


Article

The Impact of Unconventional Monetary Policy on China's Economic and Financial Cycle: Application of a Structural Vector Autoregression Model Based on High-Frequency Data

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Abstract: With the occurrence of the global financial crisis in 2008, the U.S. unconventional monetary policy affected the Chinese market. Based on a monthly data sample from 2008M1 to 2015M12, in this paper we identify U.S. and Chinese monetary policy shocks by using a structural vector autoregression (SVAR) model with multi-external instrumental variables along with principal component analysis (PCA) combined with high-frequency financial market data. The empirical results show that the unconventional monetary policies had a negative effect on China's inflation and output due to the signal effect, and China's stock and commodity markets increased in the short term. During the same period, China's monetary policy had a greater impact on the domestic economy and financial markets. The conclusion of this paper provides a significant reference for relevant departments to make decisions amidst the new wave of unconventional U.S. monetary policies due to the COVID-19 pandemic.

Keywords: SVAR-IV model; high-frequency data; unconventional monetary policy; economic and financial cycle; multi-external instrumental variables; China

MSC: 62M10; 91B84

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1. Introduction

With a dominant role in global financial sectors, the U.S. dollar is the legal currency of the largest economy in the world and is the most critical international currency. Therefore, the monetary policy decided by the Federal Reserve (the Fed), the monetary authority of the U.S., affects not only the U.S. economy but also the economies of other countries [1]. Since the global financial crisis occurred in 2008, the unconventional monetary policies widely used by authorities such as the Federal Reserve to recover the economy have influenced global financial cycles. The expectation that the Fed will maintain low interest rates for a significant period poses a challenge for the central banks of other countries, especially emerging economies. This means that the Fed's quantitative easing (QE) policy brings uncertainty to the monetary authorities of other countries, especially emerging economies.

Figures 1–4 illustrate the relationships between the Federal Reserve's unconventional monetary policy and the key macroeconomic indicators in China. With the implementation of the unconventional monetary policy, the volatility in the spread between long-term and short-term U.S. Treasury yields exhibited a negative correlation with the growth rate of China's real output from 2008M1 to 2009M11, and a positive correlation after 2009M12. In addition, the changes in U.S. Treasury bond yield spreads and Chinese M2, and the changes in China's price levels, maintained a similar overall trend. The correlation between the implementation of the unconventional monetary policy in the United States and the exchange rate of the renminbi (RMB) against the U.S. dollar is not intuitive.

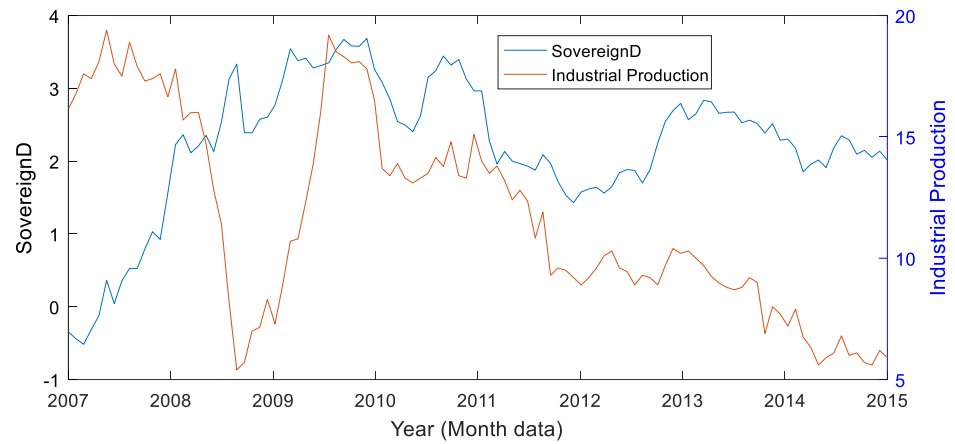


Figure 1. The Federal Reserve’s unconventional monetary policy and China’s output growth rate. Note: SovereignD refers to the monthly data of the spread between the 10-year and 3-month U.S. Treasury yields.

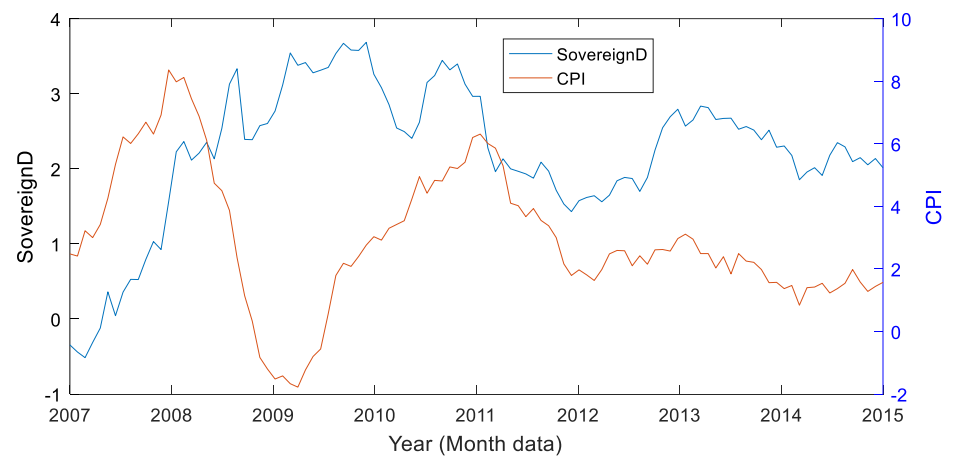


Figure 2. The Federal Reserve’s unconventional monetary policy and exchange rate.

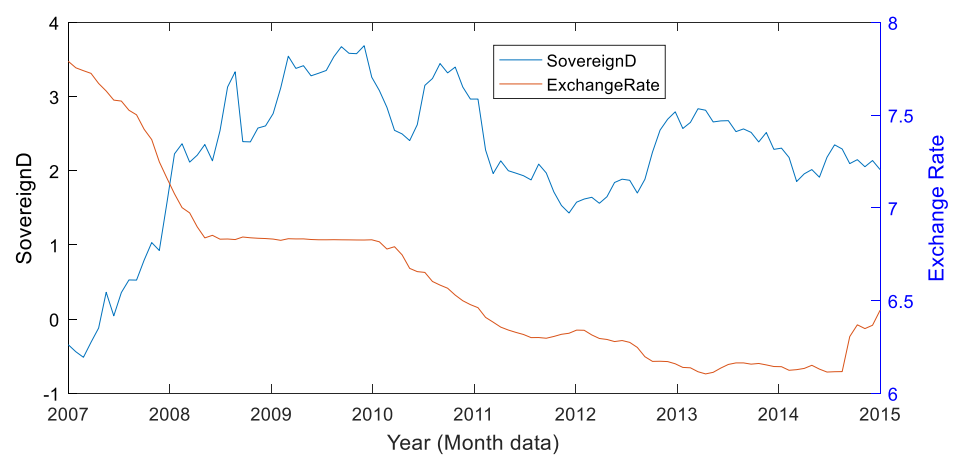


Figure 3. The Federal Reserve’s unconventional monetary policy and China’s CPI.

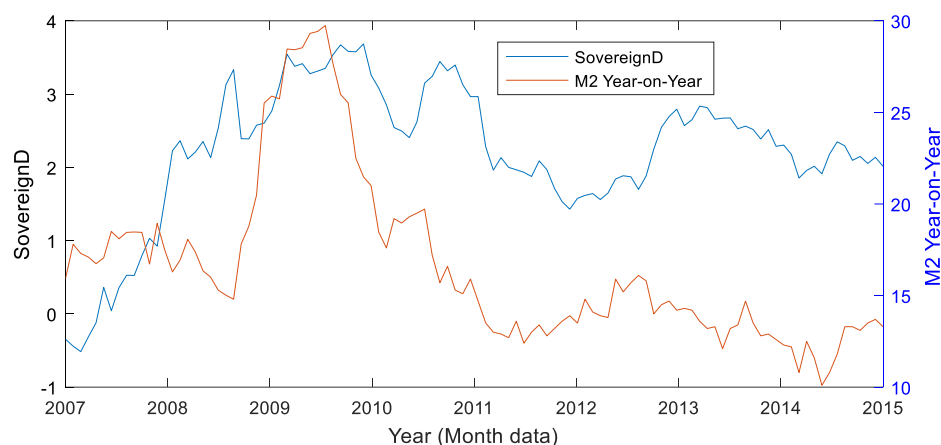


Figure 4. The Federal Reserve's unconventional monetary policy and China's M2.

However, the above observations only refer to the correlation between the time series data of Treasury spreads in the U.S. and China's macroeconomic variables, without considering that the monetary policy of China's monetary authorities during the same period also affected the domestic macroeconomy.

According to the classification given in [2], when the global financial crisis occurred in 2008, the central banks in many developed countries lowered their base interest rates to zero-lower-bound (ZLB). As economic growth remained weak, the interest rates persisted at ZLB and conventional monetary policy failed, so the central banks used unconventional monetary policy to stimulate the economy. It is generally understood that unconventional monetary policy includes quantitative easing, forward guidance, and yield curve control. The most important tools are quantitative easing and forward guidance [3]. Note that here we take unconventional monetary policy as equivalent to QE policy in order to save space.

Since COVID-19 broke out in 2020, the global economy has been severely disturbed [4], which has led to high unemployment rates. Therefore, the Federal Reserve launched unconventional monetary policies such as QE again, which triggered a liquid flood to the world economy. Therefore, how to resolve the impact of external liquidity and maintain stable economic development has become an essential challenge for the central banks of emerging markets. Evaluating the effects of the former round of the Fed's QE on China's economy and financial sectors can provide an important reference.

Joining the WTO in 2001 meant not only that China could begin to participate in global free trade and industry chain division but also that significant progress could be made in the process of globalization. Thus, the influence of global economic and financial cycles has had an increasing impact on the economic development of countries and international trade. Due to the dominant position of the United States in the world, the monetary policies of the Federal Reserve have a spillover effect on global economic and financial cycles. The authors of [5] collected high-frequency data on the U.S. dollar exchange rate and the release time of FOMC statements and macroeconomic news from 1992 to 1998. They studied the impact of policy release on the exchange rate by using the event study method. The results showed that the release of U.S. macroeconomic policy had a significant impact on the exchange rate of the U.S. dollar against the euro.

Based on the release dates of the Federal Reserve's monetary policies, data from the Bank of England and the European Central Bank, and the high-frequency data of European financial sectors from January 1993 to February 2003, the authors of [6] studied the impact of the monetary policy release of different countries on the yields of European countries. They found that, in addition to the significant impact of U.S. monetary policy announcements on yields, there was also a significant impact on both U.S. and European bond markets. Moreover, the results also suggested that the impact of the U.S. macroeconomic news shock on the European financial sector remained significant, and it was not until the introduction of the euro in 1999 that the impact of the European macroeconomic news shock on the

U.S. financial sector became significant. The authors of [7] tested the efficient market hypothesis of Asian equity markets, including China. They found that Hong Kong was the most efficient market, followed by China, and suggested that liquidity and capital restrictions may partly explain the results of equity markets. These studies mainly use the signal equation based on partial equilibrium. By using SVAR with heteroskedasticity identification, the authors of [8] collected data from the financial sectors of the United States and the European Union. They analyzed the spillover effect and international transmission mechanism of the monetary policies between the two economies. They found that when monetary policy shocks occur, the interactions between asset prices in various countries are significant, and the spillover effect is also very significant during these periods.

Since joining the WTO, China has grown to be the world's second-largest economy, while the United States has continued to be the world's largest economy; therefore, the spillover effect of the Fed's monetary policy on China's economy and financial sector has become critical. Based on data from January 2000 to December 2017, the authors of [9] estimated the effect of unanticipated changes in U.S. monetary policy and economic uncertainty on China by using the factor-augmented VAR (FAVAR) model. They found that reducing U.S. federal fund rates would increase China's deposit reserve ratio and reduce Shibor; it would also increase the stock index and P/E ratio of listed companies in the short run and push up investments in real estate. Therefore, they found that the spillover effect of the U.S. unconventional monetary policy on China would be different from the effect of the conventional monetary policy. The authors of [10] analyzed the difference between the effects on China of the Fed's conventional and unconventional monetary policies using an SVAR model with blocks and within blocks. The results suggested that QE had a positive impact on China's output and inflation, and the effect of the transmission channel through the financial sector was more potent than that of the trade channel. The authors of [11] studied cross-correlations between the Chinese exchange rate and the stock market based on daily data. They found that the overall significance of cross-correlation varies with time, and is sensitive to reform of the RMB exchange rate regime.

The authors of [12] took the U.S. monetary policy shock identified in [13] as the endogenous variable in a structural vector autoregressive error correction model (SVECM) to study its impact on China. They found that the Fed's tight monetary policy raised the final output and decreased inflation of China. They used a time-varying coefficient VAR (TVP-VAR) model to analyze each transmission channel and found that the price of importing was the main transmission channel of the spillover effect. When the global financial crisis occurred, the federal fund rate was kept at ZLB due to the implication of an unconventional monetary policy by the Federal Reserve; as a result, the traditional recursive identification strategy in the SVAR model could lead to estimation bias, so a new identification strategy was needed. The authors of [14] analyzed the spillover effects on China of the Fed's unconventional monetary policy using an SVAR model with sign restriction. The results show that QE will increase the U.S. real output growth and inflation will reduce China's real output growth and push up inflation.

China's net exports to the United States are an important component of the transmission channel for a spillover effect on the economy. Global commodity prices are a major feature of the transmission channel of inflation in China. Based on data from July 2008 to November 2013, the authors of [15] used a panel vector autoregression (PVAR) model with a proxy variable of the Fed's QE monetary policy as the independent variable and the macroeconomic indicators of BRIC countries as the dependent variable to study the spillover effects of the Fed's unconventional monetary policy on BRIC countries. The results showed that the QE policy pushed up outputs and price levels in the short run, promoting the appreciation of currencies of BRIC countries and increasing exports and stock market indices in these countries. The authors of [16] extracted nine sub-indicators of China's financial system as a financial cycle indicator based on a theoretical small open economy model, then constructed an SVAR model using the indicator of China's macroeconomy, the proxy variables of U.S. monetary policy, and China's economic cycle to study the impact of

the Fed's monetary policy on China's business and financial cycles from 2008 to 2017. The results show that different types of U.S. monetary policies have different spillover effects, and the fluctuations of the financial sector run ahead of macroeconomic fluctuations.

According to the literature review above, we can see that previous research reached some consensus on the spillover effect of the Federal Reserve's monetary policies on China by using SVAR models, and the models mainly used the recursive identification strategy. However, there are some shortcomings in the identification strategy. Recursive identification assumes that macroeconomic variables do not respond to contemporary monetary policy shocks. However, interaction between the financial sector and the macroeconomy has become increasingly rapid and significant. Therefore, the authors of [17] postulated that a shock identified using recursive restriction is essentially a mixture of exogenous shock and the response of endogenous variables to the shock.

As mentioned above, since the occurrence of the global financial crisis, the federal fund rate was kept at ZLB due to the implication of an unconventional monetary policy by the Federal Reserve, and the traditional recursive identification strategy based on the Taylor rule in the SVAR model could lead to estimation bias. The authors of [18] used the Federal Reserve's balance sheet or base money as the monetary policy indicator variable in an SVAR model with sign restriction. However, the authors of [19–21] discovered that there may be sampling bias in the model. Therefore, we used a new identification scheme to overcome these problems.

In our research, we indeed found that a slightly rise in Chinese urban real estate prices occurred as an outcome of the Fed's unconventional monetary policy. However, the domestic monetary policy shock that occurred at the same time was more significant than the QE policy. The influence of "hot money" was not significant, which means the current monetary policies in China effectively alleviated the financial risk due to the volatility of foreign capital flows.

The contributions of our paper are as follows. Firstly, we identify the monetary policy shocks of the Fed and China by using instrumental variables (IVs) constructed with high-frequency data. Compared with the traditional identification strategy of SVAR, our model is data-driven and can overcome the endogeneity caused by low-frequency data. Secondly, we evaluate the effects of the Fed's and China's monetary policy shocks simultaneously to distinguish the different impacts. This allowed us to more precisely evaluate foreign and domestic monetary policy shocks.

The remainder of this paper is organized as follows. Section 2 presents the methodology of the research. Section 3 provides a statistical description of the data. Sections 4 and 5 detail the statistical tests and report empirical results. Section 6 shows the results of the robustness check. Finally, Section 7 presents the conclusion.

2. Methodology

The identification strategy of monetary policy shocks with the external instruments seems to have considerably overcome difficulties in empirical studies recently. High-frequency data of the financial sector are used to construct external instrumental variables, and the IVs are used to identify exogenous shocks without assuming a structured relationship with the endogenous variables, so the identification strategy is data-driven and can overcome the potential problems of traditional econometric models.

2.1. External Instrument Identification Scheme

We recovered structural parameters related to monetary policy shocks in the U.S. and China by identifying external instruments. The idea behind the identification scheme is to recover the structural parameters from a reduced-form residual covariance matrix with the external data moment conditions of the VAR model. By using this strategy, we can extract the variation in the residuals related to the exogenous shocks we are interested in.

2.2. SVAR–IV Model

Consider the reduced form of VAR:

$$y_t = B_1 y_{t-1} + \dots + B_p y_{t-p} + e_t \tag{1}$$

where y_t is an $(m \times 1)$ vector of endogenous variables including a constant term; B_1 is an $(m \times p)$ matrix of coefficients; reduced-form residual e_t , satisfying $e_t = S\epsilon_t$, ϵ_t represents the structural shocks; and S is the structural matrix. Equation (1) can then be rewritten as

$$y_t = B_1 y_{t-1} + \dots + B_p y_{t-p} + s\epsilon_t^p \tag{2}$$

where ϵ_t^p is the structural shock we are interested in, and s is the column in matrix S corresponding to ϵ_t^p .

Z_t is the instrumental variable, also called the proxy variable, ϵ_t^q represents other structural shocks excluding ϵ_t^p , and these variables satisfy

$$E(Z_t \epsilon_t^p) = \phi \tag{3}$$

$$E(Z_t \epsilon_t^q) = 0 \tag{4}$$

that is, the external instruments are correlated with the monetary policy shock (ϵ_t^p) but are orthogonal to the other structural shocks. Then, we can obtain the consistent estimator of $\frac{s_t^p}{s_t^q}$ via two-stage least squares. In the first stage, we estimate

$$\hat{u}_t^p = \beta Z_t + \epsilon_t \tag{5}$$

To obtain a consistent estimator of u_t^p , we regress the other reduced-form residuals on the fitted value \hat{u}_t^p :

$$\hat{u}_t^q = \frac{s_t^p}{s_t^q} \hat{u}_t^p + \delta_t \tag{6}$$

Finally, s_t^p is normalized, and we obtain $\hat{S} = (1, \hat{s}^q)'$, which is the coefficient vector of the shock we are interested in.

2.3. Some Notes about the SVAR–IV Model

The literature based on the SVAR–IV model, such as [22], is focused on a single instrumental variable of one structural shock. However, when studying multiple contemporaneous shocks, we face the problem of not having enough restrictions to identify various monetary policy shocks. Hence, we reference the simultaneous equation given in [23] based on (3) and (4) to identify η , ζ and $S_1 S_1'$:

$$u_{1t} = \eta u_{2t} + S_1 \epsilon_{1t} \tag{7}$$

$$u_{2t} = \zeta u_{1t} + S_2 \epsilon_{2t} \tag{8}$$

We can obtain $S_1 S_1'$ and $S_1 \epsilon_{1t}$ via the procedure mentioned in Section 3.1. When there are $k(k > 1)$ instrumental variables, and S_1 is a $k * k$ matrix, we need $(k - 1) * k/k$ restrictions. The authors of [22] used the Cholesky decomposition of $S_1 S_1'$ for perfect identification.

3. Data Description

3.1. Endogenous Variables

We estimated the benchmark VAR model using monthly data for the period 2008M1–2015M12, and Table A1 in the Appendix A shows the data sources. This period covers the beginning to the end of the Fed’s QE policy. The vector of observables, Y_t , includes

four variables measured monthly: one is the federal fund rate as the U.S. monetary policy indicator as in [17], and three are Chinese variables, the M2 year-on-year growth rate and year-on-year changes in industrial production and the consumer price index. For the multiple targets of China's monetary policy framework described in [23], we could not choose a single domestic interest rate as the monetary policy indicator, so, according to [24], the growth rate of M2 was set as the Chinese monetary policy indicator. The CBOE volatility index (VIX) is a real-time index that represents the market's expectation of the relative strength of near-time price changes in the S&P 500 index, so the VIX was set as the exogenous variable, making the model a VARX model [25]. Based on the results of the Akaike information criterion (AIC), Bayesian information criterion (BIC), and Hannan–Quinn (HQ) information criterion, we used a VARX model with three lags. In addition, we also conducted stationarity and other relevant tests, as shown in Figure A1 and Tables A2 and A3 in Appendix A. All VARX models in this paper passed the stationarity test (due to spatial constraints, the test results are not appended to the paper; interested parties may request them from the authors).

3.2. Instrumental Variables (IVs)

Prior studies on U.S. monetary policy mostly used high-frequency movements of federal fund futures around FOMC meeting announcements to identify monetary policy shocks, so we took movements within a tight (30 min) window as the IVs of the Fed's monetary policy shock [26]. Meanwhile, unlike the United States, China is not equipped with futures markets for the prices of monetary markets with sufficient trading volume. Due to the unique Chinese monetary policy framework under multiple constraints, the Central Bank of the People's Republic of China (PBOC) does not clearly announce which interest rate is pegged, and the economy has been in the process of transforming into a free market economy, so the targets of monetary policy are continuously changing.

Given the above-mentioned real-world limitations, we referenced the empirical results of studies such as [27,28] and focused on the daily movements of short-term interest rates in Chinese interbank markets as candidate IVs of China's monetary policy shock.

The interbank market is the most important segment of the Chinese monetary market. Therefore, China established a benchmark interest rate system that is primarily based on the interbank repo rate indicator system and lending market rate system, in which 45 interest rates are the basis for the construction of instrumental variables. We can see that the instrumental variables contain many zeros, so we need to extract effective information about them from a high-dimensional sparse matrix. To avoid the potential problems of using a single instrumental variable, we use principal component analysis to reduce the dimensions of the candidate instrumental variables listed above by referring to [29]. The specific component measure we use as an indicator for China's monetary policy is the first principal component of the benchmark interest rates of the interbank market.

The instrumental variables of the two countries' monetary policies are assumed to be correlated with each other, so, referring to [11], we take the sum of F statistics of the two IVs being greater than 10 as the criterion for whether the IVs are appropriate. The structural relationship between the IVs is a Cholesky decomposition, which means China's monetary policy is presently influenced by the Fed's monetary policy shock, but the opposite is not true. Then, following [17], we sum the daily data of the interest rates as the IVs of the SVAR–IV model.

4. Empirical Results

In this section, we present the dynamic response to the endogenous variables in the SVAR model to U.S. and domestic monetary policy shocks and discuss the macroeconomic transmission channels of monetary policy shocks. The solid red line in the figures represents the dynamic response of the endogenous variables to monetary policy shocks, while the dashed blue lines show the 68% confidence intervals obtained by using the bias-corrected

wild bootstrap method with a sample of 5000, as employed in [22]. All impulse response functions in the paper are original values, not accumulated.

4.1. Baseline Results

Figure 5 displays the IRFs of variables of the Chinese economy following a negative 1 percentage point response to U.S. monetary policy shock. Within the regime of the Fed’s QE monetary policy, China’s M2 growth rate increased by 5% after the shock, then rapidly declined, converging at nearly 20 months. However, it can be seen from the confidence interval that the M2 growth rate was significantly negative only from the fifth to seventh months after the shock. Chinese CPI significantly decreased by 0.6%, reaching its lowest point of -1.3% in the sixth month after the shock, then recovered and converged to zero after 20 months. Upon encountering a shock, China’s industrial value-added growth rate dropped by 0.5% and then gradually recovered. However, according to the confidence interval, it remained significantly negative for eight months following the shock.

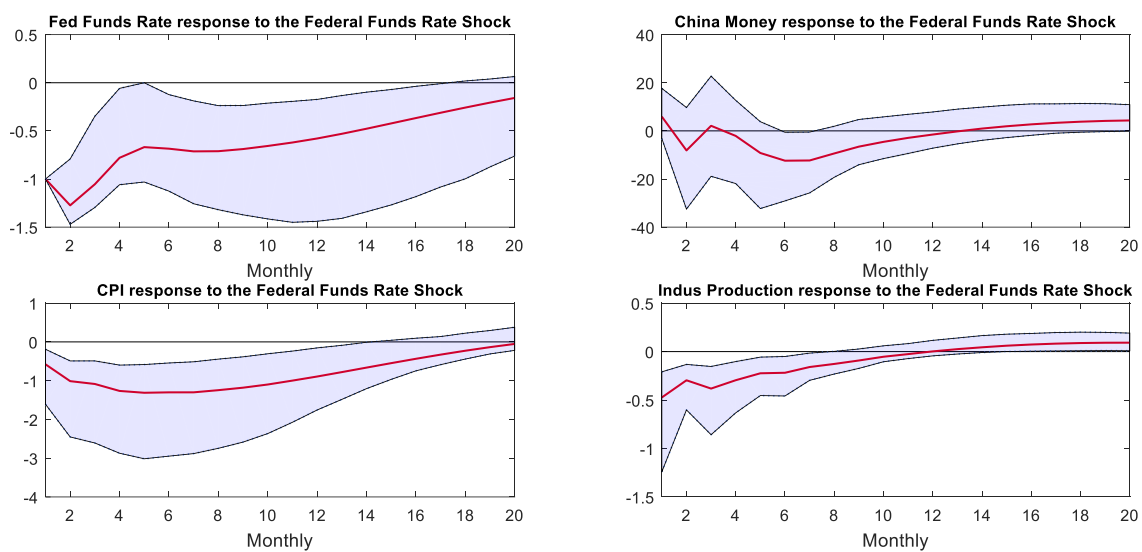


Figure 5. IRFs of the baseline model (Federal Reserve’s shock).

Figure 6 shows the IRFs of China’s economy following a +1 percentage point M2 growth rate shock during QE periods in the U.S.

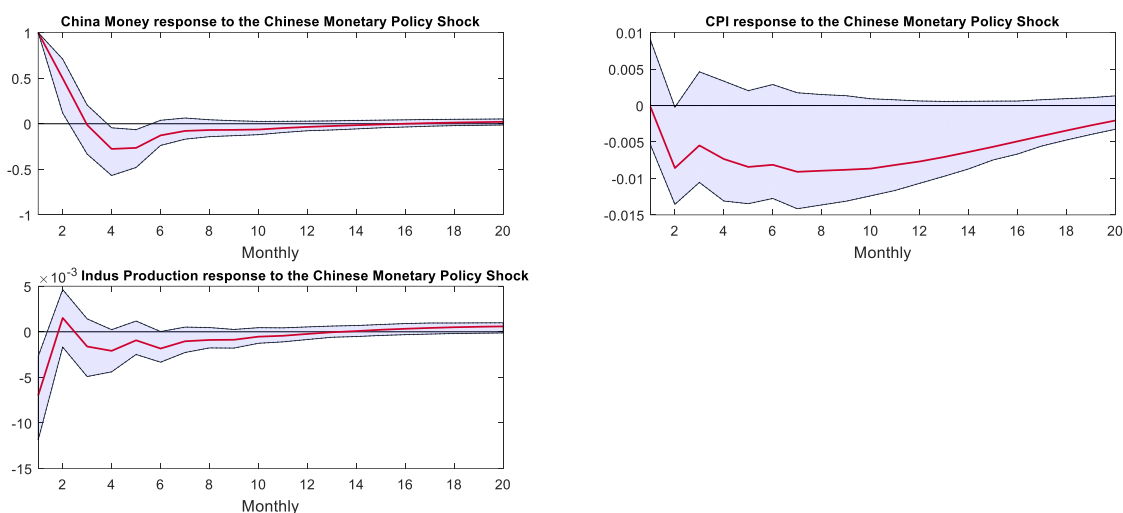


Figure 6. IRFs of the baseline model (PBOC’s shock).

When the CPI growth rate initially encountered China's loose monetary policy shock, it dropped into negative territory and then continued to decline, slowly recovering after the eighth month. However, this process was not significant. When facing the shock, the Chinese industrial value-added growth rate significantly dropped by 6.5% immediately, but then quickly rebounded and turned positive in the second month, and subsequently converged slowly. As can be seen from Figures 5 and 6, the unconventional monetary policy shock from the Federal Reserve continuously and significantly reduced China's CPI and industrial output, while the impact on M2 was not significant. On the other hand, China's loose monetary policy shock significantly reduced industrial output in a short period, but its impact on the price level was not significant.

Both of them were loose monetary policy shocks, but the impulse response functions of the Fed's and China's monetary policy shocks were not the same. A possible explanation for this finding is the signal effect. The volatility of the federal fund rate affects the expectations of Chinese producers. A reduction in interest rates by the Federal Reserve means future growth of the U.S. economy is weak, so Chinese producers expect that demand from the U.S. will decline and so they cut production. Due to the fixed exchange rate, the money in the Chinese economy rose in a short time and then reached convergence quickly. Meanwhile, the CPI kept reducing consistently. Compared with the Fed's monetary policy shock, the impact of the PBOC's loose monetary policy shock significantly reduced the domestic output growth rate in a short period but had an insignificant effect on the CPI. This indicates that China's monetary policy shocks also influenced domestic producers' expectations and had a significant effect on the domestic economy.

4.2. Macroeconomic Transmission Channels of Monetary Policy Shocks

We also considered alternative SVAR specifications to help us understand the different transmission channels of monetary policy shocks, so we augmented the baseline SVAR model with some monthly data from trade sectors. In this section, we report the responses of the endogenous variables. From the perspective of open macroeconomics and finance, bilateral trade between China and the United States is an important transmission channel of unconventional monetary policies in the real economy, while the financial equity and foreign exchange markets are the transmission channels in the financial market.

For each specification in the SVAR model, we considered the situation that a -1 percentage point change would cause a decrease in the federal fund rate and a $+1$ percentage point change would cause an increase in the China M2 growth rate.

The United States is China's most important trading partner, so we first considered the specification separately, augmented with monthly data about bilateral trade, including exports, imports, total trade volume, and net exports from China to the U.S. We present a sequence of SVAR calculations rather than a single one that includes all variables to avoid the problem of over-parameterization, according to [17]. Figure 7 shows the impulse response to the Fed's unconventional monetary policy by bilateral trade channels between China and the United States.

We can see that China's exports to the United States (top left panel) briefly increased upon the occurrence of the shock but have been declining since, though the changes were not significant. Conversely, China's imports from the United States (top right panel) initially underwent a significant but fleeting surge, then a significant downturn and convergence starting from the second to the third month. Meanwhile, the dynamic response of total trade volume (bottom left panel) between the two countries was similar to that of China's exports to the United States. The impact of the Federal Reserve's monetary policy shock on China's net exports to the United States (bottom right panel) was not significant.

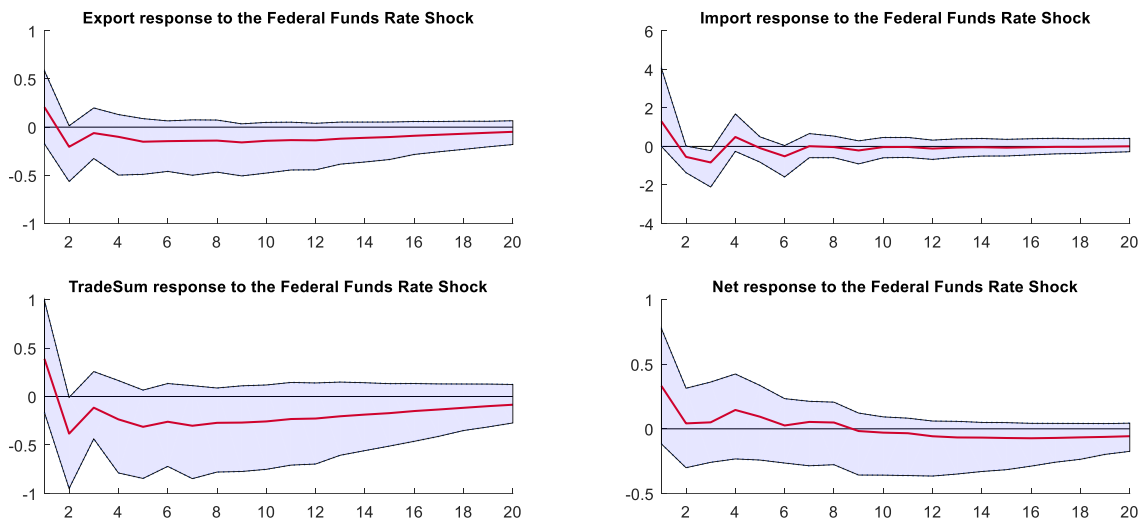


Figure 7. IRFs of trade channels (Federal Reserve’s shock).

Figure 8 shows the dynamic response to China’s loose monetary policy shock. The growth rate of China’s exports to the United States significantly dropped to a negative value in the second month after the shock, then subsequently oscillated and converged slowly. On the other hand, the growth rate of China’s imports from the United States initially increased significantly upon the shock, followed by a rapid decline to the lowest point of -0.008% in the fifth month, then gradually converged to zero thereafter. The impulse response function of the total trade volume between China and the United States was similar to that of China’s exports to the United States. Furthermore, China’s net exports to the United States significantly dropped to a negative value in the second month after the shock, followed by a slow oscillation and convergence to zero.

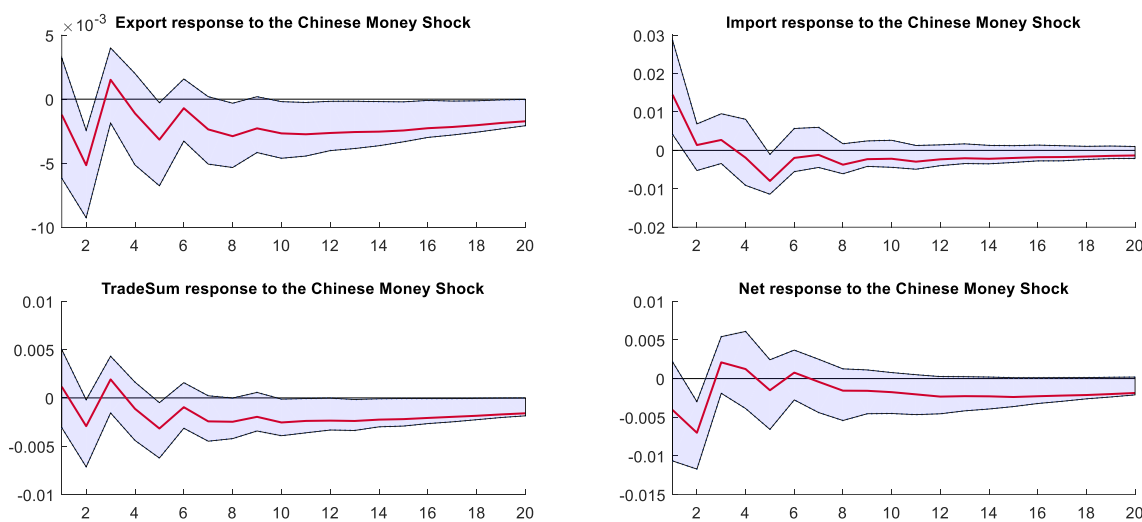


Figure 8. IRFs of trade channels (PBOC’s shock).

We can see that domestic monetary policy had a more significant impact on bilateral trade. The Federal Reserve’s QE monetary policy shock temporarily and significantly increased U.S. exports to China due to the depreciation of the U.S. dollar. However, the Chinese monetary policy shock effects lasted for a longer time, notably affecting imports, exports, total trade volume, and net exports, so the Chinese monetary policy shock had significant economic effects. A possible explanation is that the American manufacturing industry was shrinking, so exports from China as a “world factory” to the United States were nearly inelastic.

5. Financial Market Transmission Channels of Monetary Policy shocks

The authors of [30] discovered that global financial cycles are driven mainly by the monetary policies of central countries like the U.S., affecting the leverage of global banks, credit growth, and capital flows in the international financial system, so we investigated the financial market transmission channels of monetary policy shocks.

5.1. Equity Price

With the development of the global economy and integration of finance, the volatility of global commodity futures markets became an essential forecast index for changes in global liquidity. Meanwhile, with significant progress made in the reform and liberation of the Chinese economy, the Chinese stock market serves as a macroeconomic barometer. To investigate the transmission channels of the Fed’s unconventional monetary policy, the global commodity futures index and the Chinese stock market index were considered separately in the SVAR model.

Figure 9 shows the impulse response of equity prices to the QE policy. The global commodity futures index initially dropped by 0.3% following the shock and then slowly converged, but the changes were not significant. The Chinese stock market index initially declined but subsequently rose, remained significantly positive for 10 months after the shock, and then gradually converged.

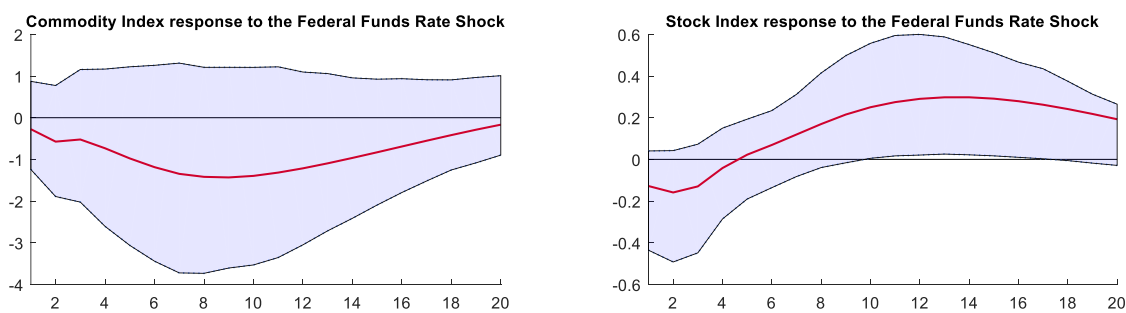


Figure 9. IRFs of equity price channels (Federal Reserve’s shock).

Figure 10 shows the impulse response to China’s loose monetary policy. As shown in the left panel, the global commodity futures market increased significantly by more than 0.02% and remained positive for nearly 5 months. Meanwhile, similar to the futures index, the Chinese stock market index significantly and continuously rose for 3 months after the shock. Hence, compared with the Fed’s unconventional monetary policy, the liquidity released by the PBOC’s policy pushed up the global commodity market significantly and persistently.

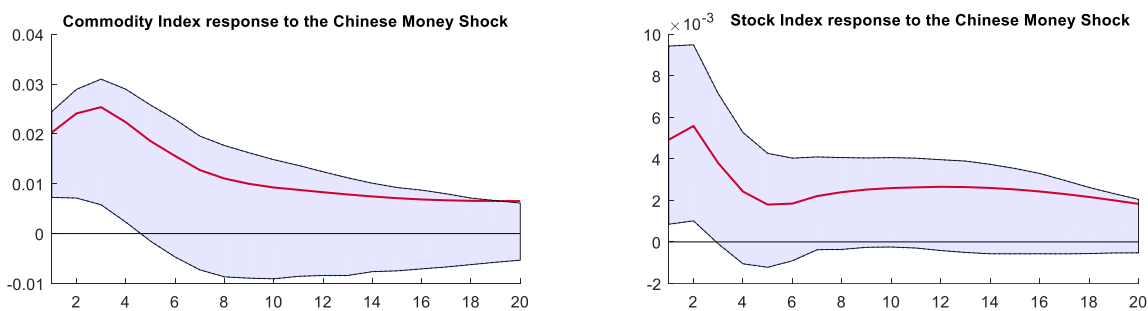


Figure 10. IRFs of equity price channels (PBOC’s shock).

As China is the largest buyer in the global commodity market, the Chinese monetary shock stimulated the growth of domestic demand and raised the prices of the commodity market. The liquidity released by the PBOC’s policy also significantly pushed up the

domestic stock market, similar to the predictions of classical theories. The empirical results indicate that, in the global commodity futures market and the domestic stock market, the transmission of Chinese monetary policy shocks is more effective, while the spillover effects of the Federal Reserve's unconventional monetary policy shocks are not significant.

5.2. House Prices

With the development of urbanization in China, population aggregation (indicating the development of real estate and related financial sectors) and house prices have been essential parts of asset prices. Thus, we added house prices as an endogenous variable in our SVAR model to study the effect of monetary policy on the real estate industry.

Figure 11 shows the impulse response of house prices to Sino–American monetary policies.

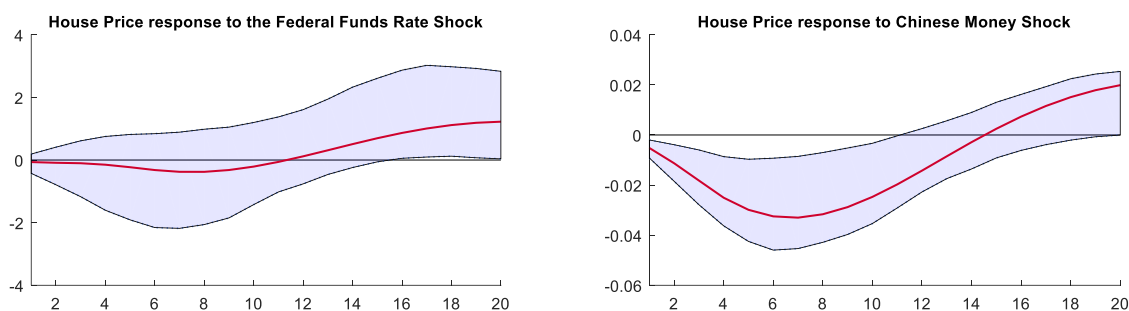


Figure 11. IRFs of house price channels.

The Federal Reserve's unconventional monetary policy shock initially caused a slight decrease in Chinese house prices, which was not significant. Prices then began to rise and turned significantly positive after the 15th month following the shock, and this positive trend continued for nearly half a year before gradually converging. China's loose monetary policy shock significantly reduced housing prices by 0.005%, followed by a continual decline, reaching the lowest point in the sixth month, followed by a gradual recovery. Compared to the QE monetary policy of the United States, the impact of China's monetary policy shock on domestic house prices was more significant and sustained. A possible explanation is that international investors remained optimistic about the future growth of the Chinese economy, so the demand for urban houses rose following the Fed's QE monetary shock. According to the benchmark model, China's loose monetary policy had a dual impact: it reduced investors' expectations and decreased total output, ultimately leading to a decline in investors' demand for real estate.

5.3. Exchange Rate

The exchange rate plays a dominant role in international trade and the international finance market. When the Fed's unconventional monetary policy was implemented, the federal fund rate, as the indicator of U.S. monetary policy, had hit the ZLB and therefore could not go lower; persistent deflation raised the effective cost of borrowing for households and businesses, especially in the trade sector. Meanwhile, the liquidity released by QE flowed to the financial sector, pushing up financial market indices. Thus, the spillover effects of both sectors influenced the exchange rate, and we took the effective RMB exchange rate and funds outstanding for foreign exchange (FOFFE) into the SVAR model separately to investigate the effects on the exchange rate in the sample.

Figure 12 shows the IRFs of the exchange rate and the funds outstanding for foreign exchange in response to the U.S. loose monetary policy shock. The effective exchange rate index of the RMB initially rose, followed by a decline, but this was not significant. Meanwhile, foreign exchange deposits declined due to the shock, then rose again, became significantly positive after the fourth month, and gradually converged thereafter.

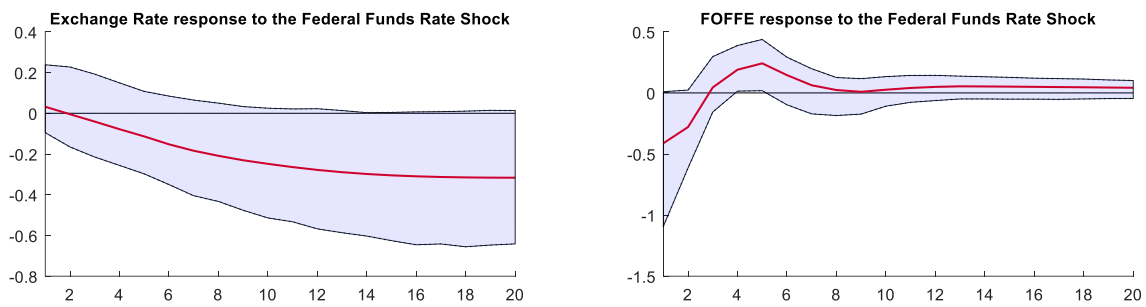


Figure 12. IRFs of exchange rate channels (Federal Reserve’s shock).

Figure 13 shows that China’s loose monetary policy shock significantly reduced the effective exchange rate index of the RMB, which lasted for nearly 8 months, followed by a slow convergence. After the impact occurred, China’s foreign exchange deposits significantly declined in the second month and remained notably low for a prolonged period. It is evident that the loose monetary policies of China and the United States had different impacts on the effective RMB exchange rate and foreign exchange holdings in foreign exchange channels. Despite the massive release of U.S. dollars under the Federal Reserve’s QE monetary policy, the impact on the RMB effective exchange rate was not significant due to pessimistic global economic expectations among international investors, which led to the depreciation of currencies in other countries. However, as the U.S. dollar serves as the world currency, demand for it tends to increase during global economic downturns, thereby increasing foreign exchange holdings. As a world factory with a relatively complete industrial chain, China is less impacted during periods of global economic downturn. International investors believe that the impact of China’s loose monetary policy will facilitate China’s future economic growth, resulting in an appreciation of the effective RMB exchange rate and a decrease in foreign exchange holdings.

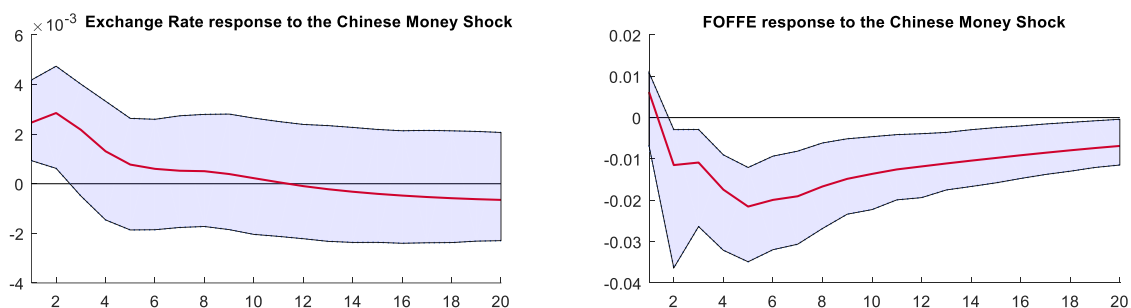


Figure 13. IRFs of exchange rate channels (PBOC’s shock).

The empirical findings in this section resonate with the predictions of the benchmark SVAR model, suggesting that monetary policy shocks are transmitted by altering the expectations of market participants. It is conceivable that Fed unconventional monetary policy shocks will be perceived as a signal of economic growth in the future, the same as Chinese monetary policy shocks in exchange rate channels.

5.4. Effects on the Price Levels of the Production Sector

At the center of the global industrial chain, China has been the largest importing country of materials and intermediate goods, which makes it the largest exporting country of final products. To study import inflation during the Fed’s QE monetary policy, we augmented the baseline SVAR with the PPI as an endogenous variable and added the variables in the transmission channels described above.

Figure 14 shows the impulse response functions of the Chinese economy following a -1 percentage point U.S. monetary policy shock. The PPI initially declined significantly by 1%, and then remained significantly negative for nearly 13 months.

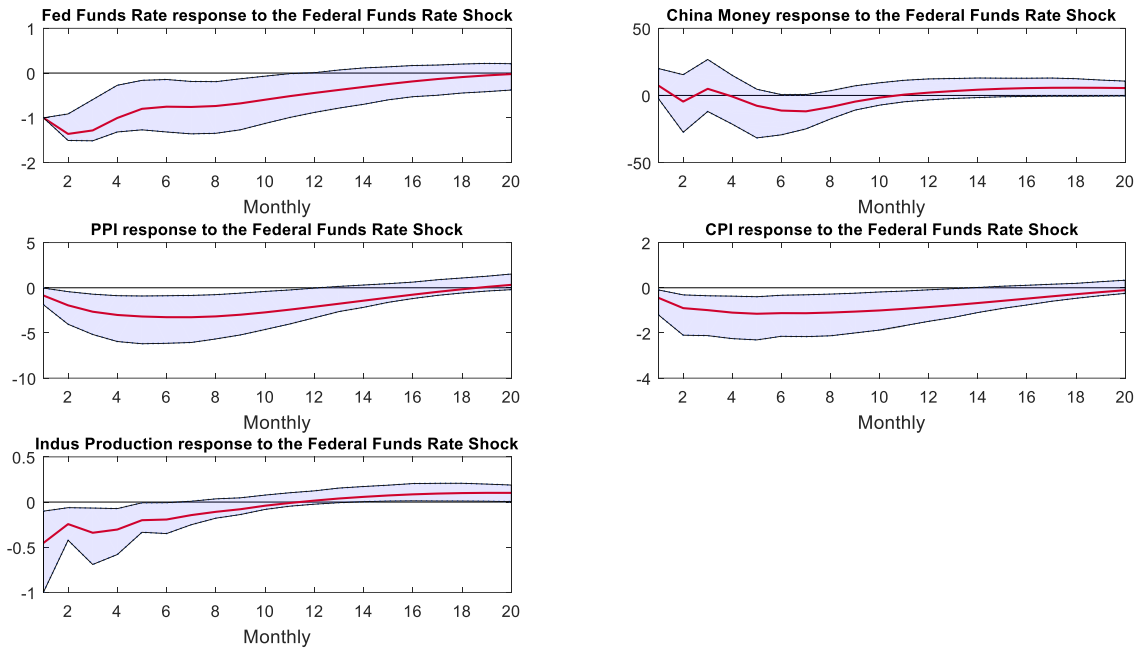


Figure 14. IRFs of the baseline model including the PPI (Federal Reserve’s shock).

The responses of other endogenous variables are similar to the baseline SVAR model in Figure 5.

Figure 15 shows the response of the commodity index, exchange rate, and PPI to the Fed’s QE monetary policy shock in the augmented SVAR model. The PPI significantly declined by nearly 1% in the initial period and remained negative for approximately 9 months, before gradually converging. The impulse response functions of the global futures index and the effective RMB exchange rate index were similar to those of the baseline model.

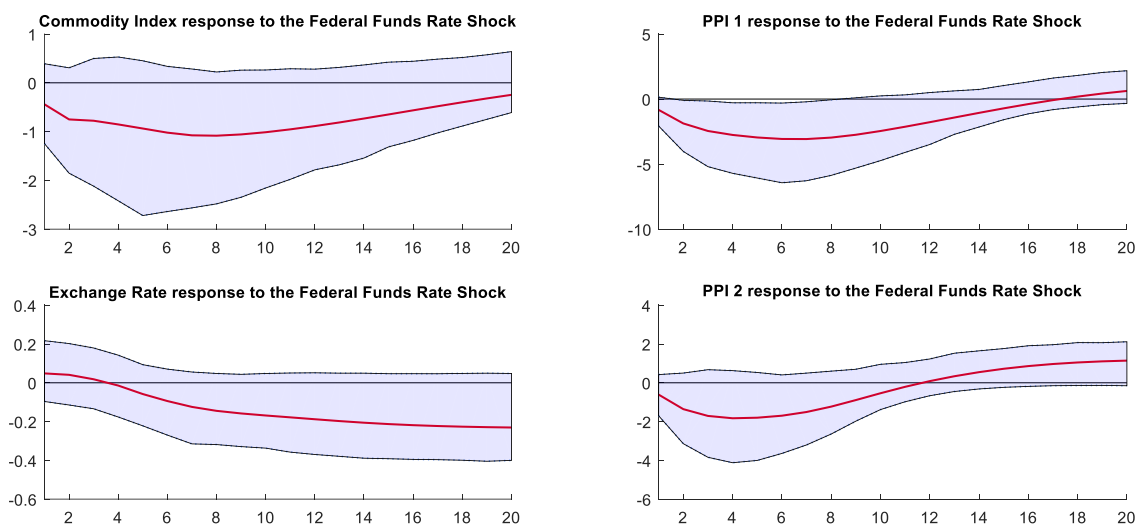


Figure 15. IRFs of exchange rate channels including the PPI (Federal Reserve’s shock).

Figure 16 shows the response of the PPI to the domestic monetary policy shock. The PPI significantly declined and reached its lowest point in the fifth month, followed by a gradual recovery.

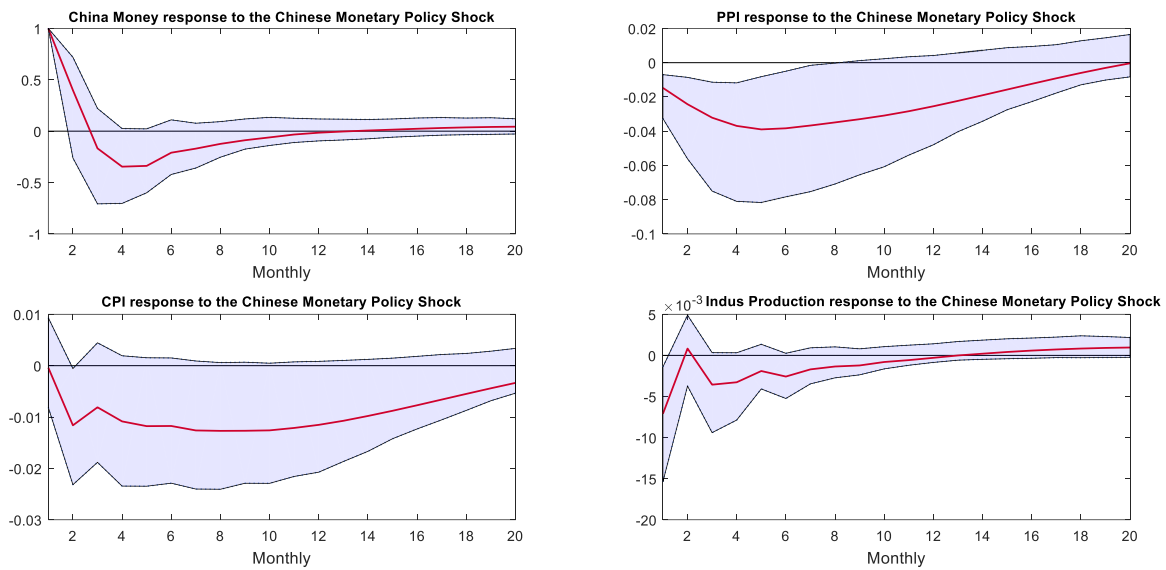


Figure 16. IRFs of the baseline model including the PPI (PBOC’s shock).

The responses of the variables describing the channels, global commodity index, and exchange rate in Figure 17 were similar to the baseline model. The impact of China’s loose monetary policy significantly increased the global futures index and the effective RMB exchange rate index in the short term. These results show that the influence of China’s loose monetary policy on the RMB exchange rate was more significant than that of the Federal Reserve’s QE monetary policy as same as PPI.

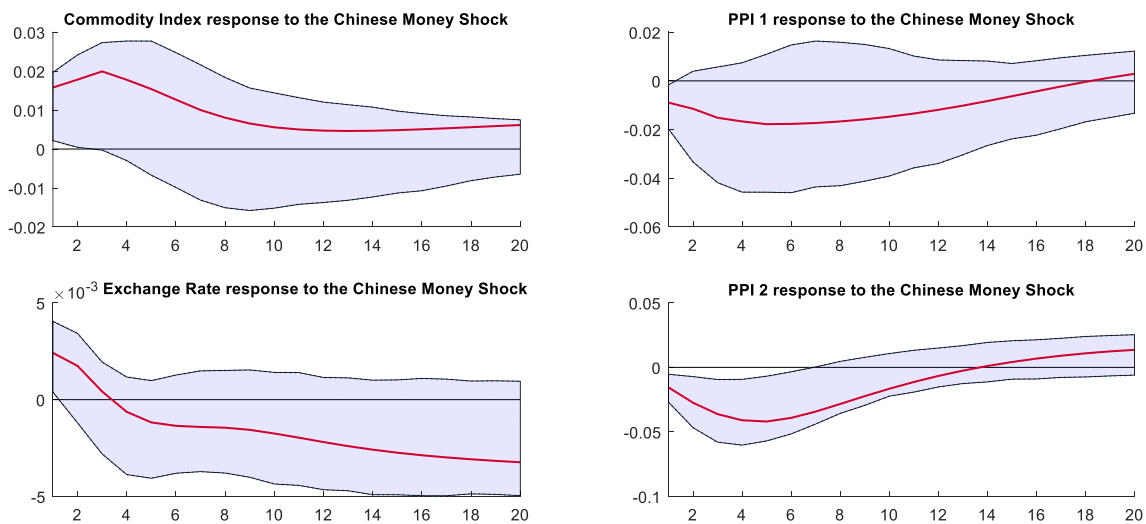


Figure 17. IRFs of the exchange rate channels including the PPI (PBOC’s shock).

Figures 14–17 show that the domestic monetary policy had more significant effects on the PPI than the QE monetary policy. These results show that the liquidity from the Fed’s unconventional monetary policy did not bring inflation to the Chinese economy through import channels. However, the Chinese monetary policy triggered statistically significant rises in both the CPI and PPI, which means that the inflation was caused endogenously. The findings of this section again prove the findings of the benchmark model.

5.5. Did “Hot Money” Trigger the Housing Boom?

Since the Southeast Asia financial crisis occurred in 1997, the impact of hot money has become increasingly important to the economy and finance markets of relevant countries. The authors of [31] found that hot money became the most critical reserve accumulation component in China to replace trade surplus. Meanwhile, there has been a sense that, instead of flowing into the stock and bond markets, as in developed economies, hot money in China mainly flows into real estate, and house prices have zoomed up. In this section, we check this by using the SVAR model.

Based on the definition of hot money (Hot money = Foreign reserves – Trade surplus – FDI) in [31], we calculated the monthly data (year-on-year) in the sample period and added it as an endogenous variable in the SVAR model to check whether hot money triggered the housing boom during the QE period.

As seen in Figure 18, the Federal Reserve’s QE monetary policy significantly reduced hot money in the short term, and it notably and consistently pushed up house prices for approximately 14 months. The impact of China’s loose monetary policy significantly increased the inflow of hot money into China for nearly 2 months in the short term. Subsequently, the growth rate of hot money gradually declined, reaching its lowest point in the fifth month, and then slowly rebounded. Correspondingly, the impact of domestic monetary policy shocks on China’s house prices was not significant in the initial stages, but then there was a significant rise, and the indicator turned positive after the 13th month. This also confirms the results of the baseline model, which suggests that the Federal Reserve’s QE monetary policy influenced Chinese investors’ expectations of future economic conditions, with the real estate market acting as a safe haven. On the other hand, China’s loose monetary policy temporarily increased hot money inflow and eventually pushed up real estate prices after a longer period.

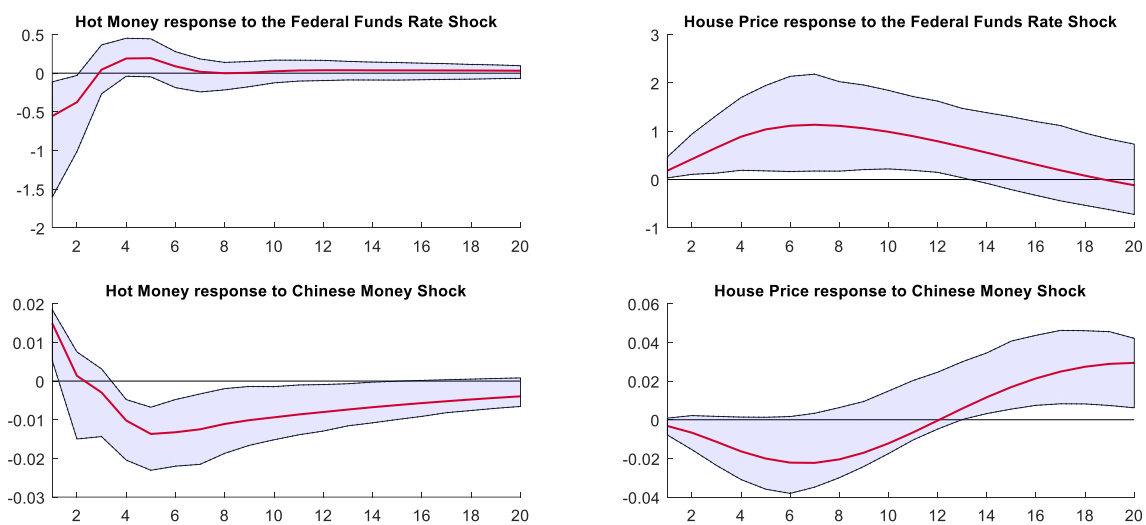


Figure 18. IRFs of the hot money channel.

5.6. Summary of Transmission Channels

Against the background of an open economy, the implementation of the Federal Reserve’s unconventional monetary policy had an impact on China’s macroeconomy through the following channels (Figure 19):

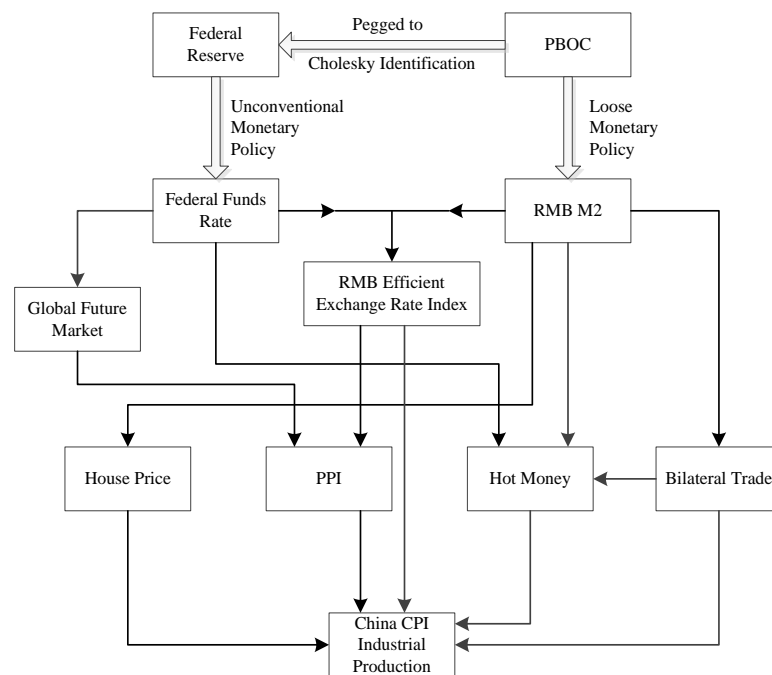


Figure 19. Transmission channels.

(1) From the fundamental perspective of bilateral trade, the implementation of the Fed’s unconventional monetary policy indirectly affected China’s macroeconomy by influencing the exchange rate of the RMB against the U.S. dollar. The unconventional monetary policy restored market liquidity and lowered asset yields, especially long-term, exerting depreciation pressure on the U.S. dollar.

Therefore, as indicated by the empirical results in Sections 4.2 and 5.3, U.S. exports to China increased in the short term. However, at the same time, the unconventional monetary policy sent a signal to market investors indicating weaker economic growth in the United States in the future, resulting in a decline in bilateral trade volume.

Meanwhile, due to the adoption of a flexible fixed exchange rate for the RMB, even though the People’s Bank of China implemented a loose monetary policy, the RMB appreciated against the U.S. dollar, resulting in a decrease in China’s exports and net exports to the United States and an increase in imports from the United States.

With the volatility of bilateral exchange rates, Chinese producers adjusted their import, export, and investment decisions toward the U.S., which ultimately impacted China’s price levels and aggregate output. This formed channels for the spillover effect of the Federal Reserve’s unconventional monetary policy on China. (2) Owing to the U.S. dollar’s status as the world currency in the international financial system, the implementation of the Fed’s unconventional monetary policy influenced China’s overall price levels, from both the aggregate supply and demand perspectives. As most global commodity futures markets are priced in U.S. dollars, the unconventional monetary policy tended to push up the prices of global commodities. This means that as the largest importers of raw materials, China’s manufacturers faced higher production costs, leading to an increase in China’s domestic CPI through the price transmission mechanism. However, due to the signaling effect of the unconventional monetary policy, the demand for commodities declined. Therefore, as indicated by the econometric results in Sections 5.1 and 5.4, the impact of the unconventional monetary policy shock on the global commodity market and PPI was not significant.

Given the Chinese economy’s heavy reliance on manufacturing and the appreciating value of the RMB, the loose monetary policy implemented by the PBOC during the same period pushed up global commodity prices, the domestic stock market, and PPI.

The empirical results indicate that the transmission of the Federal Reserve’s unconventional monetary policy shocks through financial market channels was primarily driven by signaling effects, while the transmission mechanism of China’s monetary policy shocks aligned with the predictions of classical theories.

(3) Given the Federal Reserve’s status as the global central bank, its adoption of unconventional monetary policies could lead to changes in global capital flow patterns through the portfolio balancing effect.

For instance, due to the unique and important position of U.S. Treasury bonds in the global financial market, there is a lack of substitutes for these sovereign debt assets. Therefore, when an unconventional monetary policy leads to a decrease in the yields of long-term U.S. Treasury bonds, international investors will reallocate their assets and turn to emerging market assets such as China’s.

As shown by the empirical results in Sections 5.2 and 5.5, Chinese asset prices tended to increase, and the external financing environment also improved.

(4) The Federal Reserve’s unconventional monetary policy raised the asset prices of emerging countries such as China, which meant that the wealth level of Chinese domestic residents increased.

Considering the above-mentioned global asset reallocation effects driven by international investors, the unconventional monetary policy pushed up China’s real estate prices. Meanwhile, the loose monetary policy adopted by the PBOC during the same period led to an increase in hot money and a subsequent rise in real estate prices, as described in Section 5.5, despite the tendency of the signaling effect to depress housing prices.

6. Robustness Check

6.1. Beginning of QE to Taper Tantrums

From the start of the QE monetary policy in 2008 to the initial rise in the federal fund rate in December 2015, the Fed’s unconventional monetary policy lasted for nearly 8 years. The process consisted of four rounds of QE, and the effect of each round was not the same. Notably, the taper was first discussed at the FOMC meeting in May 2013, when the Fed began to take forward guidance indicating that monetary policy would be tight in the future, which would change the market’s expectations. Therefore, we reconstructed the sample from January 2008 to May 2013 and re-estimated the SVAR model.

Figures 20 and 21 show the results of the new sample considering the “taper tantrums” and the time point of the Fed’s forward guidance. The results show that the inflation and final output responses are similar to the baseline.

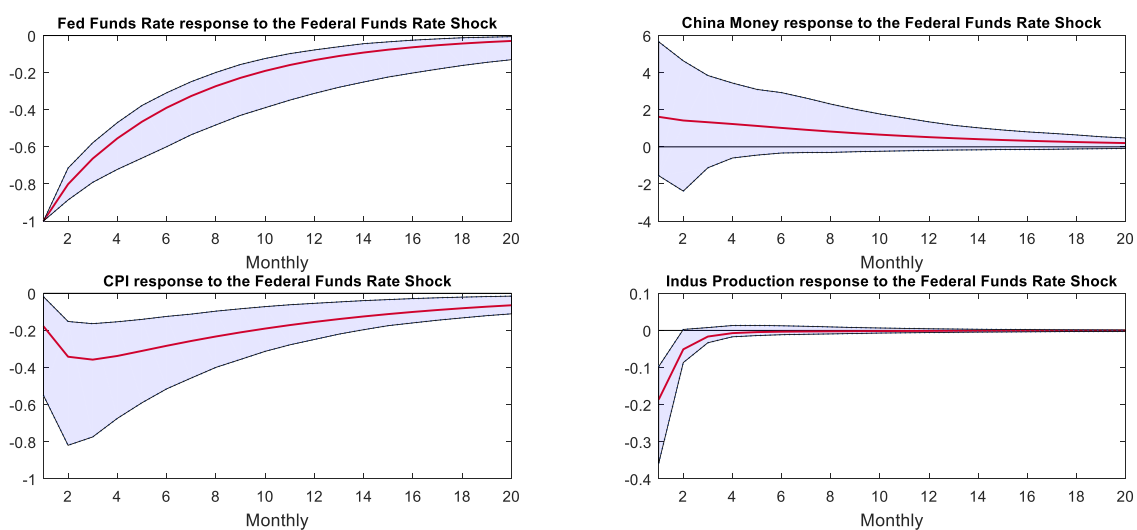


Figure 20. IRFs of the baseline model (Federal Reserve’s shock, taper tantrums).

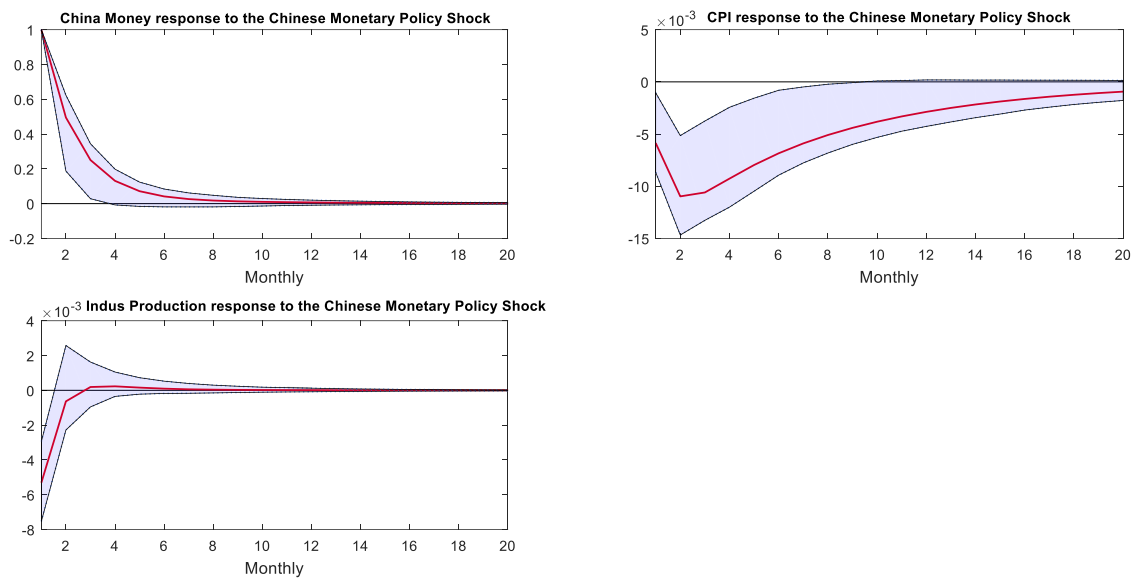


Figure 21. IRFs of the baseline model (PBOC’s shock, taper tantrums).

6.2. Effects of the Exchange Rate Policy Regime

It is common sense that the exchange rate policy of one country plays a dominant role in an open economic model [24]. The PBOC carried out an exchange rate policy reform on 11 August 2015, which means that the liberalization of China’s exchange rate has made significant progress. Did the change in the exchange rate system affect the spillover effect of the U.S. monetary policy? We changed the sample interval from January 2008 to August 2015, and the results of re-estimation show that before the 8.11 policy reform, the effects of the U.S. and domestic monetary policies were similar to the baseline model. Therefore, the influence of the exchange rate policy regime on the effects of the QE monetary policy on the Chinese economy was insignificant.

Figures 22 and 23 show the results of the baseline model considering the similarity between the exchange rate policy regime and the baseline model.

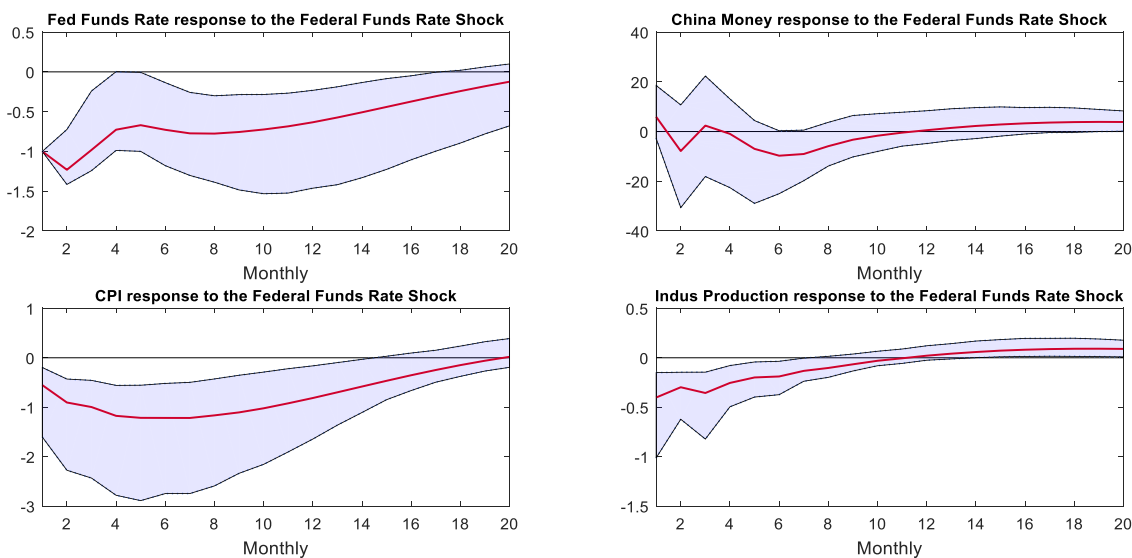


Figure 22. IRFs of the baseline model (Federal Reserve’s shock, regime).

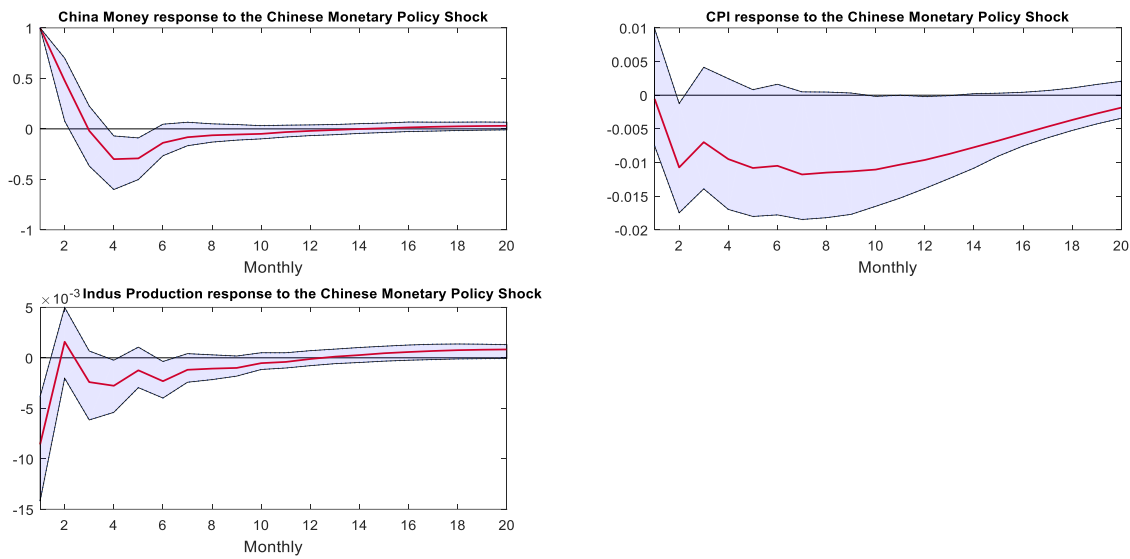


Figure 23. IRFs of the baseline model (PBOC's shock, regime).

Figure 24 shows the responses of the exchange rate to the two countries' monetary policies during the QE period, which remained robust compared with the baseline SVAR model augmented with the exchange rate. Thus, we conclude that changes in the Chinese exchange rate policy regime should have an insignificant influence on the dynamic responses of the Chinese economy following monetary policy shocks.

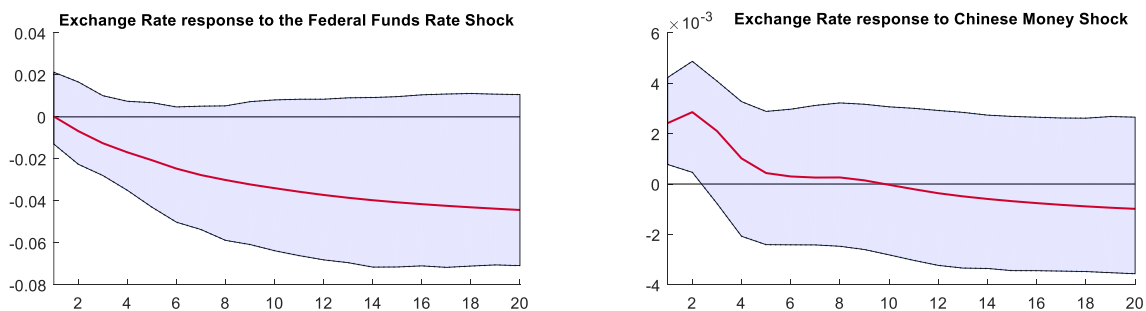


Figure 24. IRFs of exchange rate channels (regime).

6.3. SVARX to SVAR Model

We removed the monthly data of the VIX as the exogenous variable in the SVARX model, while other model settings remained unchanged. Hence, the SVARX model was transformed to an SVAR model, and the re-estimated results were similar to those from the baseline model. We can see from Figures 25 and 26 that the results remained robust considering the structure of the SVAR model.

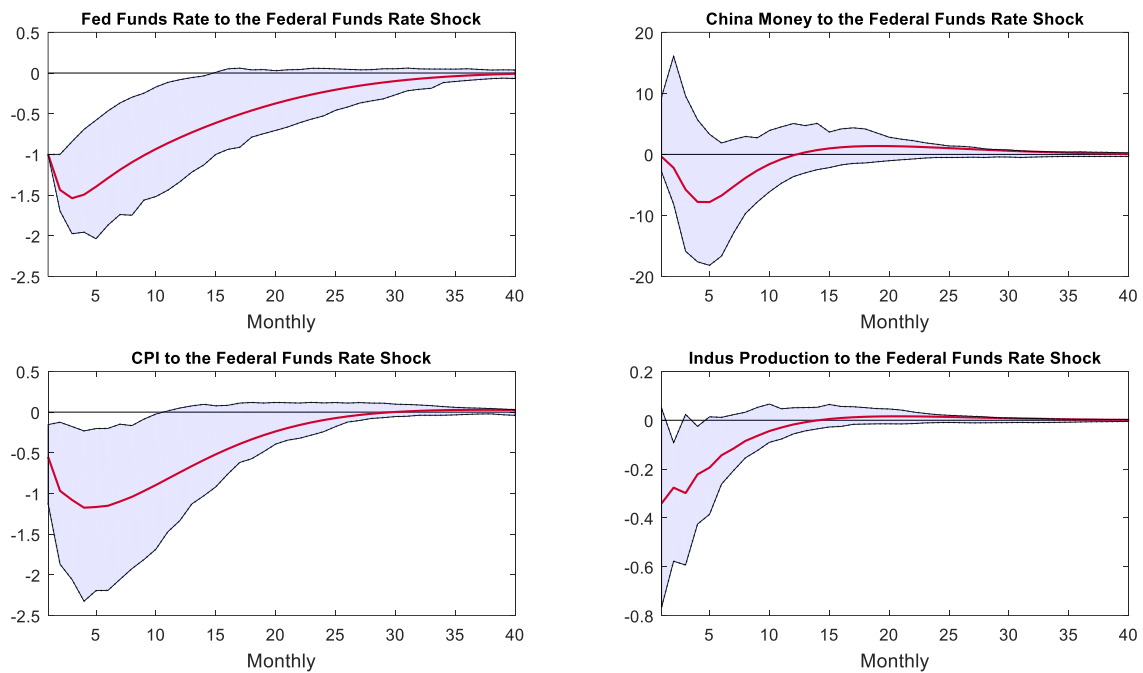


Figure 25. IRFs of the SVAR model (Federal Reserve's shock).

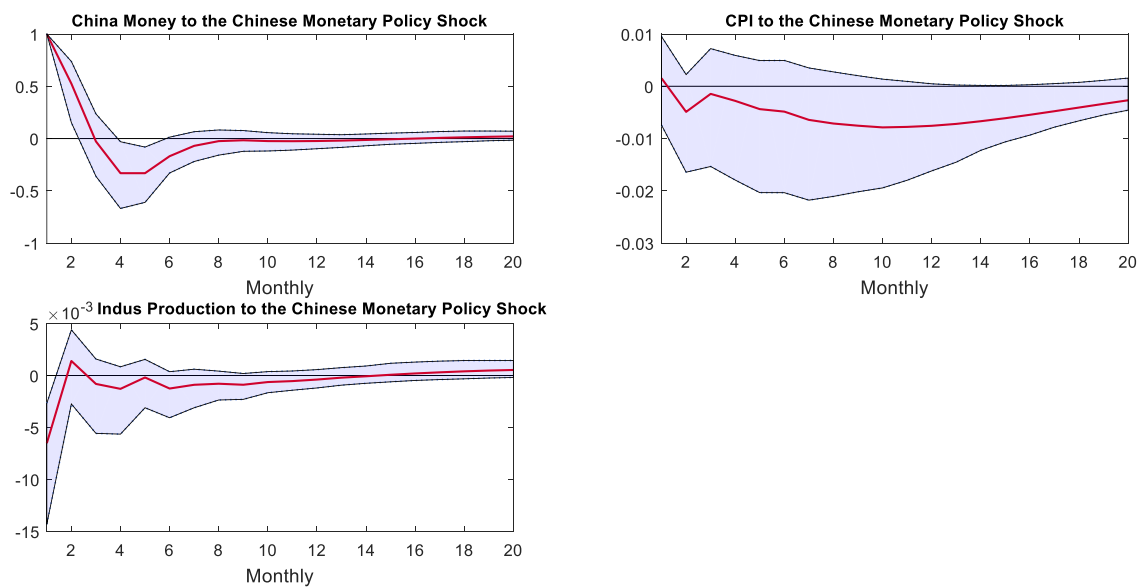


Figure 26. IRFs of the SVAR model (PBOC's shock).

7. Conclusions

Financial globalization poses a significant challenge for monetary authorities making decisions in an open economy. Foreign monetary shocks are propagated into domestic economies through international trade and integrated financial markets. Thus, the central bank in an open economy should understand the spillover effects of the global financial cycle, as noted in [32]. The aim of this research was to answer the following questions: How does an unconventional monetary policy transmit to China's financial sector and the real economy? Is the effect of a domestic monetary policy stronger than that of a QE monetary policy? Which channel is dominant among the monetary transmission channels? Do U.S. and domestic monetary policies affect the housing boom? We investigated these critical questions by using an SVAR model with a novel series of monetary policy shocks in the two countries.

To overcome the shortcomings of the traditional identification strategy, we used the high-frequency identification process pioneered by the authors of [33]. Then, we employed a series of the two countries' monetary policy shocks as the instruments in an SVAR model based on the sample cover period between 2008M1 and 2015M12. To solve identification problems in the set of instruments, we placed the Fed's unconventional monetary policy before the domestic monetary policy, which means the PBOC should respond to the Fed and not vice versa. The QE monetary policy led to a decline in economic activity and inflation, an increase in imports from the U.S., a rise in the Chinese stock market, an increase in urban house prices in China, an increase in the foreign exchange rate, and a decrease in the PPI. The domestic loose monetary policy led to a lower CPI and economic activity, a decline in exports to the U.S. and an increase in imports to China, an increase in the commodity index and the Chinese stock market, a decline in urban house prices in China, an increase in the exchange rate, and a decrease in the PPI. Finally, we also found that hot money significantly triggered the housing boom in China, and the effects of the Fed's monetary policy shocks were weaker than those of domestic shocks.

The empirical results described above differ slightly from the predictions of the standard Mundell–Fleming model of an open economy. The signaling effect was particularly prominent among the spillover effects of the unconventional U.S. monetary policy. The implementation of the unconventional monetary policy led to pessimistic expectations among market participants regarding the future growth of the economy, leading to producers actively scaling down their output. The results of the PBOC's monetary policy shock during the same period aligned closely with the predictions of the standard model. China's monetary policy shocks had a stronger effect than the Fed's monetary policy on China. The QE policy shocks increased the exports of the U.S. to China, and the domestic monetary policy exacerbated the volatility of the trade sector. The domestic loose monetary policy pushed up the commodity markets and stock market and led to an appreciation of the exchange rate while reducing foreign exchange deposits. The unconventional U.S. monetary policy led to slight rises in China's stock market and house prices. However, the impact on global commodity market prices and the effective RMB exchange rate was insignificant due to the signal effect. Although China is the largest importing country of materials and intermediate goods, its economy didn't suffer from import inflation, which was insignificant considering the PPI index. The loose monetary policies of both China and the United States significantly increased the inflow of hot money and real estate prices. However, the positive impacts of both monetary policies on the stock market, real estate prices, and foreign exchange holdings were not synchronized. This result is reflected in Figures 1–4 in Section 1.

The empirical results in this paper suggest that domestic monetary policy shocks have more significant and persistent effects on economic activity and financial markets than U.S. monetary policies, even if the central bank makes policy decisions anchoring the U.S. dollar. Furthermore, the impact of the loose monetary policies implemented by both countries during the same period on China's macroeconomy did not have consistent timing. The evidence is relevant to improving our understanding of the different transmission channels of the monetary policies of the two large economies, which has generated a strong argument. Since the global COVID-19 pandemic devastated the world economy, the Federal Reserve has launched a second round of QE, and dealing with the spillover effects of the unconventional monetary policy poses a challenge for the central banks of emerging market economics, so the conclusion of this paper provides an important reference for policymakers. It is crucial to emphasize the sequential nature of the impacts of monetary policy shocks from both countries on the Chinese economy. The essential advantage of the series of monetary policy surprises as the IVs of policy shocks is that it includes the market's reaction to the unexpected changes in liquidity due to these announcements. Considering that central banks will rely on quantitative easing in the future, we hope that this new series of surprises, together with the results presented in this paper, will be helpful for the current debate and future research in this area.

Author Contributions: Z.F.: Conceptualization, methodology, investigation, software, formal analysis, visualization, data curation, writing—original draft, writing—review and editing, X.C.: conceptualization, supervision, validation, writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest: The authors declare that they have no conflicts of interest.

Appendix A

Table A1. Data description, sources, and coverage.

Variable	Description	Source	Sample	Trans
Baseline variables				
Fed Funds Rate	Federal Funds Rate	Fred	2008M1~ 2015M12	Level
China's M2 Growth Rate	China's M2 Growth Rate Year on Year	People's Bank of China (PBOC)	2008M1~ 2015M12	Level
CPI	China's CPI Year on Year	National Bureau of Statistics (NBS)	2008M1~ 2015M12	Level
Industrial Production	Industrial Value-Added Year-on-Year	National Bureau of Statistics (NBS)	2008M1~ 2015M12	Level
Additional variables				
Export	Export (Manually calculate year-on-year growth rate)	General Administration of Customs of China (GACC)	2008M1~ 2015M12	Log
Import	Import (Manually calculate year-on-year growth rate)	General Administration of Customs of China (GACC)	2008M1~ 2015M12	Log
TradeSum	Total foreign trade volume (Manually calculate year-on-year growth rate)	General Administration of Customs of China (GACC)	2008M1~ 2015M12	Log
Net	Trade Surplus (Manually calculate year-on-year growth rate)	General Administration of Customs of China (GACC)	2008M1~ 2015M12	Log
Commodity Index	Global Commodity Index	International Money Fund (IMF)	2008M1~ 2015M12	Level
Stock Index	China Securities Index (CSI 300 Index)	Wind	2008M1~ 2015M12	Level
House Price	Housing Price Index (HPI)	General Administration of Customs of China (GACC)	2008M1~ 2015M12	Level
Exchange Rate	Real Effective Exchange Rate Index	Bank for International Settlements (BIS)	2008M1~ 2015M12	Level
FOFFE	Foreign Exchange Reserves Occupancy (Manually calculate year-on-year growth rate)	People's Bank of China (PBOC)	2008M1~ 2015M12	Log
PPI	Producer Price Index Year on Year	National Bureau of Statistics (NBS)	2008M1~ 2015M12	Level
Hot Money	hot money = foreign reserves – trade surplus – FDI (Manually calculate year-on-year growth rate)	General Administration of Customs of China (GACC)	2008M1~ 2015M12	Log

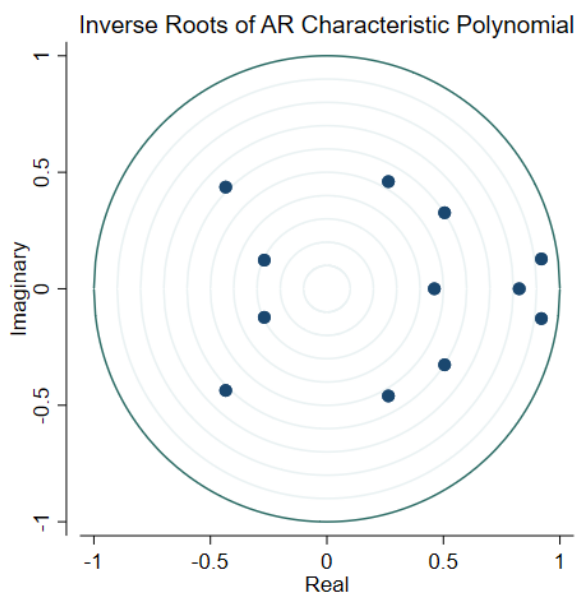


Figure A1. Stability condition test of the VAR model.

Figure A1 illustrates that VAR satisfies the stability condition.

Table A2. Residual Normality Test.

Component	Jarque-Bera	df	Prob.
1	3040.883	2	0.0000
2	149.2193	2	0.0000
3	3.077872	2	0.2146
4	17.10721	2	0.0002
Joint	3210.282	8	0.0000

Orthogonalization: Cholesky (Lutkepohl)
 Null Hypothesis: residuals are multivariate normal
 Sample: 2008M01~2015M12
 Included observations: 93

Table A3. Residual Serial Correlation Test.

Lags	LM-Stat	Prob.
1	25.801	0.0569
2	45.761	0.0001
3	24.423	0.0807

Null Hypothesis: no serial correlation
 Sample: 2008M01~2015M12
 Included observations: 93
 Probs from chi-square with 16 df.

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