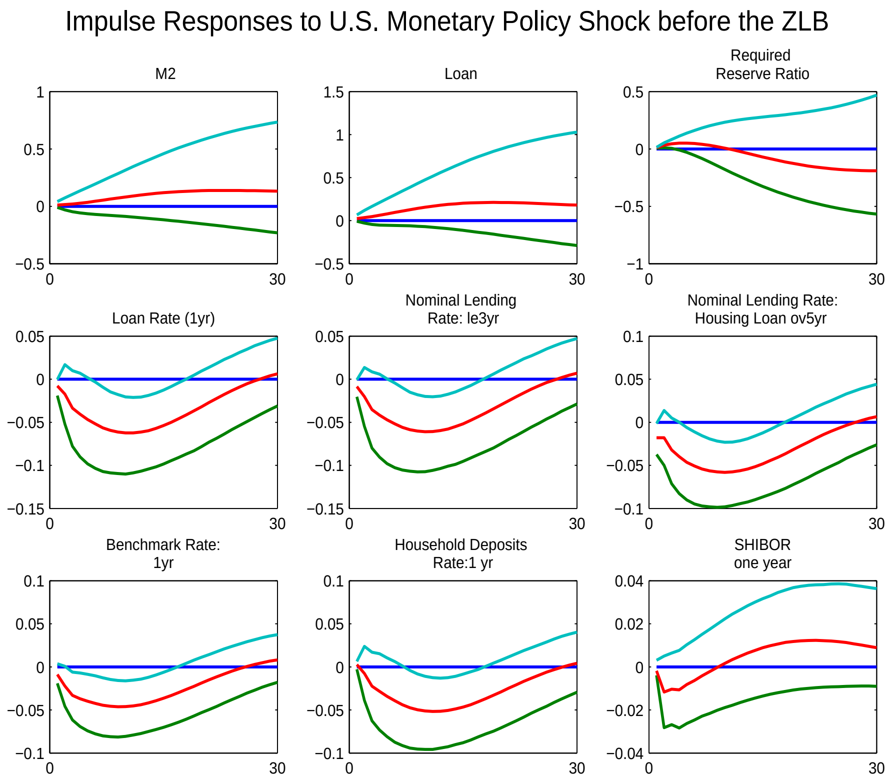

Figure 13: Impulse Responses to U.S. Monetary Policy Shock before the zero lower bound
NOTE: Impulse responses to a monetary policy shock from 0 to 30 months before the zero lower bound is binding, estimated using data from January 2000 to December 2008. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The monetary policy shock corresponds to a decrease in the Effective Federal Funds Rate of 25 basis points.

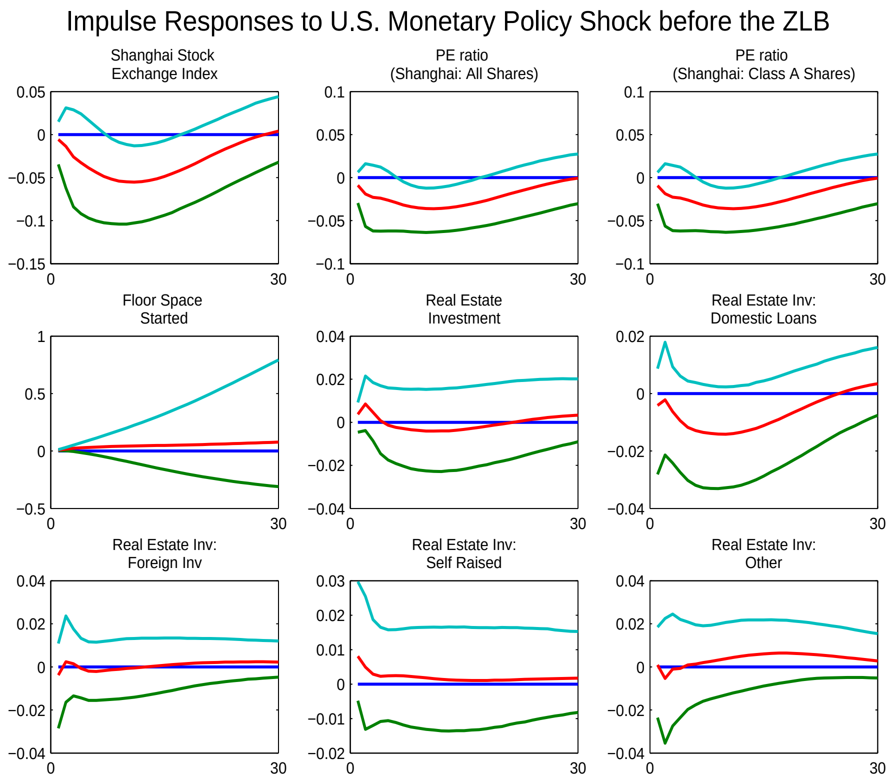

Figure 14: Impulse Responses to U.S. Monetary Policy Shock before the zero lower bound NOTE: Impulse responses to a monetary policy shock from 0 to 30 months before the zero lower bound is binding, estimated using data from January 2000 to December 2008. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The monetary policy shock corresponds to a decrease in the Effective Federal Funds Rate of 25 basis points.

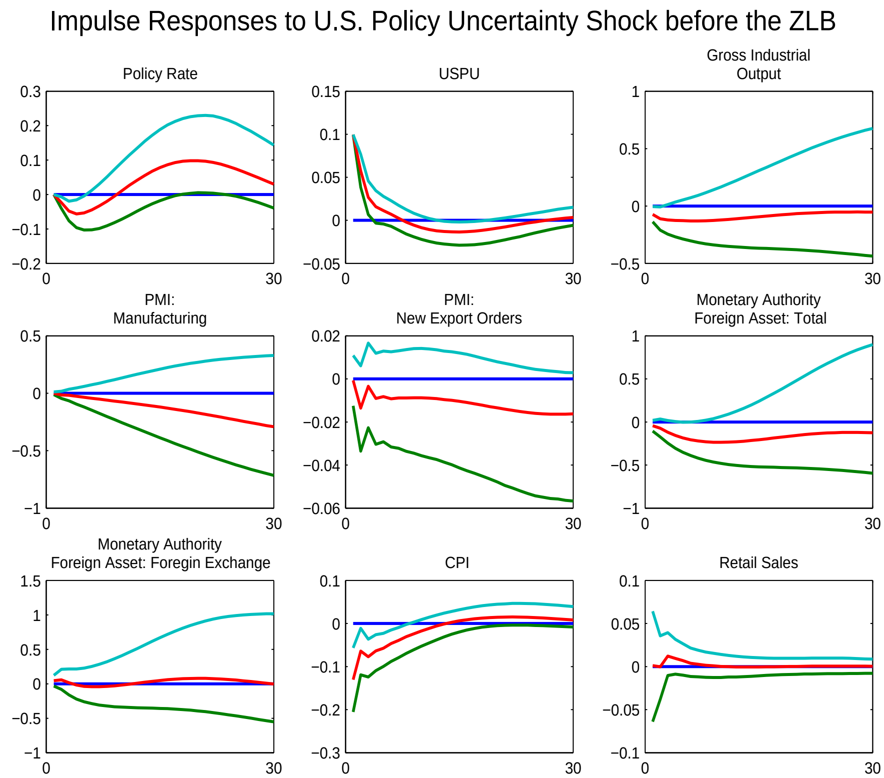

Figure 15: Impulse Responses to U.S. Policy Uncertainty Shock before the zero lower bound

NOTE: Impulse responses to a policy uncertainty shock from 0 to 30 months before the zero lower bound is binding, estimated using data from January 2000 to December 2008. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The policy uncertainty shock corresponds to an increase in the U.S. policy uncertainty index of 10% of the standard deviation.

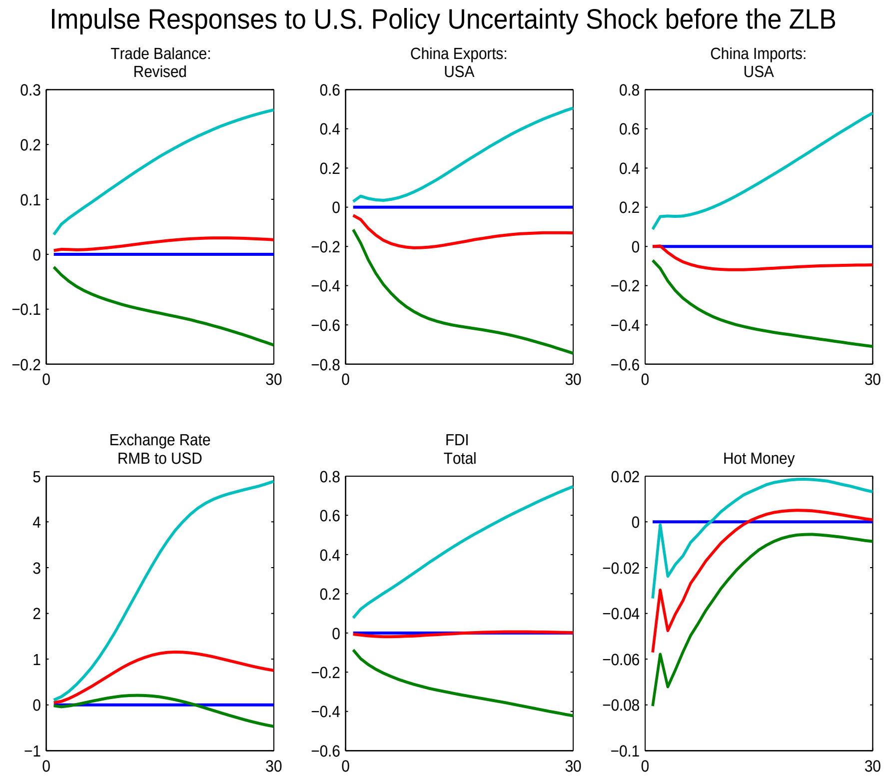

Figure 16: Impulse Responses to U.S. Policy Uncertainty Shock before the zero lower bound.

NOTE: Impulse responses to a policy uncertainty shock from 0 to 30 months before the zero lower bound is binding, estimated using data from January 2000 to December 2008. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The policy uncertainty shock corresponds to an increase in the U.S. policy uncertainty index of 10% of the standard deviation.

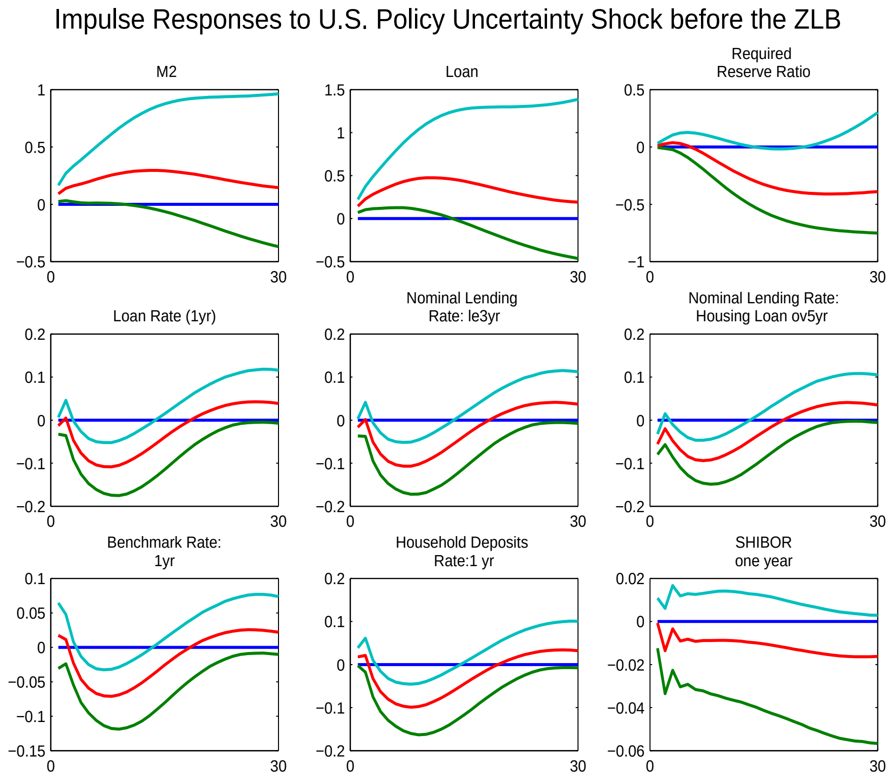

Figure 17: Impulse Responses to U.S. Policy Uncertainty Shock before the zero lower bound

NOTE: Impulse responses to a policy uncertainty shock from 0 to 30 months before the zero lower bound is binding, estimated using data from January 2000 to December 2008. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The policy uncertainty shock corresponds to an increase in the U.S. policy uncertainty index of 10% of the standard deviation.

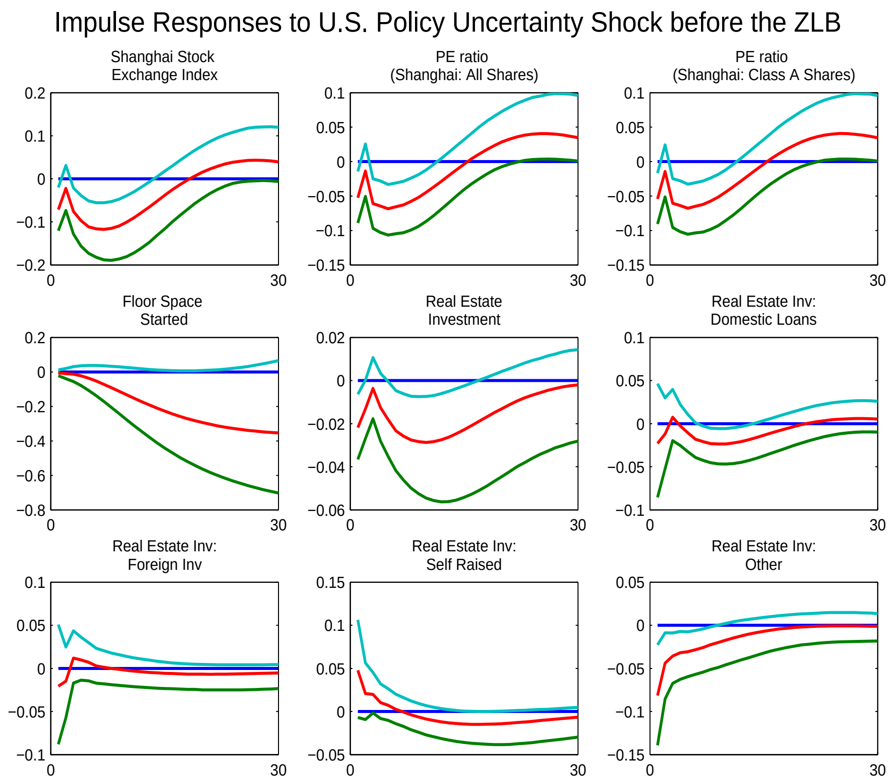

Figure 18: Impulse Responses to U.S. Policy Uncertainty Shock before the zero lower bound.

NOTE: Impulse responses to policy uncertainty shock from 0 to 30 months before the zero lower bound is binding, estimated using data from January 2000 to December 2008. The solid lines are the bootstrap median, and the dashed lines are 90 percent bootstrap confidence intervals. The policy uncertainty shock corresponds to an increase in the U.S. policy uncertainty index of 10% of the standard deviation.

Appendix C. Factor Construction for the FA-VAR

The two-step principal component approach uncovers the space spanned by the common components $C_t = (F_t', Y_t')'$. The macro factors are constructed by first extracting three principal components $\hat{F}^*$ from the slow-moving variables. All principal components are normalized to unit variance. We then run the following regression $\hat{C}_t = b_s \hat{F}_t^* + b_Y Y_t + e_t$, and $\hat{F}_t$ is constructed from $C_t - \hat{b_Y} \hat{Y}_t$. Then, the VAR equations in $\hat{F}_t$ and Y_t are recursively estimated and identified in this order.