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The Impact of US Monetary Policy and Other External Shocks on the Hong Kong Economy: A Factor-augmented VAR Approach

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Abstract

This paper uses the factor-augmented VAR (FAVAR) framework to study the impact on the Hong Kong economy of the diverging monetary policies by the Fed, ECB and BoJ as well as the Mainland economy slowdown. The empirical results show that changes in US monetary policy mainly affect interest rate-sensitive sectors in Hong Kong; while real variables such as real GDP growth, unemployment rate are more sensitive to the economic slowdown in Mainland China. Monetary easing from the ECB and BoJ to some extent offsets the tightening of the Fed. The transmission channels of external shocks are through trade and capital markets. It is estimated that the combined effect of the four external shocks will on average lower Hong Kong's quarterly GDP growth by 0.6 percentage points and quarterly inflation by 0.2 percentage points in the first 4 quarters. However, Hong Kong's financial stability, particularly with regard to loan quality, banks' capital and liquidity, is well maintained by macroprudential policies suggesting that Hong Kong's financial system is resilient to external shocks.

JEL classification: C3, E5, E3

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1. Introduction

Hong Kong as a small open economy has been greatly affected by global shocks. With the linked exchange rate system and free capital mobility, Hong Kong essentially adopts the Fed's monetary policy. Changes in the Fed's monetary policy will affect different sectors of the Hong Kong economy. As an international financial center with open capital markets, the monetary policies of other major central banks also have an impact. It is likely that monetary policies among the major central banks will diverge over the next few years with the US Fed expected to tighten but the ECB and BoJ maintaining a looser monetary stance, which will have differential effects on the Hong Kong economy. Hong Kong's real sector is also closely connected to Mainland China, and the growth slowdown of Mainland China will also have serious impact on Hong Kong.

This paper studies how external shocks are transmitted to the different sectors of the Hong Kong economy. Specifically, this paper attempts to address the following questions:

How the changes in the Fed's monetary policy are transmitted to different sectors of the Hong Kong economy, especially the financial sector and real estate sector? With several rounds of large scale quantitative easing (QE) by the Fed, how is Hong Kong's financial stability affected?

With the coming divergence of monetary policies among major global central banks, what will be the overall impact on the Hong Kong economy, especially the exchange rate? What is the combined effect of diverging monetary policies across the world on the Hong Kong economy and its financial stability?

How will the growth slowdown of Mainland China affect the Hong Kong economy? How will it add to the effects of diverging monetary policies?

Vector autoregression (VAR) is a typical method to study the impact of monetary policy changes on macroeconomic variables. However, because of a degrees of freedom problem, only a small number of macroeconomic variables can be included in a VAR. Therefore standard VAR analysis can only evaluate the impact of monetary policy changes on the included variables. In order to analyze the large number of data series available, Bernanke *et al.* (2005) suggests a factor-augmented vector autoregression (FAVAR) approach, which can incorporate a larger amount of information in a comprehensive analysis.

FAVAR is able extract a few factors from a large number of data series and estimate a VAR system using the extracted factors together with a few observable variables. The observable variables could be monetary policy shocks or Mainland China's GDP growth indicator. Through an impulse response analysis, it can show the dynamic responses of the factors to external shocks allowing the researcher to back out the dynamic response of the original data series to external shocks. The main advantage of FAVAR is that it can incorporate a large data set without having to make choices about which data series should be included in a VAR system, and the dynamic responses of all the data series can be backed out. The factors extracted can be used to represent abstract concepts such real activity, financial stability, etc. Therefore it is an ideal framework for a comprehensive analysis of the impact of monetary policy changes on different sectors of an economy. The impact of external shocks can be analysed individually or in the aggregate.

Two approaches have been suggested in the literature to estimate the FAVAR. The first approach is a two-step approach. This approach first extracts the factors from the large data set through principal component analysis and then selects the main factors to include in the VAR system together with shock variables. The second approach is a likelihood-based Gibbs sampling approach. This approach has to assume independent normal errors and uses the Bayesian method to estimate coefficients in one step. It is computationally more demanding. In this paper, we mainly use the principal component

approach (two-step approach) but use the Gibbs sampling approach (single-step approach) for robustness check.

Given that Hong Kong is a small open economy with the Hong Kong dollar pegged to the US dollar under a currency board system, the monetary policy shocks of the Fed can be considered exogenous. The same is true for the monetary policy shocks of ECB and BoJ and the economic slowdown in Mainland China. Therefore it is arguably true that a VAR might not be necessary because Hong Kong's economic variables would not be able to affect the shock variables. However, in order to analyze the dynamic impact of external shocks, a VAR is the most appropriate framework. To take into consideration the exogeneity of these external shocks, in the following FAVAR analysis, we put zero restrictions on the FAVAR coefficients to rule out feedback effects (it is worth noting at this point, that the results do not change if these restrictions are relaxed[1]). As a robustness check, we also run a standard VAR to compare the empirical results.

The main findings of this paper are the following. The impact of US monetary policy on the Hong Kong economy is mainly on interest rate sensitive sectors, for instance, the property sector, Hang Seng Index and Hong Kong dollar effective exchange rate. This shows that the market has confidence on Hong Kong's linked exchange rate system. The real sector is mainly influenced by the business cycle of Mainland China. Quantitative easing (QE) by the ECB and BoJ reinforces appreciation pressures on the Hong Kong dollar, however, it neutralizes somewhat capital outflows from a tightening in US monetary policy. The additional impact of QE by the ECB and BoJ on the real sector is not obvious. Hong Kong's macroprudential policy measures are shown to be quite effective in defending the financial stability of Hong Kong in the context of large scale QEs, and anticipated future divergence in the monetary policy stance of the major global central banks.

[1] The coefficients turn out to be insignificant, which confirms that the spillback effect from the Hong Kong economy is minimal.

The rest of the paper is organized as follows: Section 2 reviews the literature. Section 3 introduces the FAVAR framework and data. Section 4 summarizes the empirical results. Section 5 provides a robustness check. Section 6 concludes.

2. Literature Review

This paper follows two strands of literature on the international transmission of shocks. The first line of literature is on how external shocks from the US or Mainland China transmit to Hong Kong. He, Liao and Wu (2014) study Hong Kong's business cycle synchronisation with the US and China, and find that Hong Kong's short run business cycle is more synchronised with the US but that its long run growth co-moves with that of Mainland China. He, Wong, Tsang and Ho (2015) study how asynchronous monetary policies are transmitted through the supply of international dollar credit by a global bank and find that the bank's risk-taking attitude, credit risk exposure and the business model of their overseas branches are important factors affecting the extent to which unconventional monetary policies are transmitted internationally. N'Diaye and Ahuja (2012) attempt to quantify the trade and financial spillovers on the Hong Kong economy from a growth slowdown in the euro area and Mainland China, and find that Hong Kong's output growth could fall by as much as 1.5 times the decline in euro area output growth. In the event of a hard landing in China, Hong Kong's output growth could fall by about 3 percentage points below its baseline in the first two years.

The second line of literature is the FAVAR literature. Since Bernanke, Boivin and Ellasz (2005) popularized the FAVAR method, a large literature has developed using the FAVAR to study the transmission of monetary shocks both domestically and internationally. Ho, Zhang and Zhou (2014) used FAVAR to study how quantitative easing (QE) by the Fed spills over to China through hot money inflows, and finds that the decline in the US policy rate has led to a significant increase in China's regulated interest rates and housing investment. Fernald, Spiegel and Swanson (2014) use FAVAR to

study the effectiveness of China's monetary policy and find that interest rate channel is gaining in importance. Mumtaz and Surico (2009) used FAVAR to study the transmission of international shocks. Zuniga (2011) uses FAVAR to study the US monetary policy transmission to Mexico and Brazil, and finds that the interest rate is the main transmission channel and has some impact via a trade channel. Dahlhaus, Hess and Reza (2014) use FAVAR to study the US monetary policy transmission to the Canadian economy and finds that QE by the Fed boosts Canadian output, mainly through a financial channel. Finally Belviso and Milani (2006) develop a structural FAVAR to help interpret factors extracted from a large data set, and use the framework to study the effects of monetary policy on a wide range of macroeconomic variables.

This paper contributes to the literature in the following two ways. First, it is the first paper to analyze the dynamic impact of external shocks on a wide range of different sectors of the Hong Kong economy, whereas the literature usually focuses on one or two macroeconomic variables only. Second, it analyses the combined effect of monetary policy shocks arising from changes in the stance of the major central banks and a slowdown in the economy of Mainland China, in contrast to the FAVAR literature which typically focuses on a particular shock.

3. Econometric Framework and Data

The FAVAR framework used in this paper is based on Bernanke, Boivin and Eliasz (2005), which combines dynamic factor analysis with VAR analysis.

a. Model Setup

Assume that a large number of observable macroeconomic variables of an economy are driven by a few common factors, which are not observable, and external shocks, which are observable, with the

following measurement equation:

$$\boldsymbol{X_t} = \boldsymbol{\Lambda^r R_t} + \boldsymbol{\Lambda^f F_t} + \boldsymbol{\varepsilon_t} \qquad (1)$$

where $\boldsymbol{X_t}$ is a $N \times 1$ vector of observable macroeconomic variables, $\boldsymbol{R_t}$ is an $M \times 1$ vector of observable shock variables, which could include external shocks, like measures of the monetary policy stance. $\boldsymbol{\Lambda^r}$ is a $N \times M$ matrix of coefficients. $\boldsymbol{F_t}$ is a $K \times 1$ vector of unobservable common factors. The number of factors (*K*) is much smaller than *N*, usually ranges from 3 to 5. $\boldsymbol{\Lambda^f}$ is a $N \times K$ matrix of factor loadings. $\boldsymbol{\varepsilon_t}$ is a $N \times 1$ vector of idiosyncratic (series-specific) shocks. Suppose the dynamics of ($\boldsymbol{R_t}$, $\boldsymbol{F_t}$,) is given by a VAR

$$\begin{bmatrix} \boldsymbol{R_t} \\ \boldsymbol{F_t} \end{bmatrix} = \boldsymbol{\Phi}(\boldsymbol{L}) \begin{bmatrix} \boldsymbol{R_{t-1}} \\ \boldsymbol{F_{t-1}} \end{bmatrix} + \boldsymbol{\eta_t} \qquad (2)$$

where $\Phi(L)$ is a lag polynomial of finite order as in standard VAR, and the error term $\boldsymbol{\eta_t}$ is i.i.d. with mean zero.

This paper will start by including a single measure of the US monetary policy stance in $\boldsymbol{R_t}$ to evaluate the impact of US monetary policy changes on the Hong Kong economy. Besides being affected by US monetary policy, the Hong Kong economy is also influenced by the monetary policies of other major central banks such as the ECB and BoJ, and economic growth in Mainland China. The paper then examines the effects of individual shocks such as monetary policy changes by the ECB and BoJ, and an economic slowdown in Mainland China. To see the combined effect of monetary policies of the Fed, ECB and BoJ and changes in economic growth in Mainland China, the analysis is extended to include measures of the monetary policy stance in the Euro Area and Japan and Mainland China GDP growth in $\boldsymbol{R_t}$. Since financial stability and capital flows have been a major concern to policy makers in Hong

Kong, this paper also studies the impact of diverging monetary policies among the major global central banks and a Mainland China economic slowdown on these two areas by including measures of financial stability and capital flows in the vector of $\boldsymbol{X_t}$.

To take into consideration that Hong Kong is a small open economy, which does not have much influence on the decisions of monetary policies of major central banks, we restrict the VAR by putting a block of zeros in the coefficient matrix to rule out feedback effects, which is similar to the setting in Dahlhaus, Hess and Reza (2014).[2] Therefore, the dynamics of ($\boldsymbol{R_t}$, $\boldsymbol{F_t}$,) is specified as the following with $\boldsymbol{R_t}$ ordered first, which shows that $\boldsymbol{F_t}$ does not affect $\boldsymbol{R_t}$ contemporaneously. We identify the model following the standard Cholesky decomposition.[3]

$$\begin{bmatrix} \boldsymbol{R_t} \\ \boldsymbol{F_t} \end{bmatrix} = \begin{bmatrix} \boldsymbol{b_{11}(L)} & \boldsymbol{0} \\ \boldsymbol{b_{21}(L)} & \boldsymbol{b_{22}(L)} \end{bmatrix} \begin{bmatrix} \boldsymbol{R_{t-1}} \\ \boldsymbol{F_{t-1}} \end{bmatrix} + \boldsymbol{\eta_t} \qquad (3)$$

b. Estimation

The above FAVAR framework can be estimated by two approaches; a two-step (principal component) approach and a single-step (Bayesian likelihood/Gibb sampling) approach. According to Bernanke, Boivin and Eliasz (2005), these two approaches produce qualitatively similar results. For the two-step (principal component) approach, the first step involves extracting principal components from the large dataset $\boldsymbol{X_t}$ to obtain consistent estimates of common factors ($\boldsymbol{F_t}$).[4] Given that a US monetary policy shock is an external shock to Hong Kong economy, this paper, in contrast to Bernanke, Boivin and Eliasz (2005), does not separate the macroeconomic variables into fast- and slow-moving variables.[5]

[2] The result does not change if this restriction is relaxed.
[3] The combination of block of zeros restriction and applying Cholesky decomposition could restrict the US monetary policy shock and other external shocks to be completely exogenous from the perspective of Hong Kong.
[4] The data need to be standardized when obtaining the principal component analysis.
[5] Bernanke, Boivin and Eliasz (2005) introduced the classification of fast- and slow-moving variables (the former are assumed to respond to external shock contemporaneously, while the latter are not) because the estimated common factors ($\widehat{\boldsymbol{F}}_t$) include the effects of $\boldsymbol{R_t}$, hence they are correlated with variables in $\boldsymbol{R_t}$. Given that the VAR in the second step uses recursive ordering, the estimated common factors ($\widehat{\boldsymbol{F}}_t$) and the shock variables ($\boldsymbol{R_t}$) are required to have no direct dependence. So Bernanke, Boivin

In the second step, equation (3) is estimated by a standard VAR method, with the estimates of $\boldsymbol{F_t}$ The VAR system is identified using a Cholesky decomposition. The variables in the system are recursively ordered with the US monetary policy shock or other external shocks ordered before the factors to reflect the assumption that the Hong Kong economy factors reacts to external shocks in the same period, but not vice versa.

Alternatively, the FAVAR can be estimated using a single-step (Gibb sampling) approach. That is, equations (1) and (3) are jointly estimated by a likelihood-based Gibbs sampling techniques, which is a Bayesian method developed by Geman and Geman (1984), with the assumption of independent normal errors. However, this approach is computationally very demanding. Some later literature such as Boivin *et al.* (2009) only uses a two-step (principal component) approach, which is computationally much simpler and easy to implement. In this paper, we also estimate the model using a single-step (Gibb sampling) approach as a robustness check.

Belviso and Milani (2006) argue that factors from a standard FAVAR are not identified and therefore lack economic interpretation. They propose a structural FAVAR model, in which they first classified the observable macroeconomic and financial variables into *I* groups by sectors, then for each group of variables, one principal component is extracted, thought to be a structural factor. Equation (1) is then rewritten in the following way:

$$\begin{bmatrix} \boldsymbol{X_t^1} \\ \boldsymbol{X_t^2} \\ \dots \\ \boldsymbol{X_t^I} \end{bmatrix} = \boldsymbol{\Lambda^r R_t} + \begin{bmatrix} \boldsymbol{\Lambda_1^f} & 0 & \cdots & 0 \\ 0 & \boldsymbol{\Lambda_2^f} & \cdots & 0 \\ \cdots & \cdots & \cdots & \cdots \\ 0 & \cdots & \cdots & \boldsymbol{\Lambda_I^f} \end{bmatrix} \begin{bmatrix} \boldsymbol{F_t^1} \\ \boldsymbol{F_t^2} \\ \dots \\ \boldsymbol{F_t^I} \end{bmatrix} + \boldsymbol{\varepsilon_t} \qquad (4)$$

and Eliasz (2005) uses this classification to remove the direct dependence of $\widehat{\boldsymbol{F}}_t$ on policy or external shocks $\boldsymbol{R_t}$. Since the shocks in this paper are external shocks to the Hong Kong economy, such classification is not necessary for the VAR analysis. Indeed, the results do no change much if we estimate the VAR equation (3) following the procedure in Bernanke, Boivin and Eliasz (2005) by separating the variables into slow-moving or fast-moving categories.

Where $\mathbf{X}_t^i$ is a $n_i \times 1$ matrix of variables in specific group *i*. The total number of variables is *N*. $\boldsymbol{F}_t^i$, is a 1×1 vector of unobservable factor extracted from the specific group *i*, the total number of groups is *I*. $\boldsymbol{\Lambda}_i^f$ is a $n_i \times 1$ matrix of factor loadings of the n_i variables in the group *i*. $\boldsymbol{\varepsilon}_t$ is a $N \times 1$ vector of idiosyncratic (series-specific) shocks.

In this way, they claimed that $\boldsymbol{F}_t^i$ represents a specific sector with clear economic interpretation. $\boldsymbol{F}_t^i$ is used in the dynamic equation. The model is then estimated by a Bayesian approach. In the robustness check section of this paper, we estimate a similar structural model, but use the two-step (principal components) approach.

c. Data

Similar to Bernanke, Boivin and Eliasz (2005), we collect 116 series on the Hong Kong economy. All series are quarterly. The sample period is from 1998 Q4 to 2015 Q2. This is the period for which we have a balanced panel of data for all series. All data series are transformed into stationary series and seasonally adjusted where necessary. A unique feature of this data set is that we include financial stability indicators and capital flow indicators, besides standard macroeconomic series, in order to investigate how external shocks affect financial stability in Hong Kong given that Hong Kong is a very open economy, and an international financial center with free capital flow. A detailed description of the data is in Table 1.

For the external shock variables, we include four indicators. They are monetary policy rate indicators for the Fed, ECB and BoJ, and real GDP growth for Mainland China. After the policy rates reached the Zero Lower Bound (ZLB), and major central banks started quantitative easing (QE), the actual policy rates, which were close to zero failed to be good indicators of the monetary policy stance. In order to

measure the monetary policy stance, Wu and Xia (2016) develop a method to calculate a shadow federal funds rate series to proxy the Fed's policy stance after late 2008, when the Fed's policy rate reached ZLB; this series has been updated by the Atlanta Fed. Lombardi and Zhu (2014), Krippner (2013) also develop a similar series using his own methods. Indeed, before monetary policy rates reached the ZLB, shadow rates and policy rates were similar. In this paper, we use series computed by the method of Wu and Xia (2016) for both the US and the ECB's monetary policy stances.[6] The Bank of Japan (BoJ) started QE much earlier (March 2001). We use a series computed by the method in Krippner (2013) for the BoJ's monetary policy stance.[7] Figure 1 shows the shadow policy rates of major central banks. For China's quarterly GDP series, we use data from CEIC with our own calculations to extend the data series.[8]

4. Empirical Results

We present the empirical results by first showing the principal components for the key Hong Kong economic variables. It can be seen that these principal components are highly correlated with specific sectors of the economy. We then show the impulse responses of 32 major economic variables to an individual shock of the change in monetary policy by the US Fed, ECB or BoJ, or a Mainland economy slowdown in models with only one shock. We extend the analysis to a full model including all four shocks to see the combined impact of diverging monetary policies and a Mainland slowdown on Hong Kong economic and financial variables. In the next section, we provide some robustness checks.

[6] The data can be downloaded from C. Wu's website: http://faculty.chicagobooth.edu/jing.wu/research/data/WX.html

[7] The shadow rates calculated by Krippner can be downloaded from Krippner's website: http://www.rbnz.govt.nz/research_and_publications/research_programme/additional_research/comparison-of-international-monetary-policy-measures.html

[8] Official data for quarterly real GDP level of China started from 2012, and we calculated earlier data by using the series of quarterly year-on-year changes of real GDP. Then we apply the seasonal adjustment to the series and calculate the quarter-on-quarter change of the seasonally adjusted series. This series is generally in line with the official seasonally adjusted quarterly real GDP growth, which started only from 2010.

a. Principal Components for the Hong Kong economic variables

In the two-step approach of FAVAR framework, a small number of factors are extracted from a large number of macroeconomic series by principal component analysis.[9] In this paper, we extract five factors for the FAVAR analysis. These five factors explain around 60% of the variation in our 116 data series. Although the factors cannot be identified exactly, from Table 2, we can see the following pattern by looking at the correlation of the factors with the actual data series: Factor one is mainly correlated with variables related to the property market with a correlation often exceeding 75%. It also correlates with variables related to inflation, loans and financial stability. Factor two is highly correlated with variables related to real activity, the stock market and financial stability.[10] Factor three is highly correlated with interest rate variables. Factor four is highly correlated with variables related to the exchange rate, interest rates and the stock market. Factor five is highly correlated with variables related to the money supply.

b. The US interest rate hike

Figure 2 presents impulse responses of 32 selected major Hong Kong macroeconomic and financial variables (Panel A), and capital flow and financial stability variables (Panel B), to a US monetary tightening. The US monetary policy tightening is defined as a 25-basis-point increase in the US policy rate in this analysis. It is generally expected that the US Fed will raise interest rate by 25 basis points in each interest rate hike[11] (around a half of the standard deviation of the differences in US federal fund rate over the sample period) in the anticipated US monetary policy normalization.

[9] Since the FAVAR framework requires stationary variables, all non-stationary variables are differenced. Please refer to Table 1 for the detailed description of data transformation.

[10] The high correlation between Factor 2 with real activities and financial stability may imply the high correlation between growth and financial stability. However, this may not be true. As shown in equation (1), different economic and financial stability variables may have different relationship with different factors and the shock variables. Indeed, below estimation results suggest that Hong Kong's financial stability variables are more resilient than macroeconomic variables to the external shocks.

[11] Fischer (2015). As discussed above, it is very clear the US Fed raise the interest rate in the coming years, the monetary policy shock in this paper is defined as an anticipated interest rate hike rather than an unexpected change in monetary stance.

The VAR model (equation (3)) includes 5 factors plus the US shadow policy rate with 4 lags. The charts show the impulse responses of selected variables to a US monetary policy tightening up to 16 quarters in which the impulse responses represent changes of the variables in VAR. The red solid line indicates the estimated median response. The solid blue and green lines represent a 68 percent bootstrap confidence interval, and the dashed blue and green lines represent a 90 percent bootstrap confidence interval based on a 1,000 bootstrap samples.[12] In the impulse response exercise, a standard deviation unit is used and the US monetary policy change is transformed into units of standard deviations of the changes in the US federal fund rate. As stated above, the US monetary policy change is assumed to be a 25-basis-point increase in the federal funds rate, which is about 0.5 standard deviations of changes in the US monetary policy rate over the sample period. It should be noted that the impulse responses are in standard deviation units.

Following a US monetary tightening, Hong Kong's financial variables generally react significantly. The Hong Kong dollar NEER appreciates by 0.58% in one quarter. Hong Kong interbank interest rates go up immediately following an increase in the US interest rate. Under the linked exchange rate system with full capital mobility, Hong Kong's monetary policy follows the Fed's policy. It is well expected that the Hong Kong dollar exchange rate and interbank interest rates will follow the movements in their US dollar counterparts. Our empirical results confirm this point. This also shows that financial markets have confidence in the stability of Hong Kong's linked exchange rate system, otherwise the local market interest rate and exchange rate will diverge from the direction of movements in their counterparts in the US. With regard to the stock market, the Hang Seng index (HSI) has a significant but temporary negative response that only lasts one quarter, then rebounds before the impact eventually goes to zero, which means that Hong Kong's stock market quickly digests the news in a US monetary policy change.

[12] The generating method for the confidence interval is the same as that used in Bernanke *et al.* (2005).

A tightening of US monetary policy also has significant impact on Hong Kong's monetary and inflation variables but has little impact on real variables. Growth in M1 shows an immediate and significant decline. Growth in total loans also drops immediately and growth in M3 declines initially but the impact gradually dies down. In contrast to the results of Bernarke *et al.* (2005), we do not find a price puzzle[13] in Hong Kong. Underlying CPI (excluding the effect of one-off relief measures) drops an average of 0.04 percentage points in the first four quarters after a US tightening. Prices in Hong Kong are very flexible. They usually adjust to shocks very quickly. For real activity, changes in the PMI and growth in GDP do not see a significant impact but growth in retail sales drops by 0.08 percentage points in the first quarter. In the external sector, growth in the value of imports and exports shows a marginal decrease. The unemployment rate shows some increases, but it is not significant.

In the property market, the impact of a US monetary tightening is mixed. The residential property transaction and R&VD residential property price index do not show a significant reaction to a US monetary tightening. However, the growth in the Centa City Index[14] shows a cumulative decline of 0.3% in the first year after a US monetary tightening. Specifically, the percentage growth in the price of a large flat decreases by 0.56%, while that of a small flat decreases by 0.24%. Hong Kong's property market usually is very sensitive to interest rate changes. With only a one-time 25-basis-point increase in the policy rate, this impact does not seem very large. Usually after a full interest rate tightening cycle, the growth in property prices shows a significant slowdown or even becomes negative.

The impulse responses of selected variables of capital flow and financial stability to a US monetary tightening are shown in Panel B of Figure 2. The tightening in the US monetary policy has a significant impact on capital flows and leverage, but the impact on loan quality, banks' capital asset ratio and loan

[13] In VAR literature, a monetary policy tightening is found to be followed by an increase in the price level (Bernanke *et. al.*, 2005). In the robustness checking section next, we do see a price puzzle when using standard VAR model (also see Figure 13). This shows Sims' explanation that standard VAR does not control for all necessary information might be correct.

[14] Besides R&VD residential property price index (official index for all residential properties), Centa City Index is also a commly used property price index in Hong Kong. It is an average property price index for secondary private residential property based on all transaction records as registered with the Land Registry. The index is calculated and released by Centaline Property Agency Limited monthly. Details of the index can be found here: http://www1.centadata.com/cci/notes_e.htm

to deposit ratio is limited. Specifically, using percentage changes in the monetary base as a proxy of capital flows, these show a significant drop in the first year and a half after a US monetary tightening. Changes in current account and capital account balances also show significant decreases after a tightening. For financial stability, changes in household leverage, which is defined as household loans (sum of residential mortgage, credit card and other personal loans) over the nominal GDP, show a significant drop in the first year after the interest rate hike. However, loan-to-GDP ratio, new mortgage loans and the market LTV do not see a significant change in response to a US monetary tightening. The latter result is in line with Wong *et al.* (2014) that shows the Hong Kong market LTV is mainly explained by the domestic LTV policy. The classified loan ratio drops significantly and temporarily, while the drop in the credit card delinquency ratio is not significant. Net interest margins show a significant but temporary drop. For the banks' capital and liquidity, the CAR ratio does not show a significant change, while the liquidity indicator, HKD loan-to-deposit ratio declines in the first year. The above results show that Hong Kong's loans and capital flows are sensitive to US interest rate changes, however, Hong Kong's financial stability variables are mainly controlled by local macroprudential policies.

Table 3 shows a variance decomposition of the above 32 selected variables. Column II reports the fraction of the variances of forecast errors of selected Hong Kong variables explained by US monetary policy changes at a 16-quarter horizon. The results suggest that US monetary policy has bigger impact on interbank interest rate and capital flows, and a much smaller impact on other Hong Kong economic variables.[15] Column III shows the explanatory power (R^2) of the common factors[16] for the selected variables. The common factors explain a large part of variability of the selected variables, particular for

[15] The calculation of the fraction of the variance of forecasting error explained by the external shock is same as that used by Bernanke *et. al.*, 2005. For example, the fraction of forecasting error variance of variable *x* in 16 quarters explained by the US monetary shock is expressed as $\frac{var\left(x_{t+16}-\hat{x}_{t+16|t}|\varepsilon_t^{US}\right)}{var\left(x_{t+16}-\hat{x}_{t+16|t}\right)}$, where x_{t+16} is the actual value of *x* in 16 quarters after time *t* (time of shock), $\hat{x}_{t+16|t}$ is the forecasting value of *x* in 16 quarters by using information up to time *t*, $var\left(x_{t+16}-\hat{x}_{t+16|t}\right)$ is the total variance of forecasting error of *x* and $var\left(x_{t+16}-\hat{x}_{t+16|t}|\varepsilon_t^{US}\right)$ is the variance of forecasting error of *x* due to the US monetary policy shock.

[16] The common factor includes the five principal components and the US monetary policy shock variable.

real activity and property market variables. This result shows that the extracted factors can be used to analyse business cycle movements.

In order to highlight the contribution of US monetary policy changes to the growth of real activity, a historical decomposition of the real activity factor (factor 2) is calculated based on the five-factor FAVAR model. Figure 3 plots the actual series of factor 2 against the counterfactual series without US monetary policy changes. For most of the sample period, the counterfactual series follow the actual series closely. This shows that, for most of the time, the impact of US monetary policy changes on real activity factor is small. There are at least four episodes in the sample period when the two series diverge quite significantly. The first episode is around the middle of 2001, where counterfactual growth is much lower than actual growth. This is because that the counterfactual growth rate excludes the effect of an easing in monetary policy after the burst of the technology stock bubble. The second episode happens in late 2009. Again, counterfactual growth is lower than actual growth because, after the onset of the global financial crisis, the Fed quickly cut the policy rate to zero to mitigate the impact of the crisis. The third episode happens between 2012 and 2013. This is the period during which the Fed's three rounds of QEs has a big impact. It can be seen that the counterfactual line is significantly lower than the actual line. For all these three episodes, the easing of US monetary policy contributes positively to the growth rate of real economic activities summarized in factor 2. The fourth period starts in 2014, when the Fed's tapering and withdrawal of QE raises an expectation of monetary policy normalization. Here the counterfactual growth rate lies above the actual line. This shows that without tapering or a withdrawal of the Fed's QE, the growth rate of real factors would have been higher. All these four episodes show that autonomous monetary policy actions by the Fed do have a real impact on the Hong Kong economy (Romer and Romer (1989)). However, this impact usually comes with a lag. On the other hand, during normal times, the contribution of monetary policy changes to real activity is small. The result is consistent with that from the variance decomposition, which shows that the

impact of US monetary policy changes on Hong Kong real economic variables in general is relatively small.

c. Monetary Easing from ECB and BoJ

Figure 4 and Figure 5 provide the impulse responses of the 32 Hong Kong variables to individual shocks, namely the ECB and BoJ easing. The VAR system now includes the five common factors and one shock variable, being either the ECB's shadow policy rate or BoJ's shadow policy rate. Both shocks are defined as a 25 basis point cut in policy rates.

From Figure 4, Panel A, it can be seen that after the ECB easing, the Hong Kong dollar NEER appreciates and the 3-month HIBOR rate goes down. The impact on the Hang Seng index, M1 and PMI are not significant. Real GDP, retail sales, import and export all go down and the unemployment rate goes up. Property prices go down initially and the impact quickly dies out. Panel B of Figure 4 shows that the monetary base increases initially owing to capital inflows. Household leverage and the market LTV both rise because of more liquidity. The impact on other financial stability variables is not significant. Overall, an easing by the ECB causes more liquidity to flow to Hong Kong, however, the reaction of real economic variables such as GDP growth and unemployment rate are rather negative. One possible reason for these counter-intuitive results is that the main transmission channel from the Euro area to Hong Kong is through trade. When the ECB lowers the policy rate, the real economy in Euro area is rather weak and it is the inter-regional trade slow down which causes GDP growth in Hong Kong to slow down and the unemployment rate to go up. This transmission channel is very different to that of US monetary policy changes, where the financial channel is also significant.

For the impulse responses of an easing by the Bank of Japan, Figure 5 shows that the Hong Kong dollar NEER depreciates and 3-month HIBOR goes down initially. The impact on the Hang Seng index,

loans, inflation, PMI is limited. The impact on real variables such as real GDP growth, retail sales, imports and exports, unemployment rate is also very small. Property prices across all categories go up. For the financial stability variables, the monetary base goes up initially, which means there are capital inflows. Household leverage, the loan to deposit ratio and new mortgage loans also rise, while other variables do not react significantly. This shows that shocks from the BoJ affect Hong Kong mainly through interest rate arbitrage and liquidity inflows. The impulse responses of real economic variables are not significant. The reaction of the Hong Kong dollar NEER is a bit counter-intuitive, instead of appreciating after the easing by BoJ, the Hong Kong dollar depreciates. One possible reason is that Japanese yen is appreciating for most of the sample period, even with the zero interest rate policy of the BoJ.

d. A Mainland China's GDP shock

He, Liao and Wu (2014), Genberg, Liu and Jin (2006) argue that the Hong Kong economy is increasingly affected by the shocks emanated from Mainland China. This reflects an on-going progress of economic and social integration between the two economies. In this sub-section, we add the quarterly real GDP growth of Mainland China to the VAR system to see how shocks in China's economic growth affect Hong Kong's economic variables. We first study the impulse responses only including Mainland growth variable in the $\boldsymbol{R}_t$, then compare the results from the model with both US monetary policy shocks and Mainland growth variables.[17] The shock of a Mainland slowdown is defined as 0.25-percentage-point contraction of Mainland GDP growth (which is a one-percentage-point reduction in China GDP growth in annual rate).

Figure 6 shows that the main impact of a Mainland economic slowdown are on real GDP growth, retail sales, imports, exports and unemployment rate. All the above variables except the unemployment rate

[17] This means $\boldsymbol{R}_t$ in equations (1) to (3) includes both the US shadow policy rate and Mainland China GDP growth.

go down significantly, while the unemployment rate increases dramatically. The 3-month HIBOR and Hang Seng index also declines, but Hong Kong dollar NEER appreciates because of the weakening of RMB. The impact on financial stability variables is generally not significant.

To compare the above result, we include both US monetary policy variable and Mainland growth variable in the VAR system and turn on only the Mainland growth shock. Figure 7 shows that Hong Kong's real activity variables decline significantly immediately after a 0.25-percentage-point contraction shock in China's quarterly GDP growth. The magnitude of the decline is much bigger than that arising from a tightening of the US monetary policy only. Hong Kong real GDP decreases by 0.7 percentage points in the first quarter, compared to a 0.08 percentage points decline following a US monetary tightening shock, The PMI decreases by 1.15 compared to 0.02, retails sales decrease by 0.56% compared to 0.77% and external trade drops by around 1.5% compared to less than 0.5%. The unemployment rate is slightly higher at 0.1% compared to 0.02%.

Again 3-month HIBOR declines immediately, possibly due to the relaxation of pressure on liquidity following a contraction shock in Mainland China GDP. The HKD NEER increases, and the stock market declines. The property market (except for large properties) does not show a significant change. In addition, capital flows and financial stability (Panel B of Figure 7) are generally unaffected by this shock.

This shows that a shock from Mainland GDP growth mainly affects Hong Kong's real variables, not so much nominal variables.

To summarize, we find that Hong Kong's interest rate and exchange rate mainly follow their US counterparts. An increase in US monetary policy rates mainly affects Hong Kong's monetary and financial variables. Real economic variables are mainly affected by shocks from Mainland growth. Shocks from monetary policy from ECB and BoJ play marginal roles. Shocks from the ECB mainly

transmit through international trade, while shocks from the BoJ mainly transmit through international capital markets by interest rate and exchange rate arbitrage.

Hong Kong as an international financial center with open capital markets, it is constantly influenced by shocks arising from the rest of the world economy. In the next part, we analyse the aggregate impact of simultaneous shocks from monetary policies of the Fed, ECB, BoJ and a Mainland economy slowdown. We do it in a VAR system with all four shock variables. Together with the five common factors, the VAR system now has 9 variables[18]. Again, we take four lags.

e. Diverging Monetary Policies

This sub-section studies the impact of diverging monetary policies on the Hong Kong economy. Currently the Fed has raised the Fed fund target rate to 0.25% – 0.50%, the ECB and BoJ have imposed negative interest rates on bank reserves. What is the joint impact of these diverging monetary policies on Hong Kong? Will the effects of diverging monetary policies cancel out each other?

In the following impulse response analysis, we assume a 25-basis-point decrease in shadow policy rates by both ECB and BoJ, and a 25-basis-point increase in the policy rate of the Fed. Figures 8 – 10 provide the impulse responses of an individual monetary policy change in the full VAR model of 9 variables with other shock variables turned off. These are broadly similar to those in Figures 2, 4 and 5. Figure 11 provides the combined effect of these monetary policy changes with the Mainland economic slowdown shock turned off. It is interesting to see that when three monetary policy variables are added to the system, the combined effect is broadly similar to that with only the US monetary policy variable. This is not surprising given that with free capital mobility Hong Kong's monetary policy follows exactly

[18] This means $\boldsymbol{R}_t$ in equations (1) to (3) includes the shadow monetary policy rates of the Fed, ECB and BoJ, plus Mainland GDP growth.

the Fed's policy. Therefore, the effect of the Fed tightening dominates the impulse responses. While an easing policy by the Bank of Japan to some extent neutralizes a tightening policy by the Fed, an easing by ECB plays a very marginal role. This may be because traditionally Japanese banks have more exposure to the Hong Kong economy. Businesses in Hong Kong take advantage of low interest rates in Japan to arbitrage in order to save funding cost. On the other hand, ECB monetary policy affects the Hong Kong economy through a real economy channel such as international trade. Usually the reason for easing by the ECB is because of weakness in the real economy in the Euro Area. This in turn weakens external demand of Hong Kong from Euro area. That is why in the impulse responses, the effect of monetary easing by ECB is sometimes in the same direction as that of tightening by the Fed. For example, in Figure 9, the impulse response of easing by the ECB suggests that it reduces real GDP growth, the growth of both imports and exports, the growth in housing prices and raises the unemployment rate. It also raises the nominal effective exchange rate through a weakening of the euro. For other variables, the impulse responses are not statistically significant.

From Panel A of Figure 11, it can be seen that the HKD nominal effective exchange rate appreciates significantly in the first year. The total appreciation is 1.26% in the first year, which is higher than the 0.35% with only US monetary policy change. This is understandable because the easing by the ECB weakens the euro. Since the Hong Kong dollar is pegged to the US dollar, the movement of the Hong Kong dollar exchange rate against the currencies other than the US dollar mainly reflects the appreciation of the US dollar against other currencies.

From Panel B of Figure 11, it can be seen that growth in the monetary base and the current account go down, but the capital account shows an initial increase. Compared with Panel B of Figure 8, capital outflows (the change in the monetary base and capital account balance are used as proxies) are lower. This shows that the easing by the BoJ and ECB neutralizes the effect of tightening by the Fed. Capital

outflows to the US are offset by capital inflows from Japan. This result is in line with He, Wong, Tsang and Ho (2015).

The 3-month interbank rate increases during the first year following a Fed tightening. Growth in property prices, the money supply and inflation also declines. The most interesting result is the combined effect on real variables. Growth in real GDP, retail sales, imports and exports goes down, while that of unemployment goes up. This result shows that the combined effects are more or less the sum of individual effects. Given that the monetary shocks are generally exogenous to each other, this result is not surprising.

For the financial stability variables, the impact from monetary policy shocks dies out within the first year. Shocks from the BoJ increase household leverage and the market LTV ratio, and new mortgage loans. Shocks from the ECB have a very small marginal effect. Overall, the financial stability variables are mainly affected by local macroprudential policies.

With diverging monetary policies of major central banks, what is the combined impact together with a growth slowdown in Mainland China? Now we add back the contraction shock of Mainland GDP growth of 0.25 percentage point in one quarter. Figure 12 shows the impulse responses of the aggregate effects including a negative shock in Mainland growth. Comparing with Figure 11, real GDP growth in Hong Kong goes down even further, the unemployment goes up by much more. Both imports and exports decline by more. The differences in the effect on inflation and other financial variables are not significant. This further confirms our view that a Mainland GDP growth shock mainly affects Hong Kong's real economic variables. Specifically, Hong Kong quarterly GDP growth will be lower by around 0.4 percentage points on average in the first year with only diverging monetary policy shocks. But it will be lowered by 0.6 percentage points if there is an additional negative shock in Mainland GDP growth However, Mainland China's economic slowdown has only a very limited additional impact on Hong

Kong's inflation. The quarterly decrease in inflation is only 0.2 percentage points on average in the first year for scenarios with or without a Mainland China economic slowdown. For the property market, the average quarterly decrease in the Centa City Index is 1.4 percentage points without the negative growth shock from the Mainland, and is 1.8 percentage points with the negative shock. Table 4 reports the variance decomposition and R^2 of 32 selected variables at a 16-quarter horizon in the full model with all four shocks. It can be seen that the common factors (including five principal components and four shock variables) can explain the main part of the variance of the selected variables. The R^2 for most of the variables is higher than 60%. The notable exception is capital account balance, for which the R^2 is quite low. With free capital mobility in Hong Kong, the capital account balance is very volatile and sensitive to market sentiment. For most of the 32 variables, the variance decomposition shows that shocks arising from Fed policy and Mainland growth carry a higher percentage in the variance of the forecast error. Shocks from monetary policies arising from the ECB and BoJ mainly affect financial variables, despites the percentages being lower.

To summarize, the combined effect of diverging monetary policies among the major global central banks and a Mainland GDP slowdown will drive up Hong Kong's dollar nominal effective exchange rate, lower GDP growth, raise the unemployment rate, and lower the property prices. Hong Kong's financial stability is well managed by the local macroprudential policies in the context of global shocks.

5. Robustness Check

This section, we estimate four alternative models for robustness checks. The models are estimated with only the US monetary policy variable.

a. Standard VAR model

Figure 13 compares the impulse responses of the standard VAR model with five selected variables with that of the same five variables from the FAVAR model with only US monetary policy changes. It can be seen that for the monetary base and household leverage, both models show that initial responses are negative after a US monetary tightening. The responses from the FAVAR model are much bigger and more volatile. In general, for all five variables, the responses are more volatile from the FAVAR model. This volatility comes from the fact that FAVAR model includes more information. In the standard VAR model, Hong Kong inflation initially goes up after US tightening, which is similar to the price puzzle investigated in Bernanke *et al.* (2005); while in the FAVAR model, inflation initially goes down before it goes up again. Hong Kong's inflation, property prices and GDP growth are affected by factors more other than just US monetary policy. Therefore, the impulse responses from US monetary policy changes only capture part of the dynamics. For variables sensitive to interest rates, such as the monetary base and household leverage, including more information in the model makes the impulse responses more accurate in terms of capturing the actual dynamics of the economic variables.

b. Sub-sample analysis: Periods from Crisis (since 2008)

This sub-section looks at sub-sample estimation beginning with the global financial crisis in 2008. Figure 14 shows the impulse responses of 32 selected variables of the sub-sample analysis with only the US monetary policy variable and three factors from the principal component analysis. We choose three factors because of the short sample. Compared with Figure 2, it can be seen that the impact of a US monetary tightening is broadly similar to that using the full sample, although the responses are a bit smaller.

c. Gibbs Sampling approach (single-step approach)

As discussed in Section 3, the FAVAR framework can also be estimated by the Gibbs Sampling approach (single-step approach). Figure 15 shows the impulse responses of the 32 selected variables to a US monetary policy tightening using a single-step (Gibbs Sampling) approach. Compared with the results shown in Figure 2, the results from the single-step approach are very similar. Given that this approach is computationally very demanding, we only use the two-step estimation approach in the analysis presented above.

d. Structural FAVAR

Figure 16 shows the impulse responses of a structural FAVAR model using the principal components by groups. In this model, seven factors, which are extracted from seven groups of Hong Kong economic variables by principal components, are included in the VAR system. These include a financial factor, monetary and inflation factor, real activity factor, international trade factor, property market factor, capital flow factor, and financial stability factor. The impulse responses of the 32 selected variables are similar to those from the five-factor (extracted from all 116 Hong Kong variables) model in Figure 2, except for the NEER (which shows insignificant change), trade (both exports and imports increase) and the property market (prices show initial increase). The structural FAVAR may help to identify factors and provide some economic meaning, however, the factors only take into account the information of the variables within the individual groups. This may partly reduce the benefit of using a FAVAR, which aims to include as much information as possible in estimation.

6. Conclusions

Hong Kong as an international financial center is subject to constant external influences. It's open capital markets and linked exchange rate system means that monetary policy changes of the Fed, ECB and BoJ will have a significant impact on the Hong Kong economy. The anticipated divergence in the monetary policy stance of the major central banks around the World – with the Fed poised to further tighten and the ECB and BoJ continue their QEs and negative interest rate policies – and a Mainland economy slowdown will affect the Hong Kong economy. But their combined effect is hard to gauge.

This paper aims to provide a comprehensive analysis of the impact of these different shocks on the Hong Kong economy using a FAVAR model. We first estimate the impacts of a single shock. Then we estimate the aggregate impact of combining the above shocks. Our main empirical findings are as follows.

We find that a US monetary policy tightening raises the Hong Kong dollar exchange rate and HIBOR, leading to capital outflows. It generally lowers inflation and growth in property prices. Its impact on real economic variables is, however, not significant. A monetary easing by the ECB drives up the exchange rate, lowers the HIBOR, and increases inflation, capital inflows and leverage. However, its impact on real variables is negative: GDP growth goes down, unemployment goes up, and property price growth goes down. This could be because the transmission channel is mainly through international trade. An easing by the BoJ lowers the exchange rate because of a strong yen. It lowers the HIBOR, raises money supply and growth in property prices. It also raises GDP growth and lowers the unemployment rate, and increases capital inflows and leverage. A Mainland slowdown raises the exchange rate, money supply, lowers Hang Seng Index, GDP growth and growth in imports and exports. Its impact on

property prices, however, is not significant. For all these shocks, the impact on financial stability variables is moderate suggesting that Hong Kong's financial stability is well maintained by macroprudential policies.

Since these shocks are exogenous, the combined effect of diverging monetary policies is more or less the sum of individual effect. So the Hong Kong dollar nominal exchange rate appreciates more significantly. However, the effects on some financial variables to some extent offset each other, for instance, the capital outflows are lower. The growth in real GDP slows down and the unemployment rate goes up. With shocks from Mainland slowdown, the growth in real GDP goes down further and unemployment rises by more. Again financial stability is well maintained.

These results suggest that a normalization of US monetary policy combined with continued quantitative easing policies by the ECB and BoJ could have an overall negative impact on the Hong Kong economy. This may be significantly amplified by a simultaneous slowdown in growth in Mainland China. However, our results suggest that Hong Kong's financial stability – as reflected in loan quality, banks' capital and liquidity – may be resilient to the combined effect of all of the above external shocks, although these will have some temporary effects on the economy.

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Table 1 Data Description

This appendix summarises the 4 external shock variables and 116 Hong Kong macroeconomic and financial variables included in the estimation. The sample period is from 1998 Q4 to 2015 Q2. The data series are seasonally adjusted if necessary. The transformation codes are 1 – no transformation; 2 – first difference; 4 – logarithm; 5 – first difference of logarithm. An asterisk * next to the mnemonic denotes a variable assumed to be slow-moving (see footnote 4).

Variable	Source	Transformation
External shocks		
US shadow policy rate	Wu and Xia (2014)	2
Euro Area shadow policy rate	Wu and Xia (2014)	2
Japan shadow policy rate	Krippner (2013)	2
Mainland China GDP	CEIC and author's estimation	5
Exchange rate		
HKD REER	HKMA	5
HKD/Euro	HKMA	5
HKD/USD	HKMA	5
HKD/RMB	HKMA	5
HKD/JPY	HKMA	5
HKD NEER	HKMA	5
Interest rate		
3-month HIBOR	HKMA	2
6-month HIBOR	HKMA	2
12-month HIBOR	HKMA	2
Yield of 3-month Exchange Fund bills and notes	HKMA	2
Yield of 6-month Exchange Fund bills and notes	HKMA	2
Yield of 12-month Exchange Fund bills and notes	HKMA	2
Yield of 5-year Exchange Fund bills and notes	HKMA	2
Yield of 10-year Exchange Fund bills and notes	HKMA	2
Stock		
Hang Seng Index	CEIC	5
Hang Seng Finance Index	CEIC	5
Hang Seng China Enterprises (H Share) Index	CEIC	5
Total market capitalization	CEIC	5
P/E ratio for Hang Seng Index	CEIC	1
P/E ratio for Hang Seng Finance Index	CEIC	1
P/E ratio for all Hong Kong stocks	CEIC	1
Dividend yield ratio for Hang Seng Index	CEIC	1
Dividend yield ratio for Hang Seng Finance Index	CEIC	1
Dividend yield ratio for all Hong Kong stocks	CEIC	1
Stock market turnover	CEIC	5
Loans		
Total loans	HKMA	5
Hong Kong Dollar loans	HKMA	5
Foreign currency loans	HKMA	5
Money		
M1	HKMA	5
M2	HKMA	5
M3	HKMA	5
Currency in circulation	HKMA	5
Price		
CPI: meals away from home*	C&SD	5
CPI: food, excluding meals away from home*	C&SD	5
CPI: alcoholic drinks and tobacco*	C&SD	5
CPI: clothing and footwear*	C&SD	5
CPI: durable goods*	C&SD	5
CPI: miscellaneous goods*	C&SD	5
CPI: Transport*	C&SD	5
CPI*	C&SD	5
CPI: Housing*	C&SD	5
CPI: electricity, gas and water*	C&SD	5
CPI: miscellaneous services*	C&SD	5
GDP deflator*	C&SD	5

Output		
PMI*	Bloomberg	2
Real GDP*	C&SD	5
Real GDP: private consumption*	C&SD	5
Real GDP: gross fixed capital formation*	C&SD	5
Real GDP: government consumption*	C&SD	5
Inventory-to-GDP ratio*	C&SD and author's calculation	1
Real GDP: exports of goods*	C&SD	5
Real GDP: exports of services*	C&SD	5
Real GDP: imports of goods*	C&SD	5
Real GDP: imports of services*	C&SD	5
Retail sales		
Retail sales value*	C&SD	5
Retail sales volume*	C&SD	5
Labour		
Labour force participation rate*	C&SD	1
Unemployment rate*	C&SD	2
Median weekly working hours*	C&SD	1
Youth unemployment rate (age: 15-19)*	C&SD	2
Median duration of unemployment*	C&SD	1
Nominal wage index*	C&SD	5
Real wage index*	C&SD	5
Property market		
Property sales and purchases value	R&VD	5
Property sales and purchases volume	R&VD	5
Property price index: residential	R&VD	5
Property price index for large residential properties	R&VD	5
Property price index for small residential properties	R&VD	5
Centa City Leading Index	Centa	5
Centa City Index	Centa	5
Centa City Leading Index for mass estate	Centa	5
Centa City Leading Index for large properties	Centa	5
Centa City Leading Index for small properties	Centa	5
Centa City Index for mass estate	Centa	5
Centa City Index for large properties	Centa	5
Centa City Index for small properties	Centa	5
Property rental index: residential	R&VD	5
Property rental index for large residential properties	R&VD	5
Property rental index for small residential properties	R&VD	5
Property price index: office	R&VD	5
Property price index: grade A office	R&VD	5
Property price index: grade A office in core districts	R&VD	5
Property rental index: office	R&VD	5
Property rental index: grade A office	R&VD	5
Property price index: retail premise	R&VD	5
Property rental index: retail premise	R&VD	5
Property price index: flatted factories	R&VD	5
Property rental index: flatted factories	R&VD	5
Trade		
Trade balance (% of total export)	C&SD	1
Terms of trade index	C&SD	5
Import values	C&SD	5
Export values	C&SD	5
Quantum index for import	C&SD	5
Quantum index for export	C&SD	5
Unit value index for import*	C&SD	5
Unit value index for export*	C&SD	5
Capital flow indicators		
Monetary base (capital flow)	HKMA	5
Current account balance (% of GDP)*	C&SD and author's calculation	2
Capital account balance (% of GDP)*	C&SD and author's calculation	2
Financial Stability indicators		
HSI Volatility Index (VHSI)	Bloomberg	5
New mortgage loans	HKMA	5
Average market LTV ratio for new mortgage loans	HKMA	2
Average contract life for new mortgage loans (no. of months)	HKMA	2
Problem loan ratio for mortgage loans	HKMA and author's calculation	2
Classified loan ratio (gross)*	HKMA	1
Overdue (>3 months) and rescheduled loan ratio*	HKMA	1
Net interest margin*	HKMA	1
Bad debt charge as percentage of average total assets*	HKMA	1
Cost-to-income ratio*	HKMA	1
Capital adequacy ratio (CAR)*	HKMA	1
Credit card loans*	HKMA	4
Credit card delinquency ratio*	HKMA	1
Household leverage*	HKMA, C&SD and author's culculation	2
Loan-to-GDP ratio*	HKMA, C&SD and author's culculation	2
Loan-to-deposit (LTD) ratio	HKMA and author's calculation	2
HKD Loan-to-deposit (LTD) ratio	HKMA and author's calculation	2

Table 2 Correlation of individual variables to the extracted factors

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Exchange rate					
HKD REER	-8%	-56%	14%	-40%	-9%
HKD/Euro	22%	30%	-28%	26%	5%
HKD/USD	18%	16%	24%	2%	41%
HKD/RMB	43%	-7%	2%	40%	6%
HKD/JPY	-14%	22%	-25%	50%	-6%
HKD NEER	-34%	-41%	30%	-43%	-1%
Interest rate					
3-month HIBOR	37%	-24%	73%	-39%	-5%
6-month HIBOR	36%	-26%	72%	-41%	-3%
12-month HIBOR	38%	-28%	69%	-44%	-1%
Yield of 3-month Exchange Fund bills and notes	33%	-25%	65%	-48%	13%
Yield of 6-month Exchange Fund bills and notes	34%	-26%	66%	-51%	11%
Yield of 12-month Exchange Fund bills and notes	36%	-25%	64%	-54%	9%
Yield of 5-year Exchange Fund bills and notes	34%	-12%	47%	-60%	0%
Yield of 10-year Exchange Fund bills and notes	31%	-5%	41%	-58%	0%
Stock					
Hang Seng Index	11%	47%	-28%	-34%	-53%
Hang Seng Finance Index	5%	48%	-30%	-29%	-44%
Hang Seng China Enterprises (H Share) Index	-1%	29%	-17%	-39%	-46%
Total market capitalization	26%	59%	-24%	-23%	-43%
P/E ratio for Hang Seng Index	19%	76%	24%	14%	5%
P/E ratio for Hang Seng Finance Index	9%	78%	27%	19%	7%
P/E ratio for all Hong Kong stocks	32%	69%	27%	22%	-3%
Dividend yield ratio for Hang Seng Index	-24%	-49%	-30%	-43%	1%
Dividend yield ratio for Hang Seng Finance Index	-41%	-47%	-14%	-42%	9%
Dividend yield ratio for all Hong Kong stocks	-52%	-37%	-29%	-35%	8%
Stock market turnover	16%	34%	-16%	-21%	-41%
Loans					
Total loans	73%	-41%	-3%	18%	-15%
Hong Kong Dollar loans	49%	-35%	8%	8%	-12%
Foreign currency loans	78%	-28%	-10%	24%	-13%
Money					
M1	-3%	16%	-48%	-19%	-7%
M2	25%	-8%	-11%	-8%	-70%
M3	26%	-10%	-11%	-8%	-70%
Currency in circulation	6%	0%	-3%	-6%	-9%
Price					
CPI: meals away from home	58%	-61%	-20%	20%	-4%
CPI: food, excluding meals away from home	60%	-38%	-12%	37%	9%
CPI: alcoholic drinks and tobacco	4%	-11%	-39%	-25%	0%
CPI: clothing and footwear	34%	-21%	0%	-11%	-21%
CPI: durable goods	33%	3%	-29%	24%	-25%
CPI: miscellaneous goods	36%	-1%	-29%	39%	-4%
CPI: Transport	53%	-18%	12%	32%	6%
CPI	66%	-62%	-6%	20%	-3%
CPI: Housing	44%	-67%	-1%	5%	-5%
CPI: electricity, gas and water	27%	8%	0%	13%	12%
CPI: miscellaneous services	51%	-20%	10%	31%	0%
GDP deflator	42%	-40%	-19%	5%	-35%
Output					
PMI	10%	47%	-7%	-37%	-27%
Real GDP	49%	57%	29%	-10%	-29%
Real GDP: private consumption	55%	28%	-3%	-26%	-31%
Real GDP: gross fixed capital formation	-7%	1%	2%	22%	-8%
Real GDP: government consumption	-8%	5%	-11%	17%	-33%
Inventory-to-GDP ratio	35%	3%	34%	8%	10%
Real GDP: exports of goods	32%	55%	31%	5%	-21%
Real GDP: exports of services	23%	42%	21%	1%	-19%
Real GDP: imports of goods	39%	57%	34%	3%	-21%
Real GDP: imports of services	34%	25%	10%	0%	-23%

Retail sales					
Retail sales value	68%	12%	2%	11%	-11%
Retail sales volume	53%	21%	4%	2%	-11%
Labour					
Labour force participation rate	-53%	36%	7%	-13%	8%
Unemployment rate	-64%	-21%	-37%	-16%	13%
Median weekly working hours	7%	39%	43%	22%	12%
Youth unemployment rate (age: 15-19)	-36%	-4%	-16%	-20%	-12%
Median duration of unemployment	15%	65%	17%	-15%	22%
Nominal wage index	61%	-34%	-12%	17%	-9%
Real wage index	-8%	4%	-3%	10%	10%
Property market					
Property sales and purchases value	29%	22%	-11%	-39%	6%
Property sales and purchases volume	33%	30%	-39%	-28%	9%
Property price index: residential	86%	14%	-34%	-21%	18%
Property price index for large residential properties	80%	35%	-25%	-20%	20%
Property price index for small residential properties	86%	12%	-35%	-21%	18%
Centa City Leading Index	75%	31%	-44%	-15%	21%
Centa City Index	79%	28%	-33%	-22%	26%
Centa City Leading Index for mass estate	72%	28%	-50%	-17%	22%
Centa City Leading Index for large properties	77%	39%	-30%	-2%	23%
Centa City Leading Index for small properties	74%	28%	-47%	-17%	21%
Centa City Index for mass estate	79%	24%	-34%	-25%	27%
Centa City Index for large properties	79%	42%	-25%	-11%	20%
Centa City Index for small properties	79%	25%	-35%	-24%	26%
Property rental index: residential	87%	8%	10%	9%	6%
Property rental index for large residential properties	78%	11%	30%	21%	8%
Property rental index for small residential properties	88%	8%	7%	7%	6%
Property price index: office	86%	26%	-13%	-5%	10%
Property price index: grade A office	79%	34%	-9%	-6%	12%
Property price index: grade A office in core districts	76%	34%	-9%	-10%	24%
Property rental index: office	69%	-32%	38%	29%	-5%
Property rental index: grade A office	64%	-32%	40%	31%	-1%
Property price index: retail premise	84%	19%	-16%	-21%	9%
Property rental index: retail premise	76%	-10%	14%	11%	-24%
Property price index: flatted factories	89%	-6%	11%	-5%	-2%
Property rental index: flatted factories	81%	-24%	7%	14%	-12%
Trade					
Trade balance (% of total export)	-45%	57%	27%	13%	0%
Terms of trade index	-32%	-30%	-21%	-5%	-22%
Import values	54%	53%	34%	11%	-19%
Export values	45%	49%	34%	14%	-24%
Quantum index for import	41%	60%	33%	6%	-22%
Quantum index for export	30%	56%	33%	10%	-24%
Unit value index for import	69%	-10%	17%	35%	-6%
Unit value index for export	58%	-28%	7%	35%	-17%
Capital flow indicators					
Monetary base (capital flow)	-15%	-8%	-28%	-6%	-25%
Current account balance (% of GDP)	-14%	-2%	20%	31%	-26%
Capital account balance (% of GDP)	-2%	-3%	4%	12%	-3%
Financial Stability indicators					
HSI Volatility Index (VHSI)	-10%	-16%	8%	39%	-7%
New mortgage loans	31%	39%	-39%	-29%	3%
Average market LTV ratio for new mortgage loans	-18%	10%	-14%	-13%	5%
Average contract life for new mortgage loans (no. of months)	30%	-7%	-22%	1%	7%
Problem loan ratio for mortgage loans	-58%	10%	-33%	10%	-8%
Classified loan ratio (gross)	60%	-69%	-20%	-4%	-18%
Overdue (>3 months) and rescheduled loan ratio	-59%	64%	20%	8%	16%
Net interest margin	-58%	59%	21%	20%	17%
Bad debt charge as percentage of average total assets	-63%	54%	-14%	16%	-4%
Cost-to-income ratio	39%	-48%	-24%	-14%	-5%
Capital adequacy ratio (CAR)	-42%	40%	1%	-9%	12%
Credit card loans	42%	-74%	-25%	-11%	-18%
Credit card delinquency ratio	-62%	62%	9%	-4%	21%
Household leverage	6%	12%	-52%	-4%	7%
Loan-to-GDP ratio	55%	-38%	-15%	7%	-4%
Loan-to-deposit (LTD) ratio	59%	-43%	1%	9%	27%
HKD Loan-to-deposit (LTD) ratio	44%	-22%	19%	19%	63%

Table 3 Contribution of the US monetary policy shock to the variance of forecasting errors of selected variables

Variables	Variance decomposition	R^2
HKD NEER	0.044	0.492
3-month HIBOR	0.319	0.487
Hang Seng Index	0.086	0.684
Loans	0.084	0.620
M1	0.149	0.268
M3	0.304	0.615
CPI	0.090	0.687
PMI	0.059	0.435
Real GDP	0.148	0.730
Retail sales	0.065	0.488
Import values	0.127	0.738
Export values	0.160	0.634
Unemployment rate	0.159	0.610
Property sales and purchases volume	0.031	0.430
Property price index: residential	0.036	0.985
Property price index for large residential properties	0.032	0.960
Property price index for small residential properties	0.038	0.977
Centa City Index	0.041	0.977
Centa City Index for large properties	0.029	0.972
Centa City Index for small properties	0.043	0.970
Monetary base (capital flow)	0.420	0.238
Current account balance (% of GDP)	0.148	0.221
Capital account balance (% of GDP)	0.091	0.018
Household leverage	0.352	0.272
Loan-to-GDP ratio	0.100	0.396
New mortgage loans	0.034	0.480
Average market LTV ratio for new mortgage loans	0.110	0.068
Classified loan ratio	0.062	0.744
Credit card delinquency ratio	0.165	0.693
Net interest margin	0.177	0.700
Capital adequacy ratio (CAR)	0.231	0.286
HKD Loan-to-deposit (LTD) ratio	0.173	0.653

Note: The column titled “Variance decomposition” reports the fraction of the variance of the forecast error, at the 16-quarter horizon, explained by the US monetary policy shock variable. “R^2” refers to the fraction of the variance of the variable explained by the common factors, which includes five principal components and the US monetary policy shock variable.

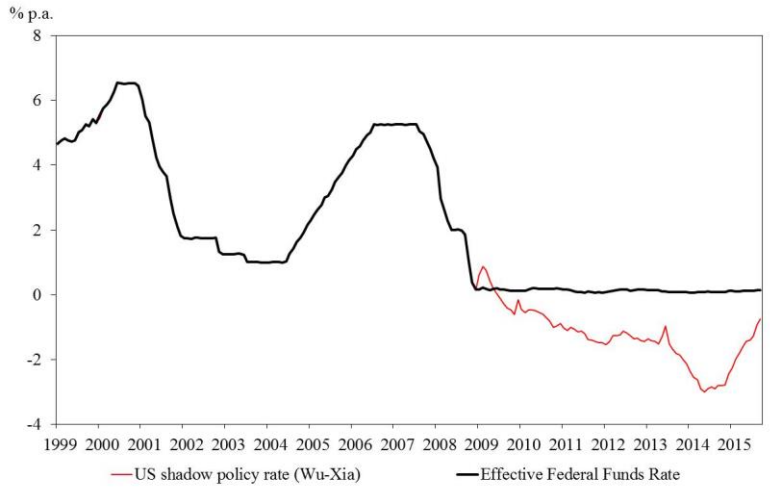
Table 4 Contributions of various shock variables to the variance of forecasting errors of selected variables

Variables	Variance decomposition				R^2
	US shadow rate	Euro Area shadow rate	Japan shadow rate	Mainland China GDP	
HKD NEER	0.032	0.037	0.030	0.402	0.507
3-month HIBOR	0.291	0.087	0.038	0.168	0.472
Hang Seng Index	0.092	0.100	0.174	0.071	0.693
Loans	0.116	0.132	0.045	0.218	0.626
M1	0.096	0.255	0.073	0.089	0.304
M3	0.255	0.119	0.123	0.102	0.615
CPI	0.099	0.098	0.107	0.105	0.718
PMI	0.092	0.224	0.118	0.114	0.488
Real GDP	0.219	0.096	0.054	0.125	0.730
Retail sales	0.089	0.237	0.049	0.213	0.512
Import values	0.179	0.134	0.075	0.134	0.740
Export values	0.190	0.163	0.081	0.087	0.660
Unemployment rate	0.215	0.112	0.069	0.162	0.614
Property sales and purchases volume	0.080	0.185	0.132	0.095	0.451
Property price index: residential	0.035	0.064	0.071	0.134	0.986
Property price index for large residential properties	0.046	0.072	0.071	0.166	0.970
Property price index for small residential properties	0.036	0.064	0.071	0.132	0.979
Centa City Index	0.039	0.075	0.065	0.138	0.979
Centa City Index for large properties	0.026	0.059	0.068	0.171	0.975
Centa City Index for small properties	0.042	0.076	0.066	0.133	0.973
Monetary base (capital flow)	0.331	0.111	0.121	0.092	0.289
Current account balance (% of GDP)	0.186	0.272	0.047	0.032	0.253
Capital account balance (% of GDP)	0.179	0.320	0.173	0.085	0.048
Household leverage	0.329	0.046	0.148	0.159	0.371
Loan-to-GDP ratio	0.098	0.156	0.080	0.187	0.423
New mortgage loans	0.069	0.250	0.143	0.088	0.523
Average market LTV ratio for new mortgage loans	0.102	0.224	0.273	0.072	0.117
Classified loan ratio	0.075	0.019	0.061	0.251	0.735
Credit card delinquency ratio	0.168	0.102	0.038	0.112	0.698
Net interest margin	0.120	0.019	0.080	0.062	0.718
Capital adequacy ratio (CAR)	0.118	0.040	0.234	0.422	0.373
HKD Loan-to-deposit (LTD) ratio	0.175	0.054	0.134	0.092	0.698

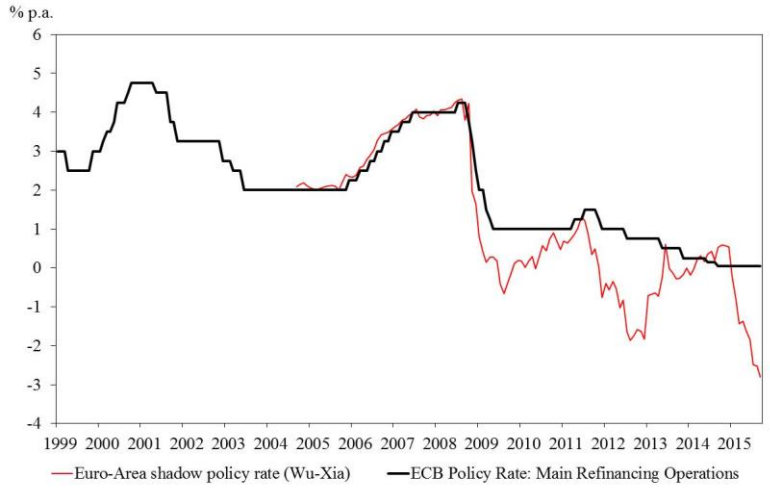
Note: The column titled "Variance decomposition" reports the fraction of the variance of the forecast error, at the 16-quarter horizon, explained by the individual shock variable (monetary policy shocks by the Fed, ECB and BoJ, and Mainland China GDP). "R^2" refers to the fraction of the variance of the variable explained by the common factors, which includes five principal components plus four shock variables.

Figure 1 Policy Rates and Shadow Policy Rates

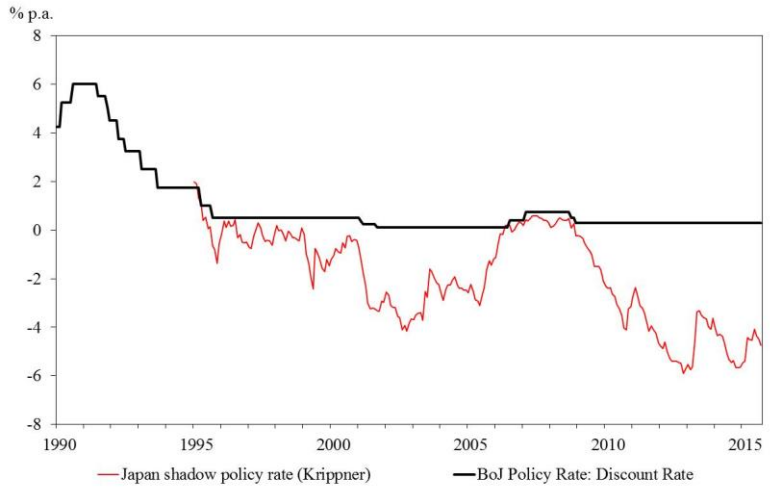
A. The US (Fed)



B. Euro Area (ECB)



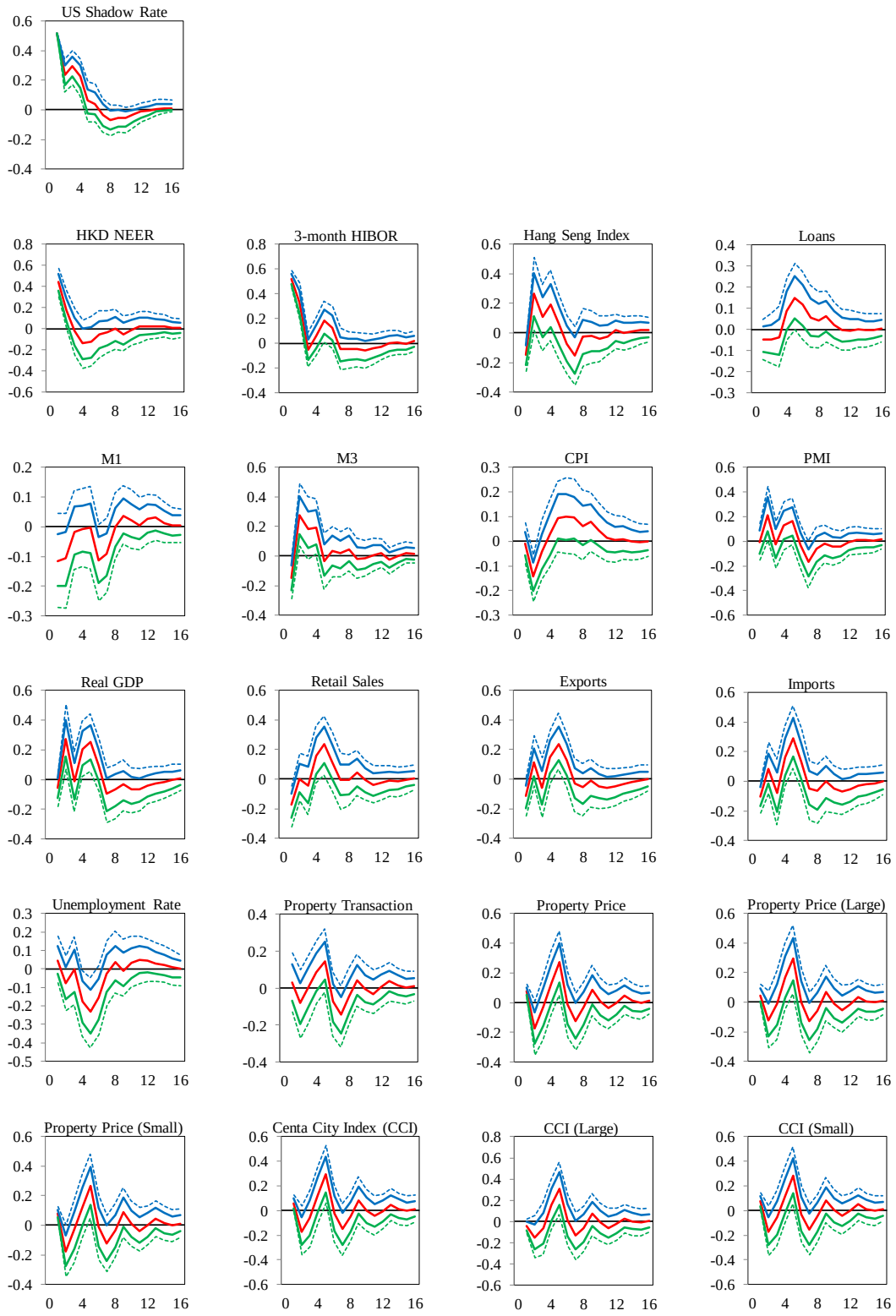
C. Japan (BoJ)



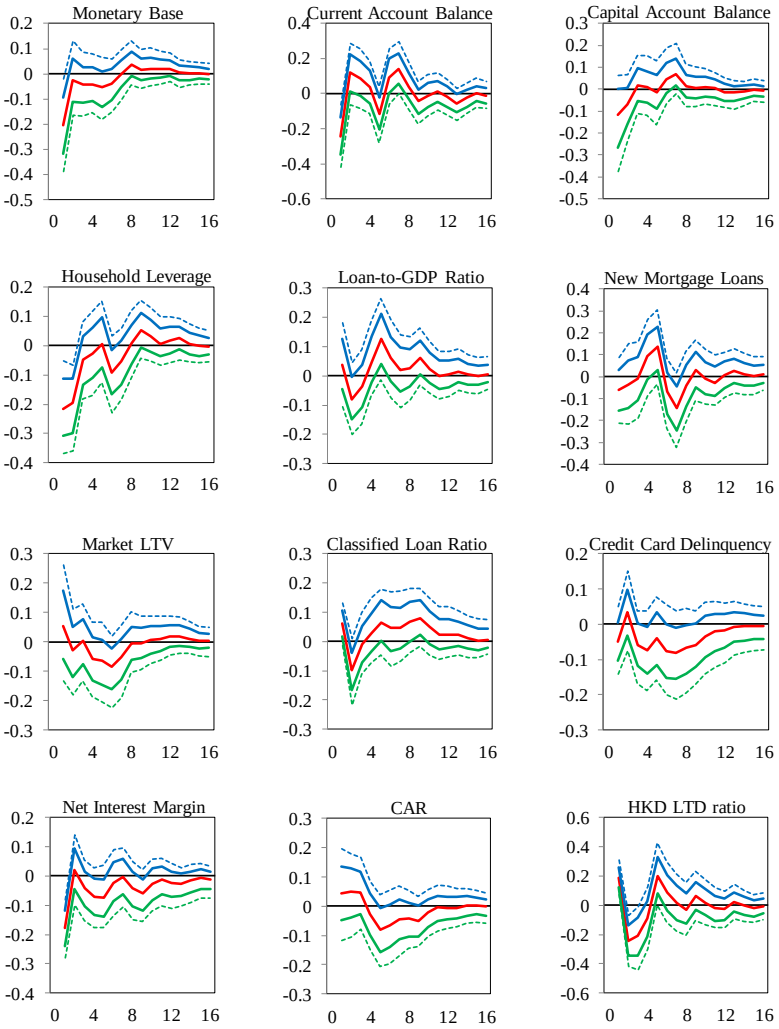
Sources: CEIC, Wu and Xia (2014) and Krippner (2014).

Figure 2 Impulse responses for selected Hong Kong variables to the monetary policy shock of the Fed

A: Macroeconomic and financial variables



B: Capital flow and financial stability variables



Note: The red line indicates the estimated median response. The solid blue and green lines represent the 68 percent bootstrap confidence interval, and the dashed blue and green lines represent the 90 percent bootstrap confidence interval based on 1,000 bootstrap samples. All the charts are in standard deviation units.

Figure 3 Contribution of US monetary Policy to Hong Kong Economic Activity

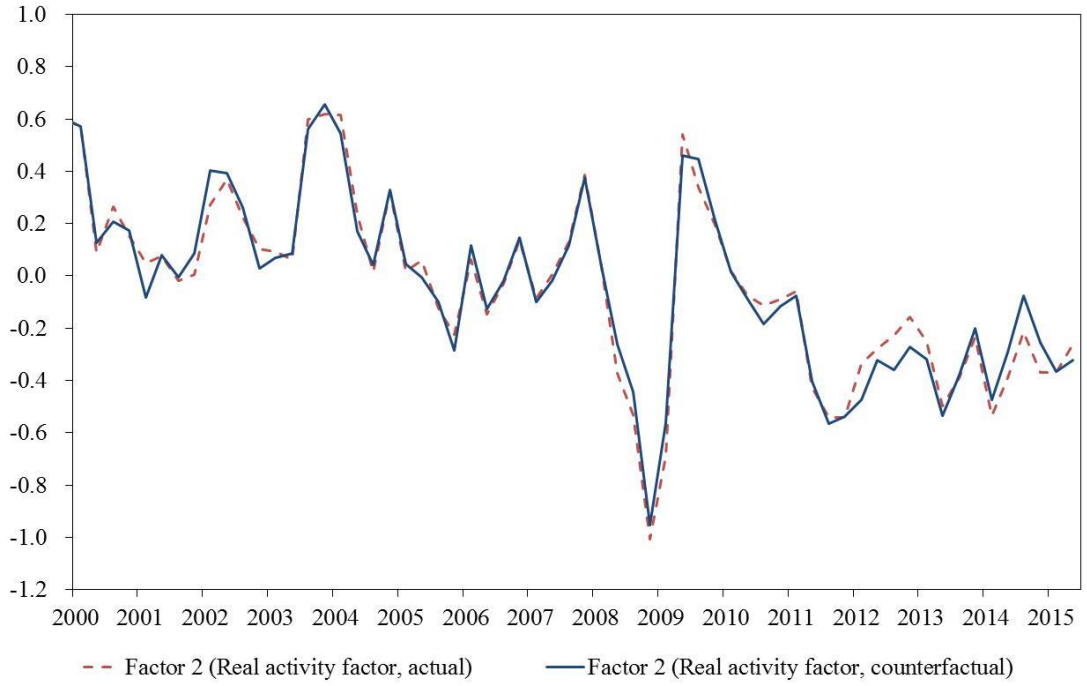
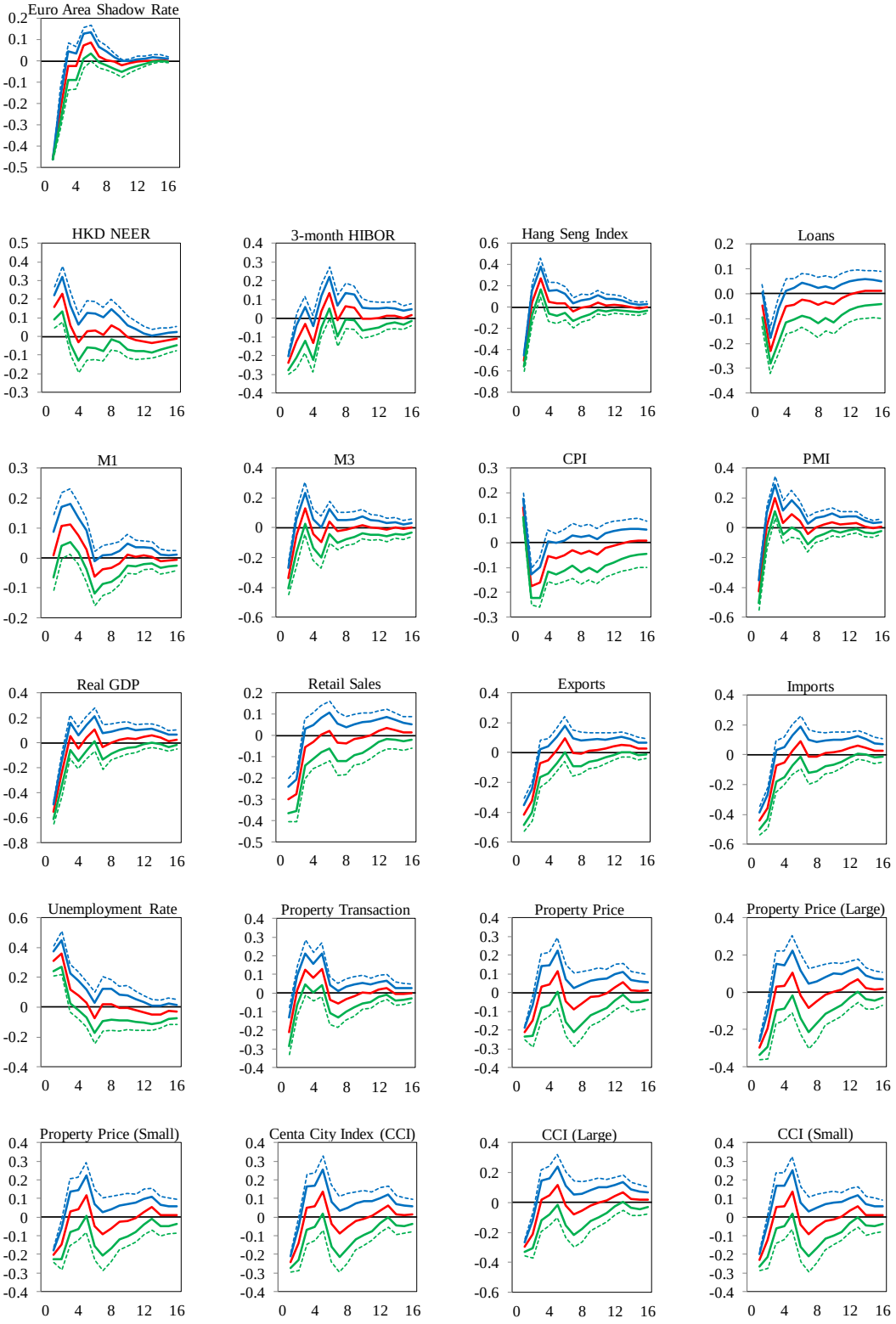
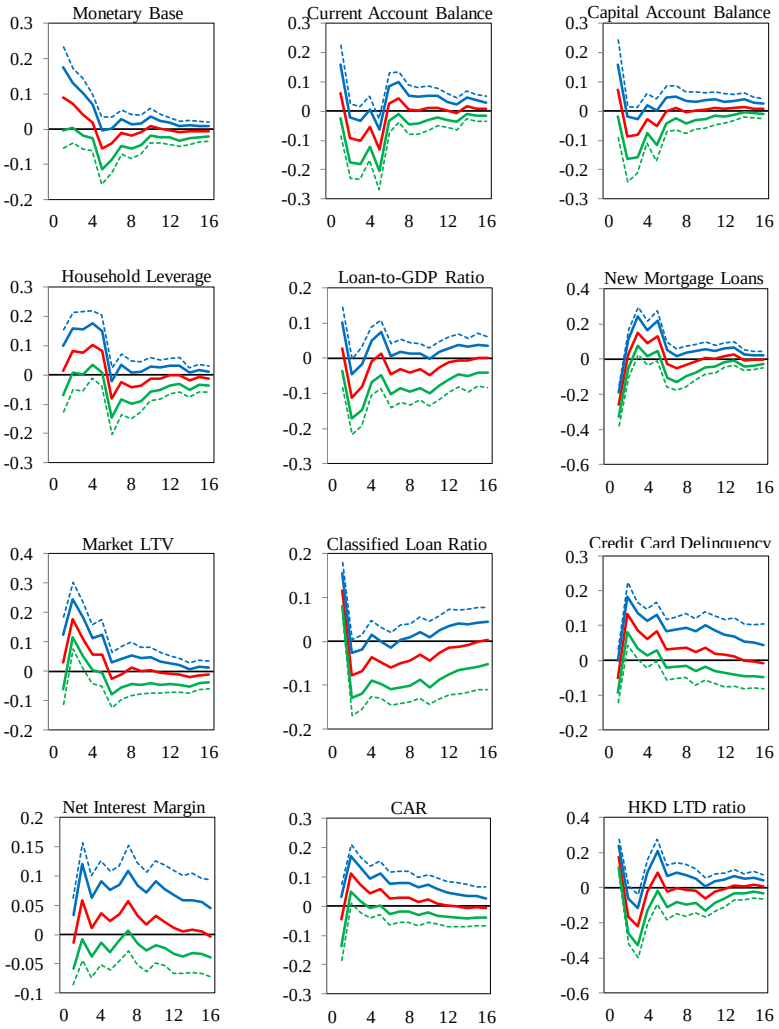


Figure 4 Impulse responses for selected Hong Kong variables to the monetary policy shock of ECB

A: Macroeconomic and financial variables



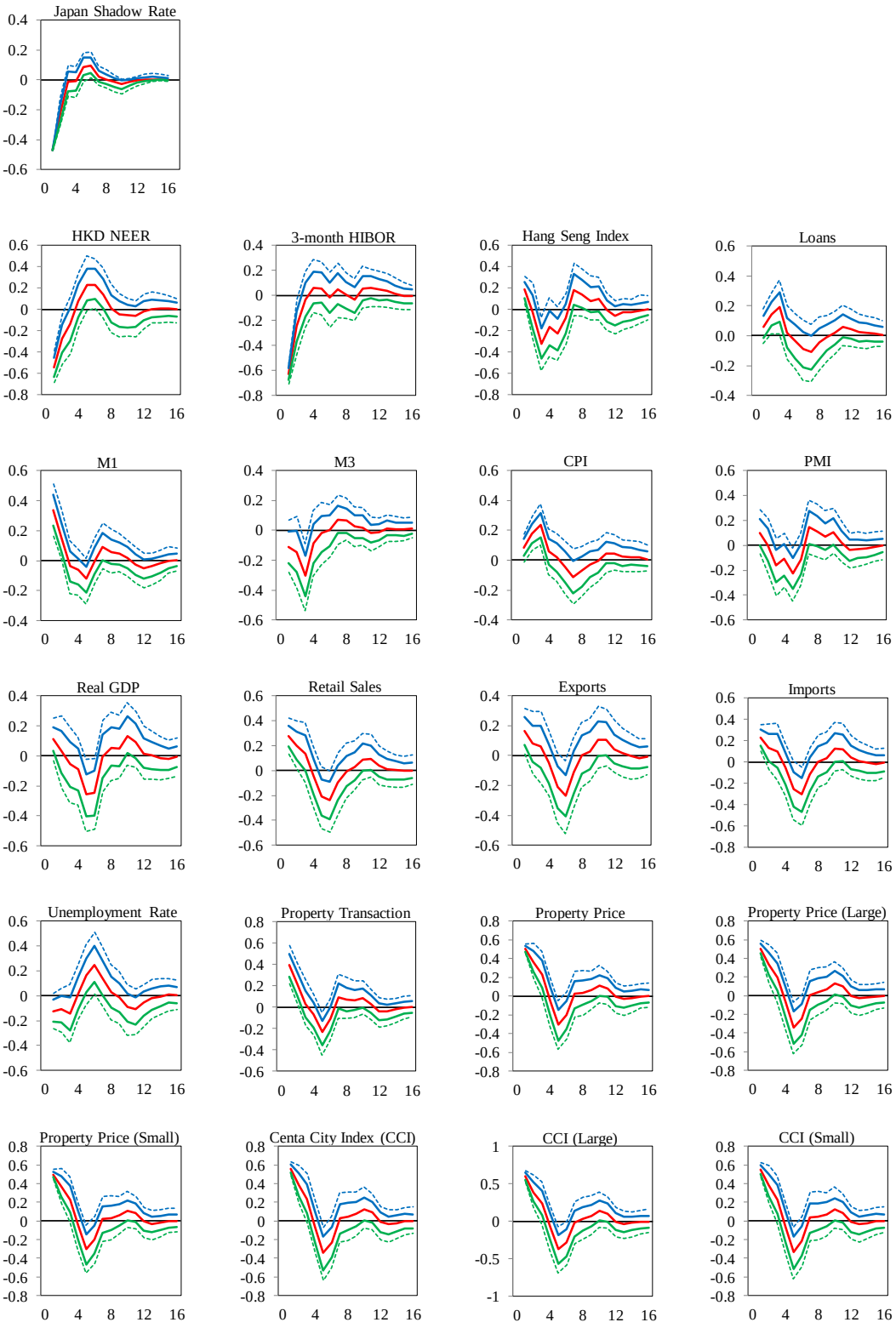
B: Capital flow and financial stability variables



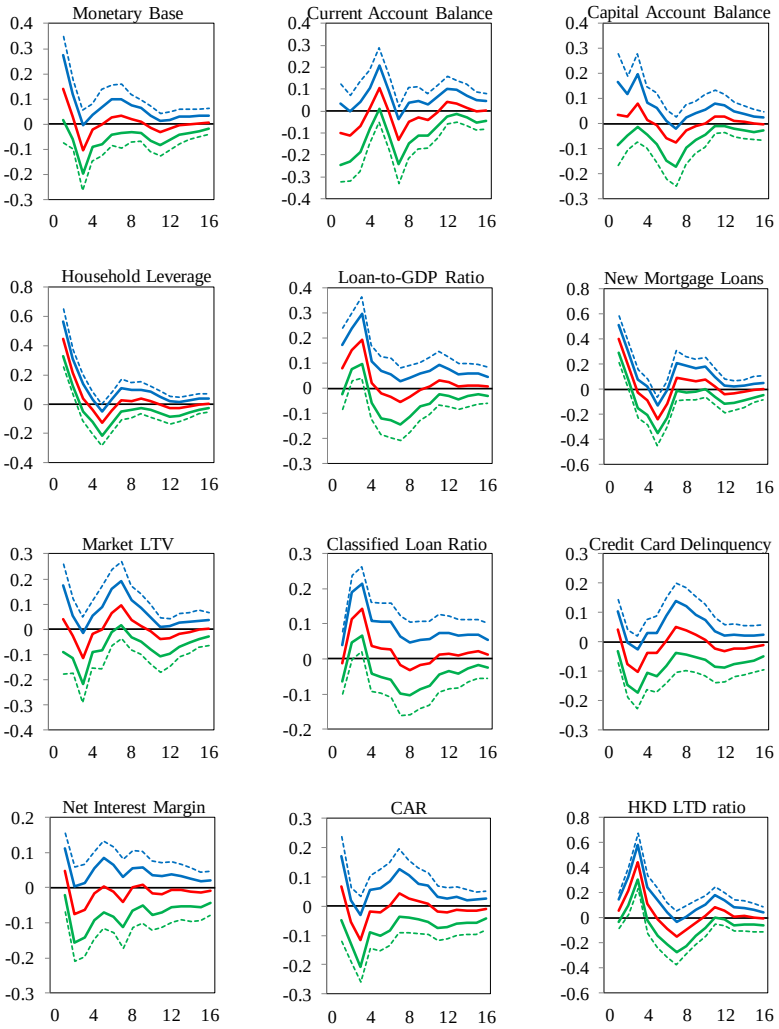
Note: The red line indicates the estimated median response. The solid blue and green lines represent the 68 percent bootstrap confidence interval, and the dashed blue and green lines represent the 90 percent bootstrap confidence interval based on 1,000 bootstrap samples. All the charts are in standard deviation units.

Figure 5 Impulse responses for selected Hong Kong variables to the monetary policy shock of BoJ

A: Macroeconomic and financial variables



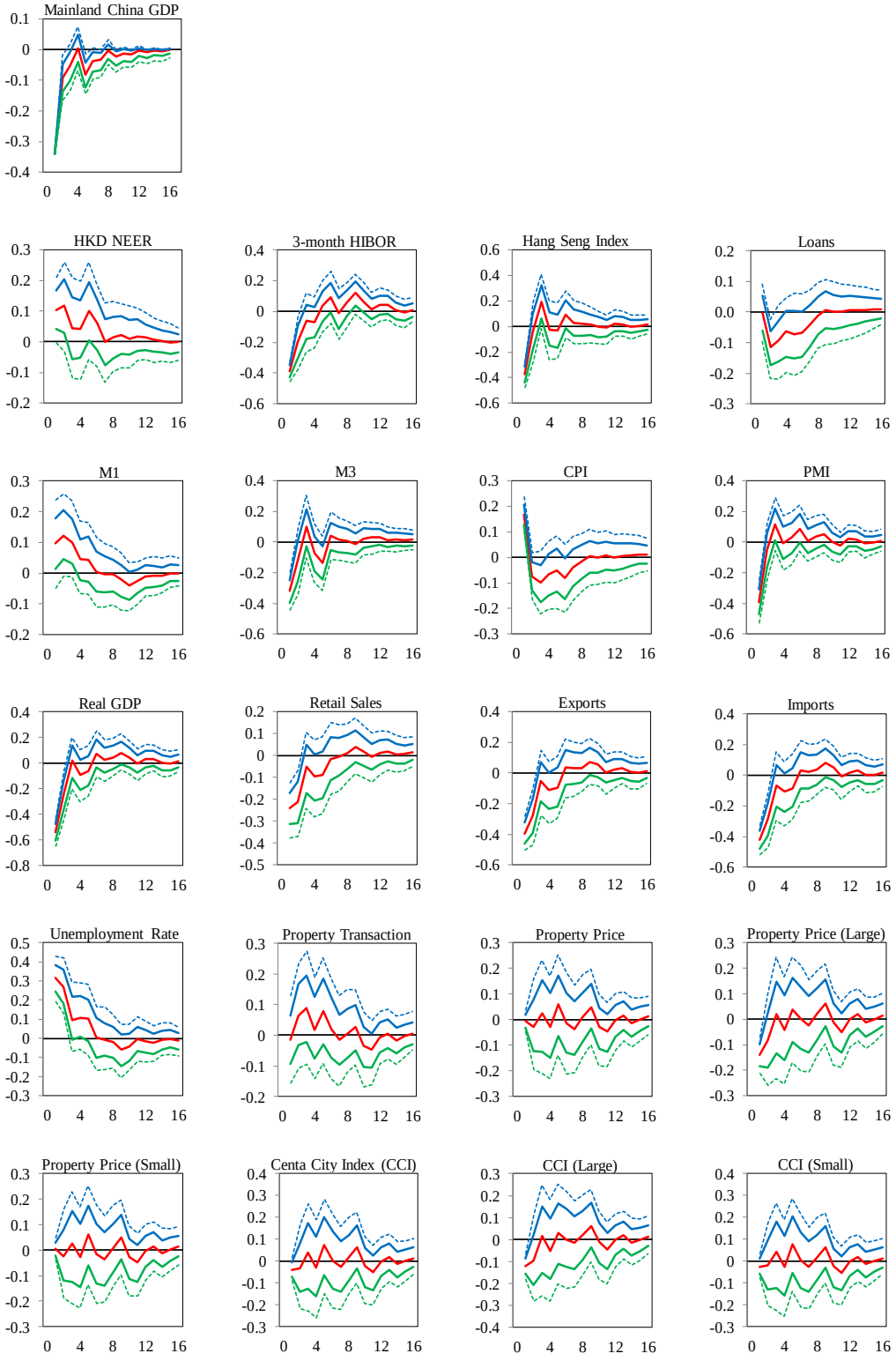
B: Capital flow and financial stability variables



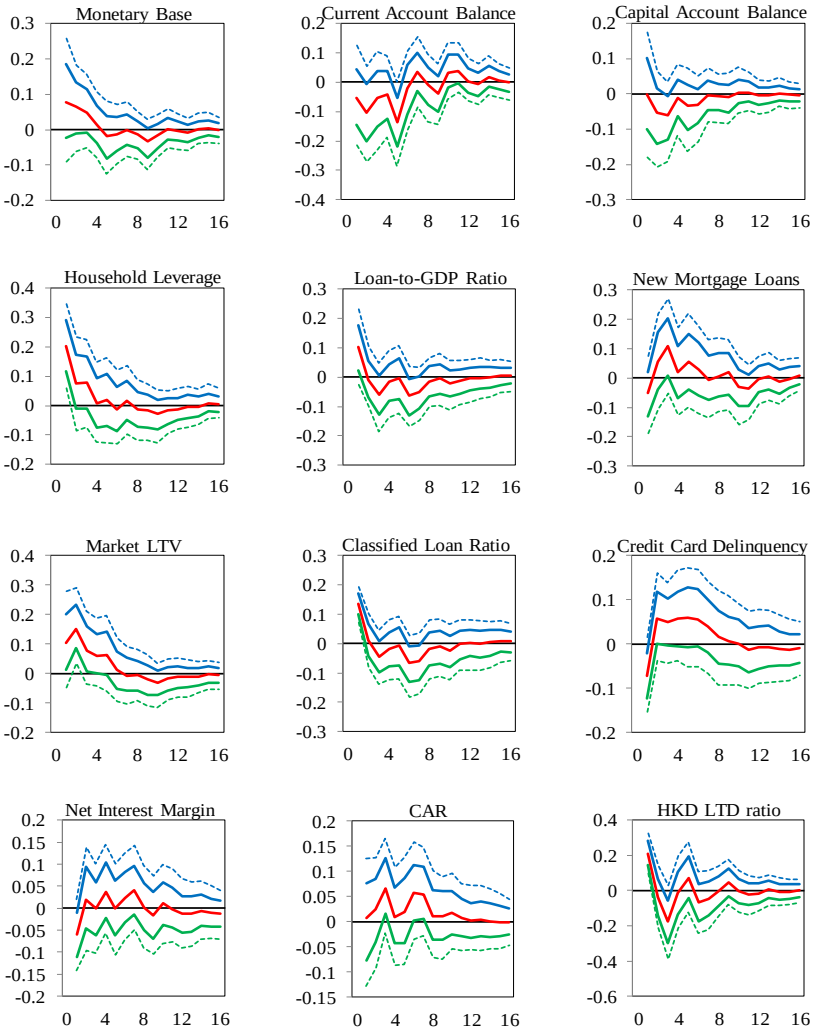
Note: The red line indicates the estimated median response. The solid blue and green lines represent the 68 percent bootstrap confidence interval, and the dashed blue and green lines represent the 90 percent bootstrap confidence interval based on 1,000 bootstrap samples. All the charts are in standard deviation units.

Figure 6 Impulse responses for selected Hong Kong variables to Mainland China GDP shock

A: Macroeconomic and financial variables



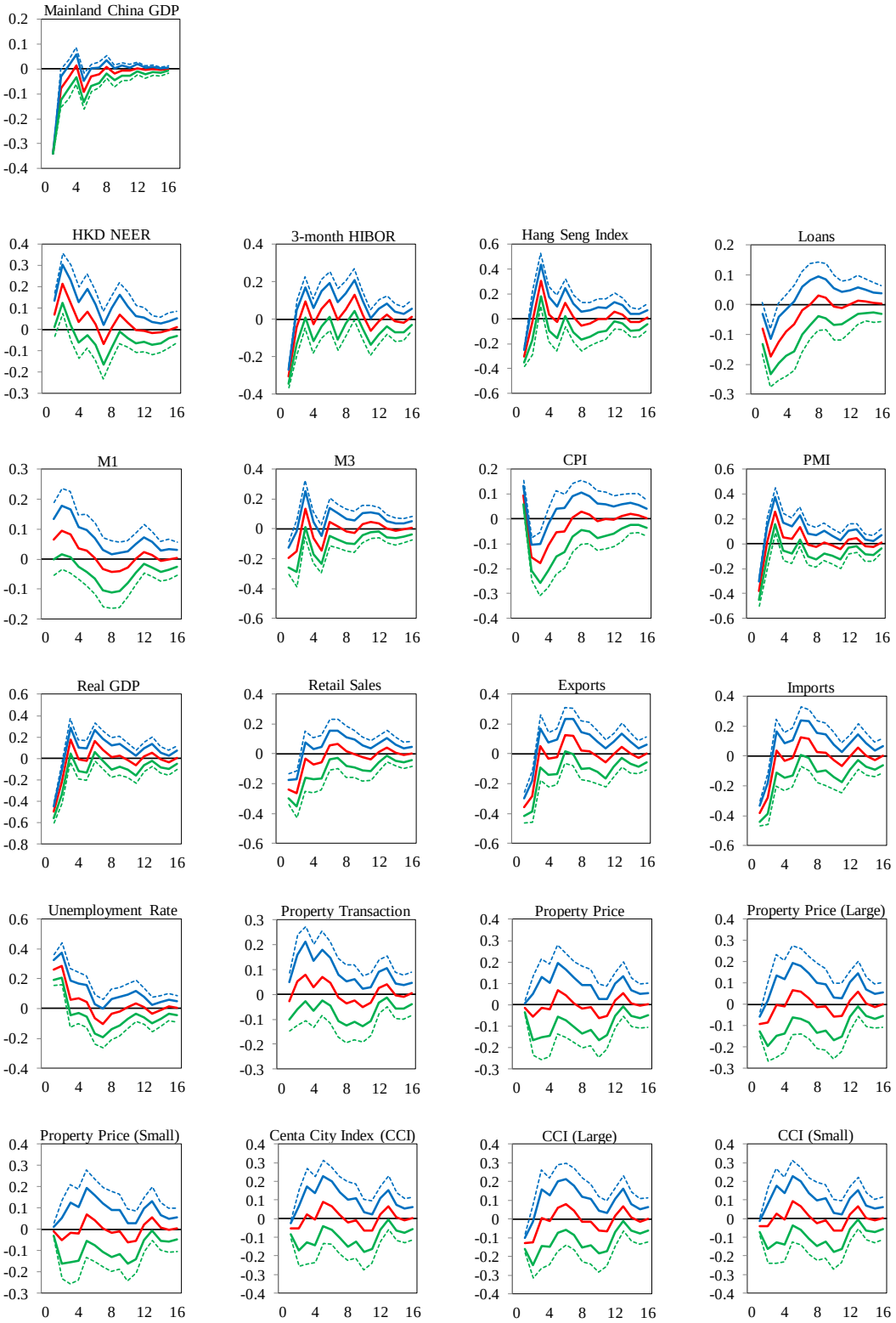
B: Capital flow and financial stability variables



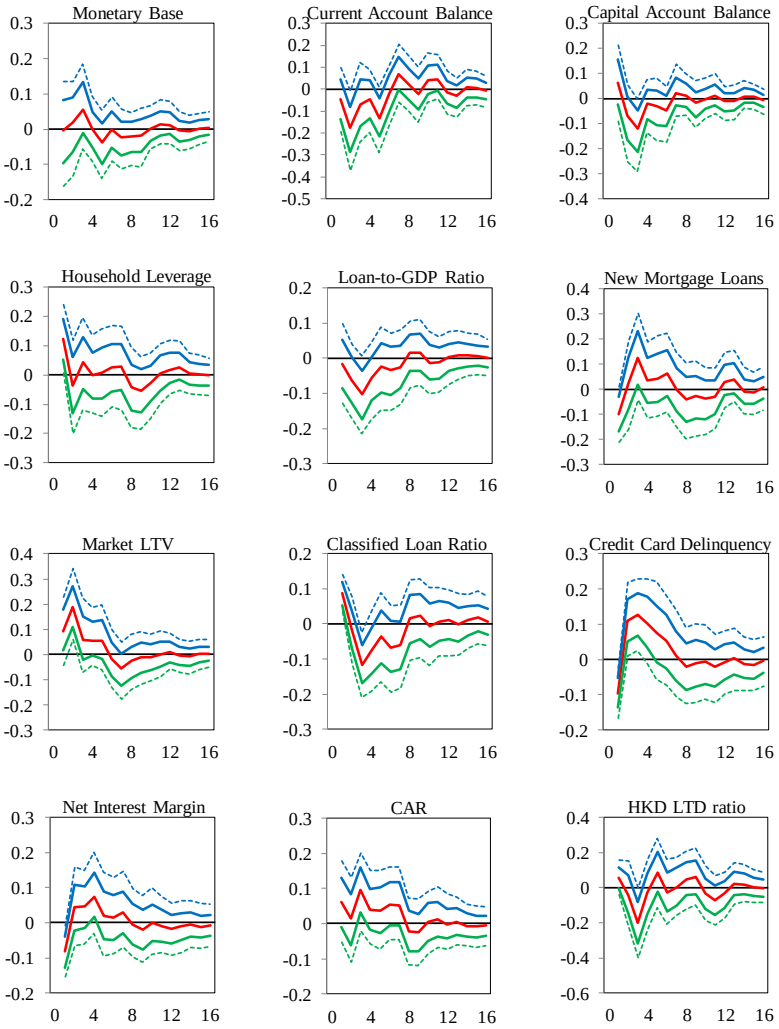
Note: The red line indicates the estimated median response. The solid blue and green lines represent the 68 percent bootstrap confidence interval, and the dashed blue and green lines represent the 90 percent bootstrap confidence interval based on 1,000 bootstrap samples. All the charts are in standard deviation units.

Figure 7 Impulse responses for selected Hong Kong variables to the Mainland China GDP shock in the model with both US monetary policy shock and Mainland growth

A: Macroeconomic and financial variables



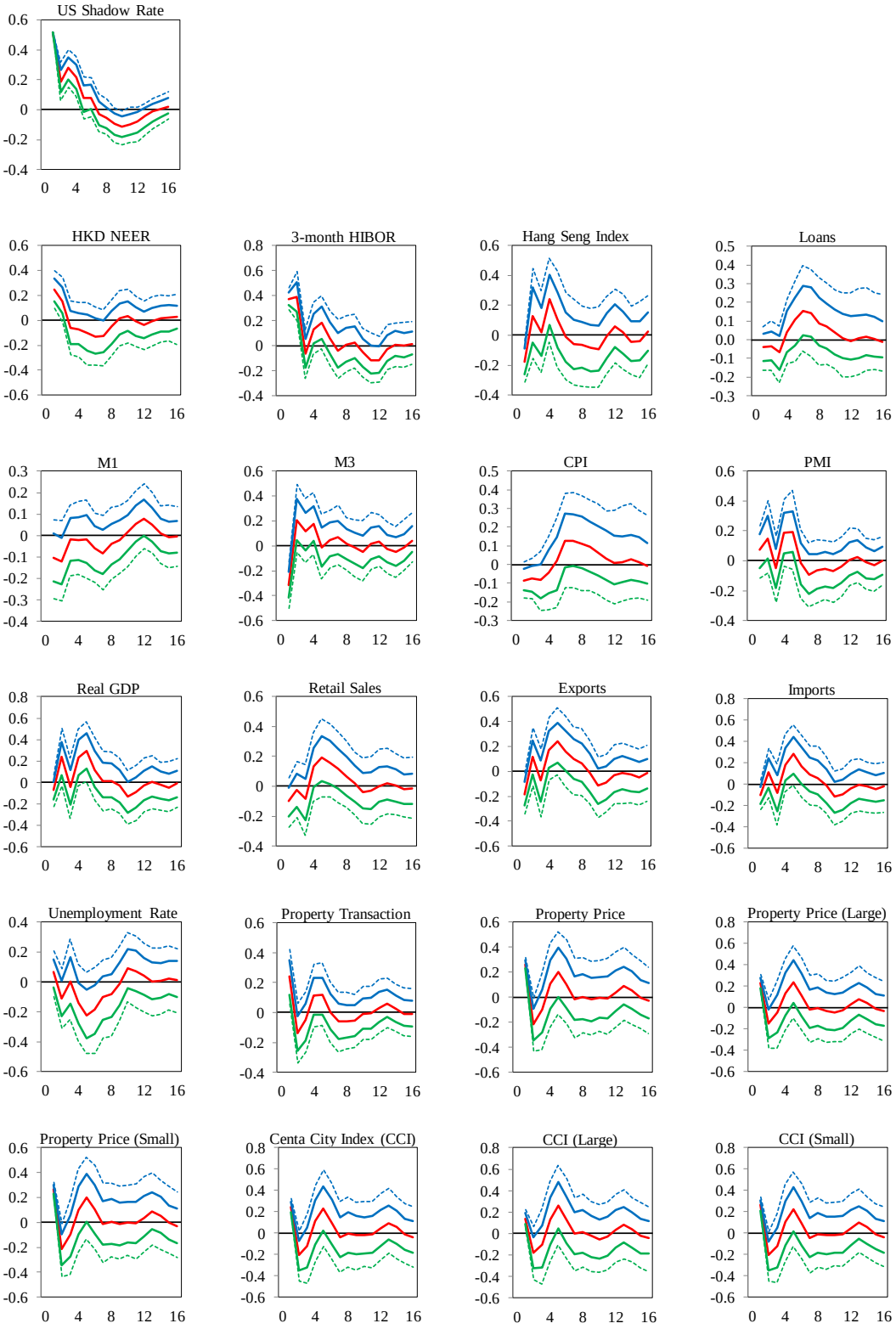
B: Capital flow and financial stability variables



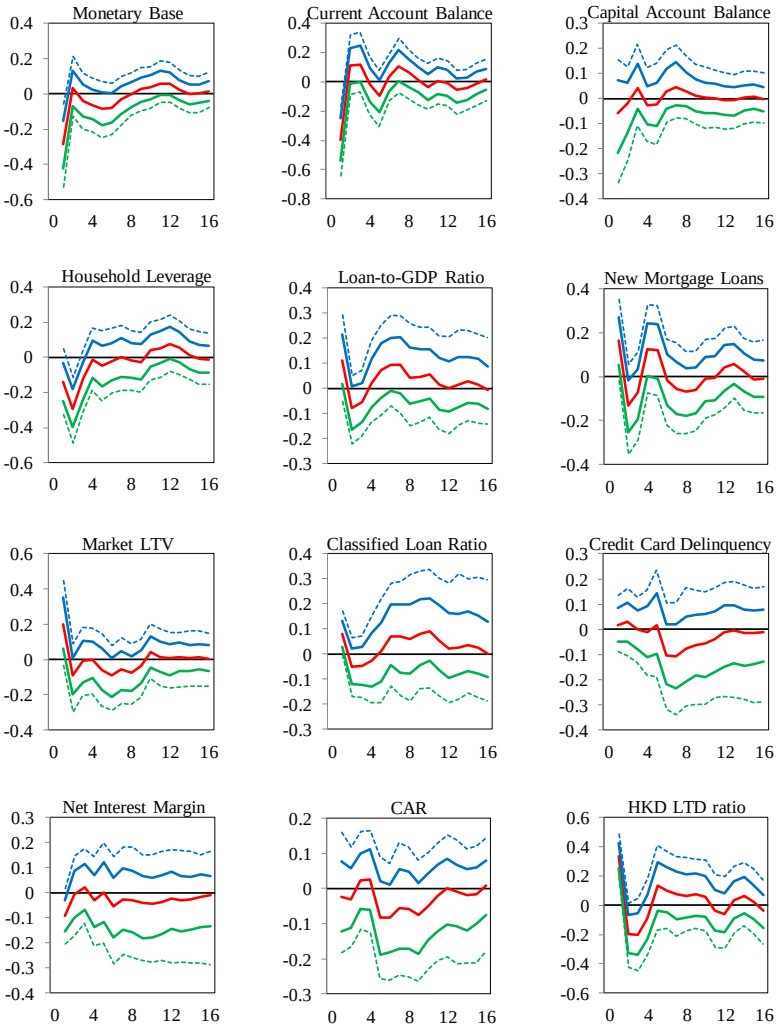
Note: The red line indicates the estimated median response. The solid blue and green lines represent the 68 percent bootstrap confidence interval, and the dashed blue and green lines represent the 90 percent bootstrap confidence interval based on 1,000 bootstrap samples. All the charts are in standard deviation units.

Figure 8 Impulse responses for selected Hong Kong variables to the monetary policy shock of the Fed in the full model

A: Macroeconomic and financial variables



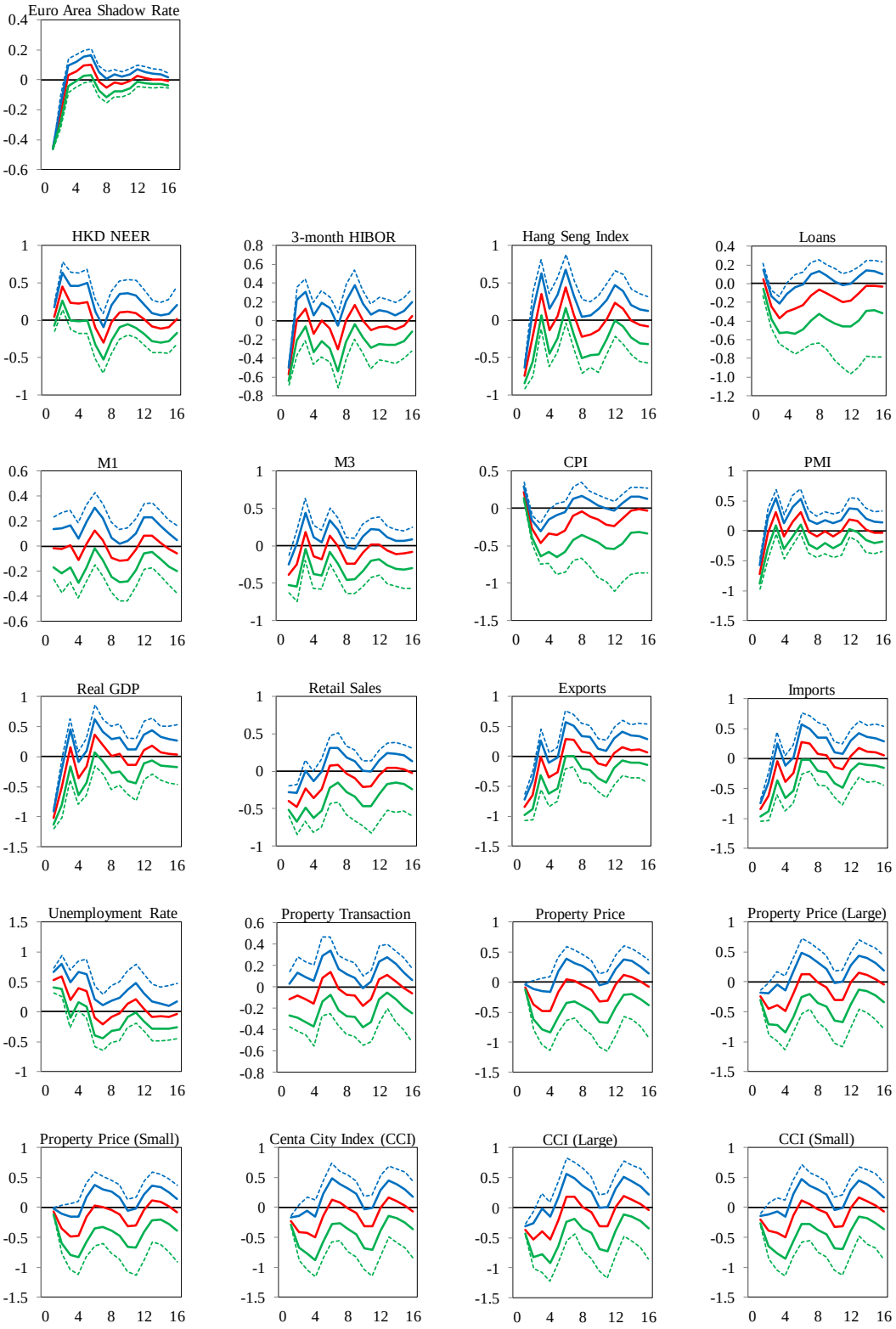
B: Capital flow and financial stability variables



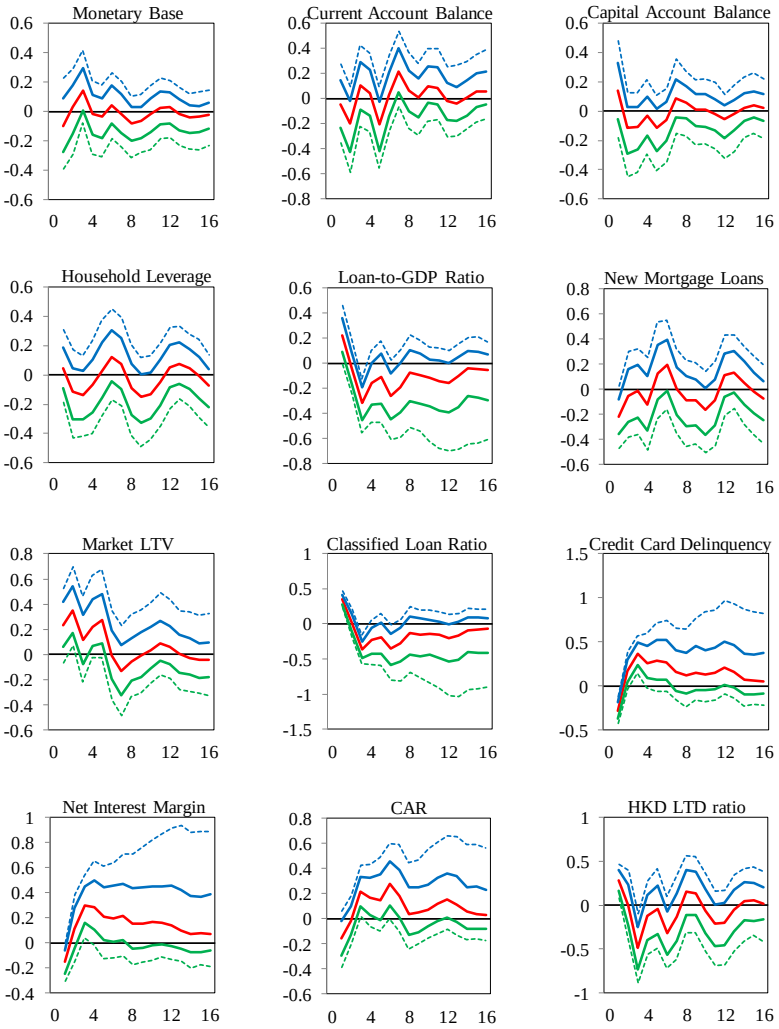
Note: The red line indicates the estimated median response. The solid blue and green lines represent the 68 percent bootstrap confidence interval, and the dashed blue and green lines represent the 90 percent bootstrap confidence interval based on 1,000 bootstrap samples. All the charts are in standard deviation units.

Figure 9 Impulse responses for selected Hong Kong variables to the monetary policy shock of ECB in the full model

A: Macroeconomic and financial variables



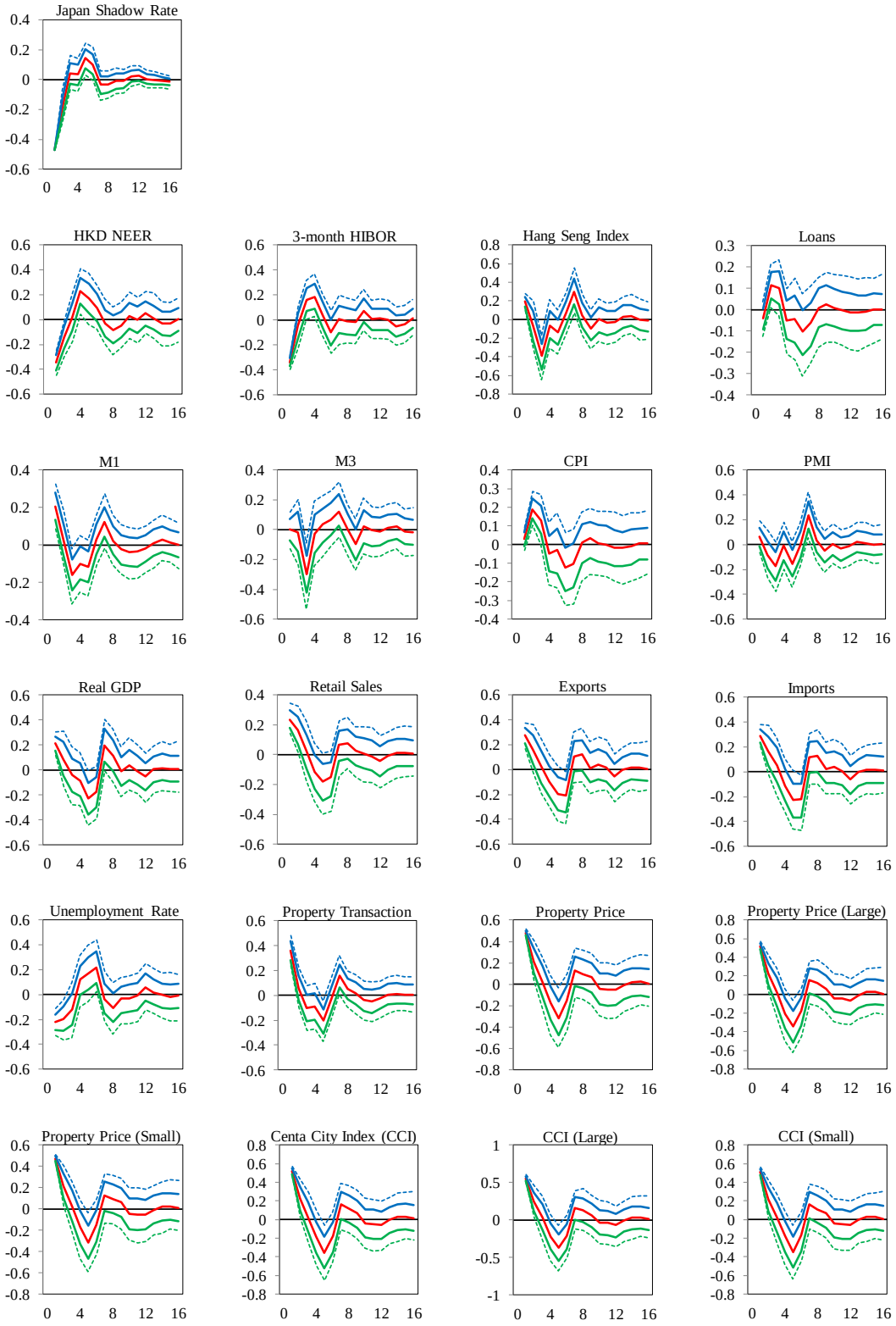
B: Capital flow and financial stability variables



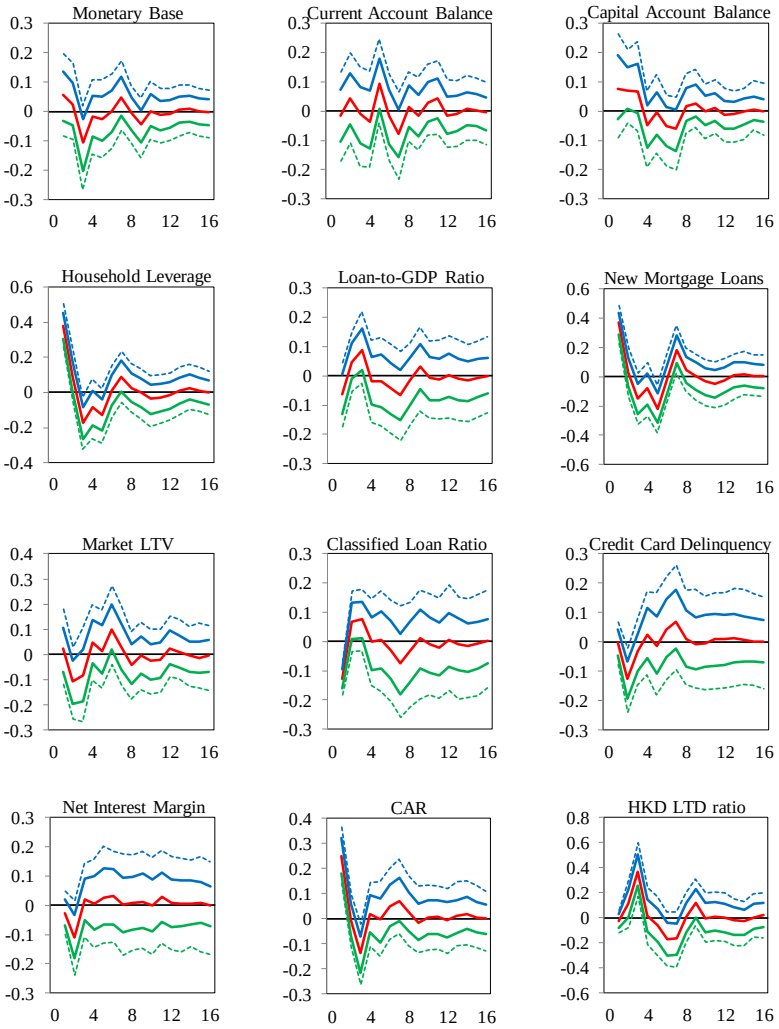
Note: The red line indicates the estimated median response. The solid blue and green lines represent the 68 percent bootstrap confidence interval, and the dashed blue and green lines represent the 90 percent bootstrap confidence interval based on 1,000 bootstrap samples. All the charts are in standard deviation units.

Figure 10 Impulse responses for selected Hong Kong variables to the monetary policy shock of BoJ in the full model

A: Macroeconomic and financial variables



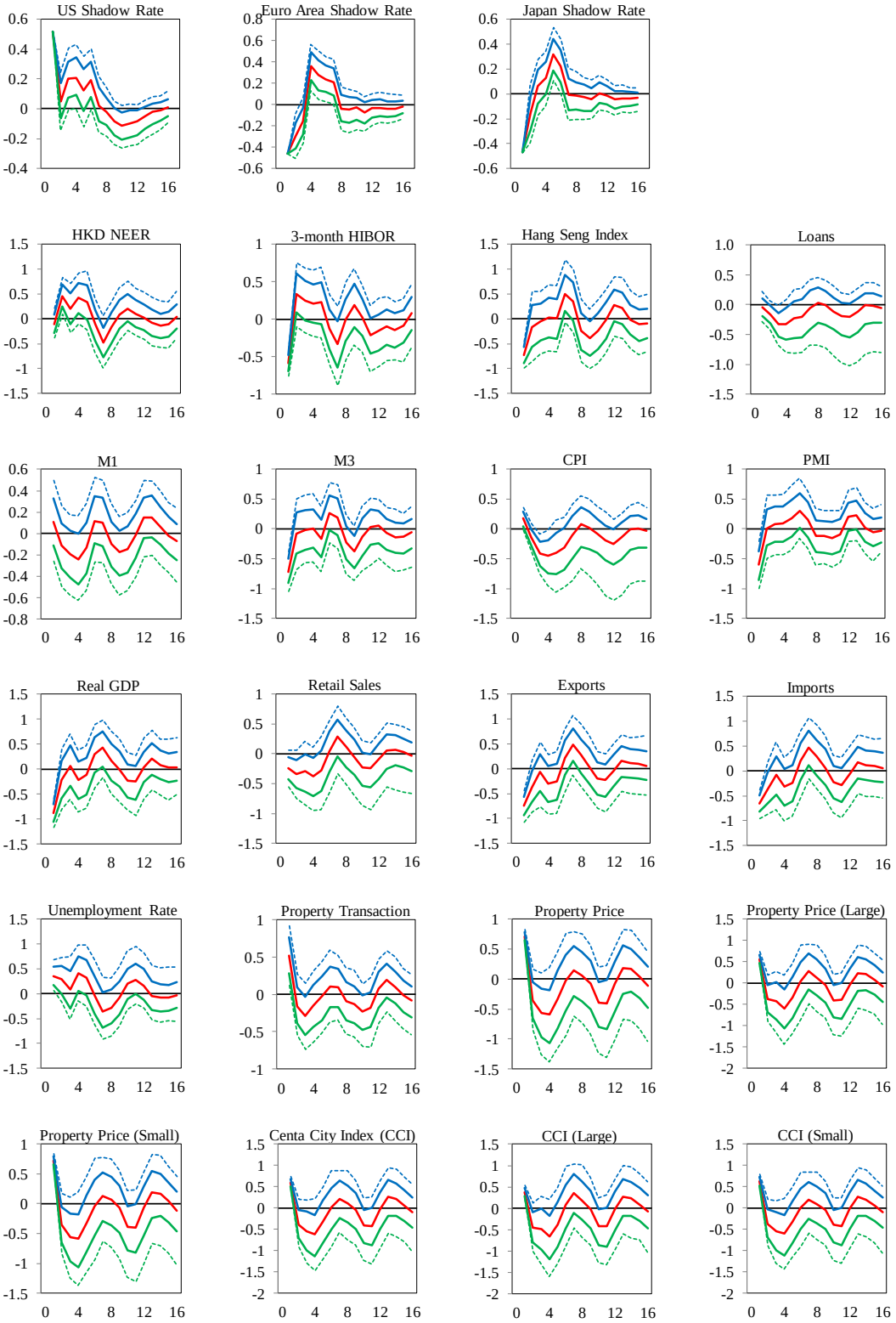
B: Capital flow and financial stability variables



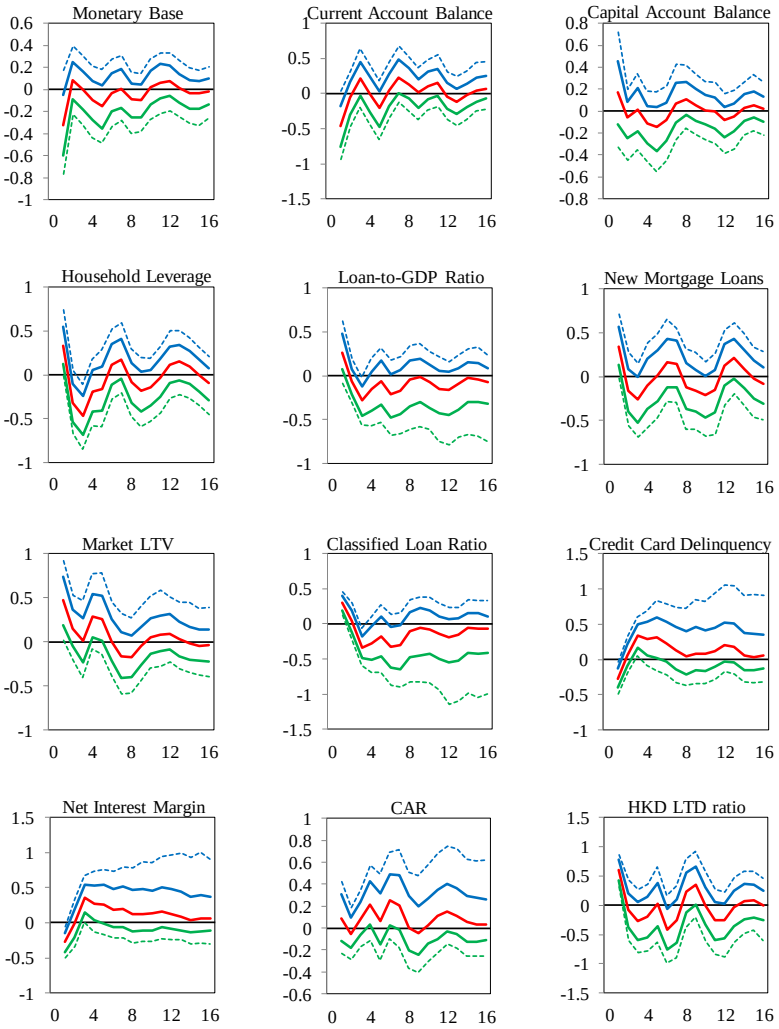
Note: The red line indicates the estimated median response. The solid blue and green lines represent the 68 percent bootstrap confidence interval, and the dashed blue and green lines represent the 90 percent bootstrap confidence interval based on 1,000 bootstrap samples. All the charts are in standard deviation units.

Figure 11 Aggregate impact of monetary policy shocks of the Fed, ECB and BoJ on selected Hong Kong variables in the full model with Mainland economic slowdown turned off

A: Macroeconomic and financial variables



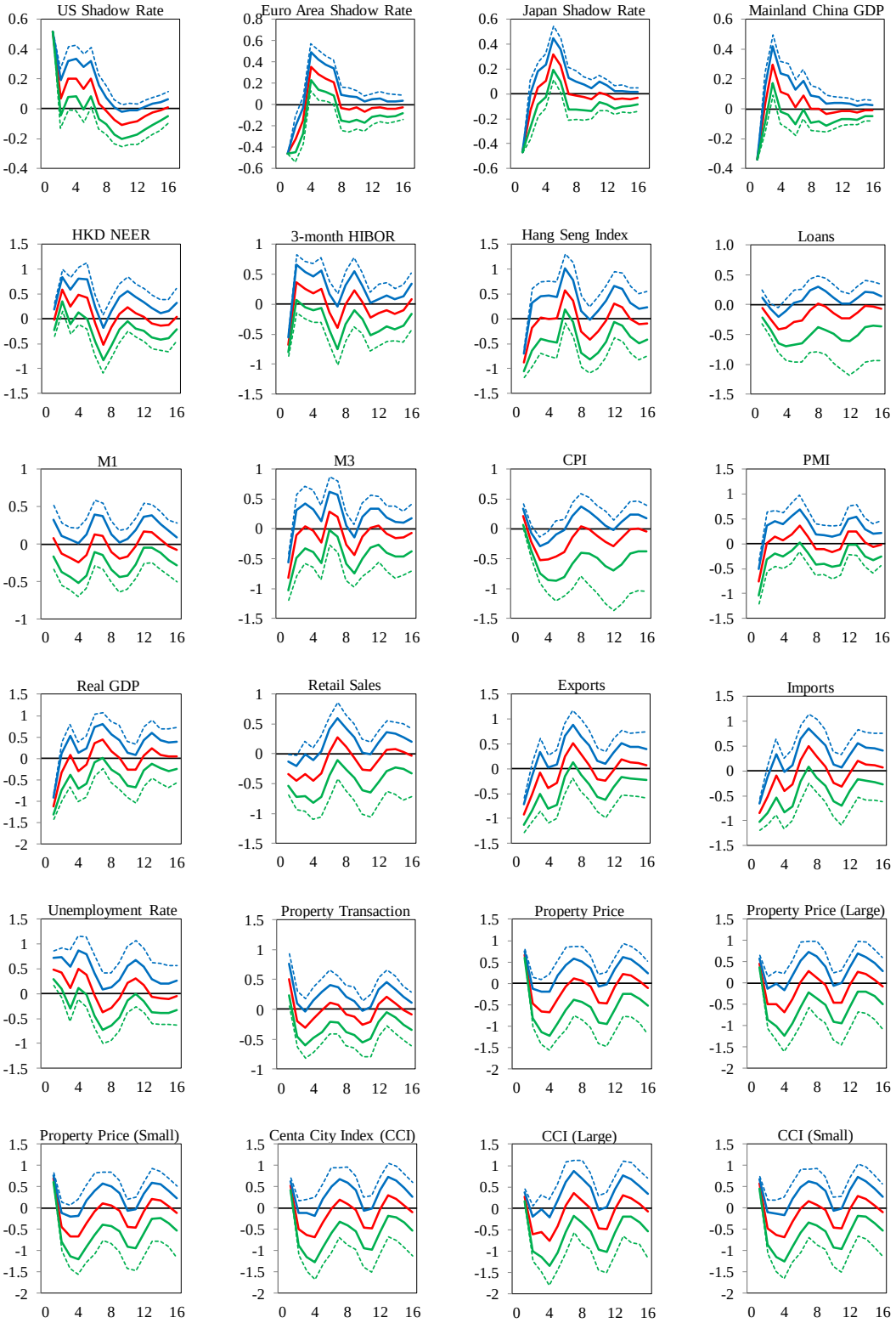
B: Capital flow and financial stability variables



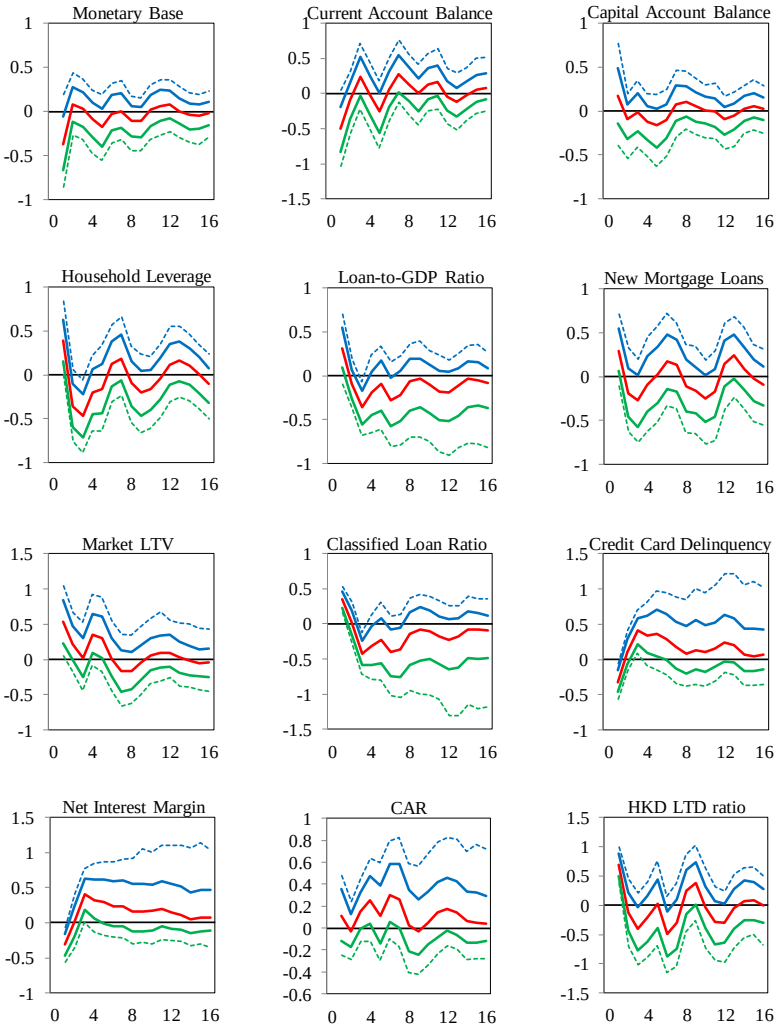
Note: The red line indicates the estimated median response. The solid blue and green lines represent the 68 percent bootstrap confidence interval, and the dashed blue and green lines represent the 90 percent bootstrap confidence interval based on 1,000 bootstrap samples. All the charts are in standard deviation units.

Figure 12 Aggregate impact of monetary policy shocks of the Fed, ECB and BoJ and Mainland economic slowdown on selected Hong Kong variables in the full model

A: Macroeconomic and financial variables

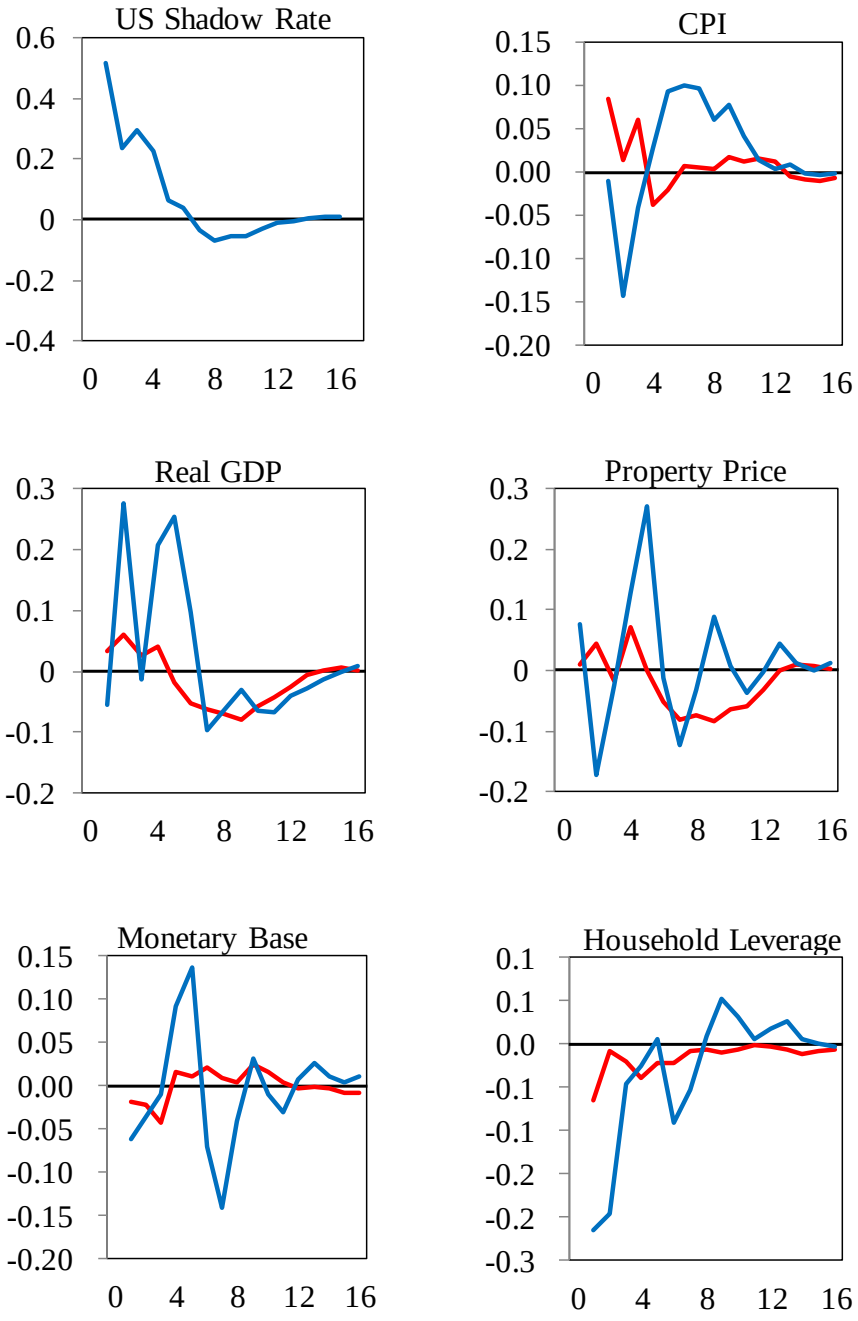


B: Capital flow and financial stability variables



Note: The red line indicates the estimated median response. The solid blue and green lines represent the 68 percent bootstrap confidence interval, and the dashed blue and green lines represent the 90 percent bootstrap confidence interval based on 1,000 bootstrap samples. All the charts are in standard deviation units.

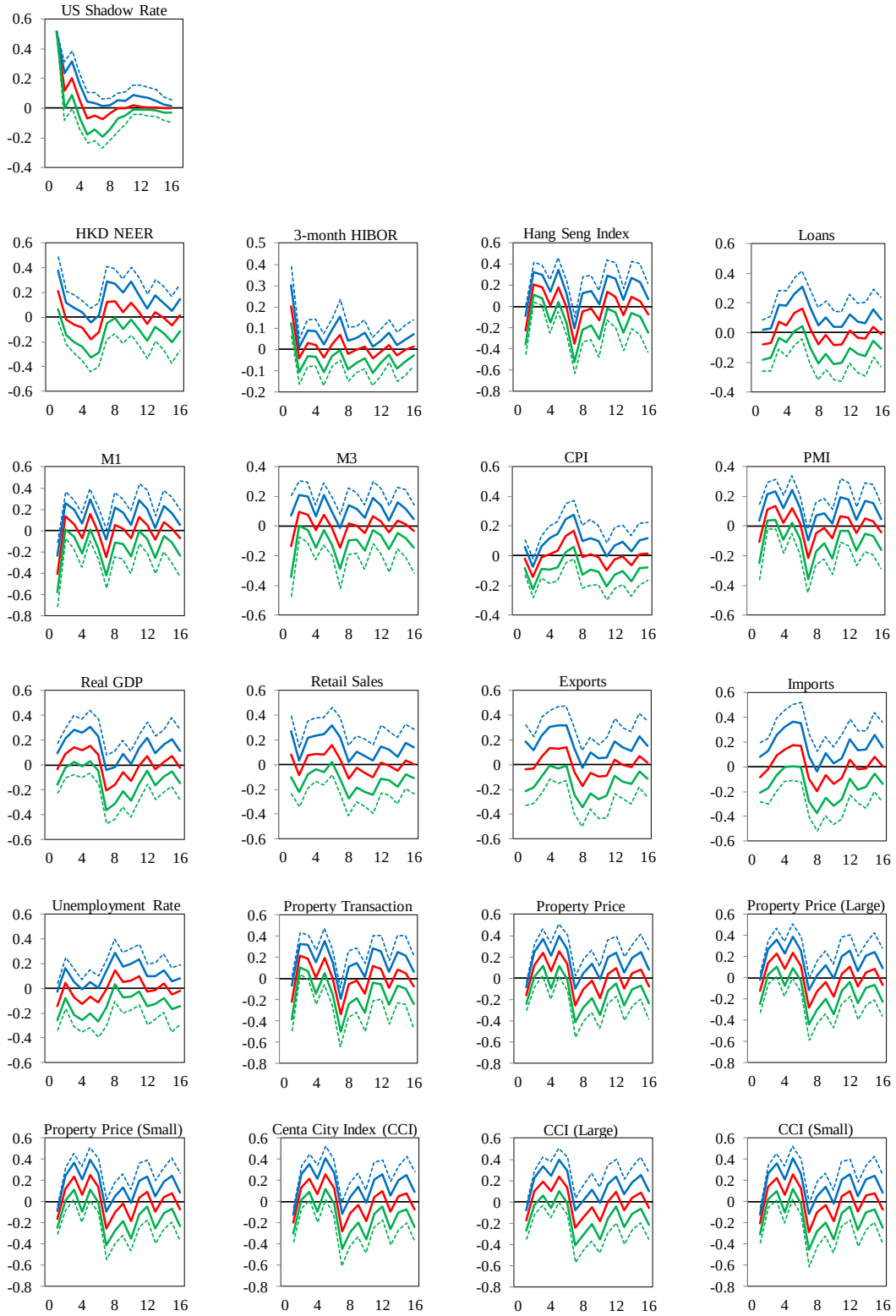
Figure 13 Comparison of standard VAR model and FAVAR model – impulse responses for selected Hong Kong macroeconomic variables to the monetary policy shock of the Fed



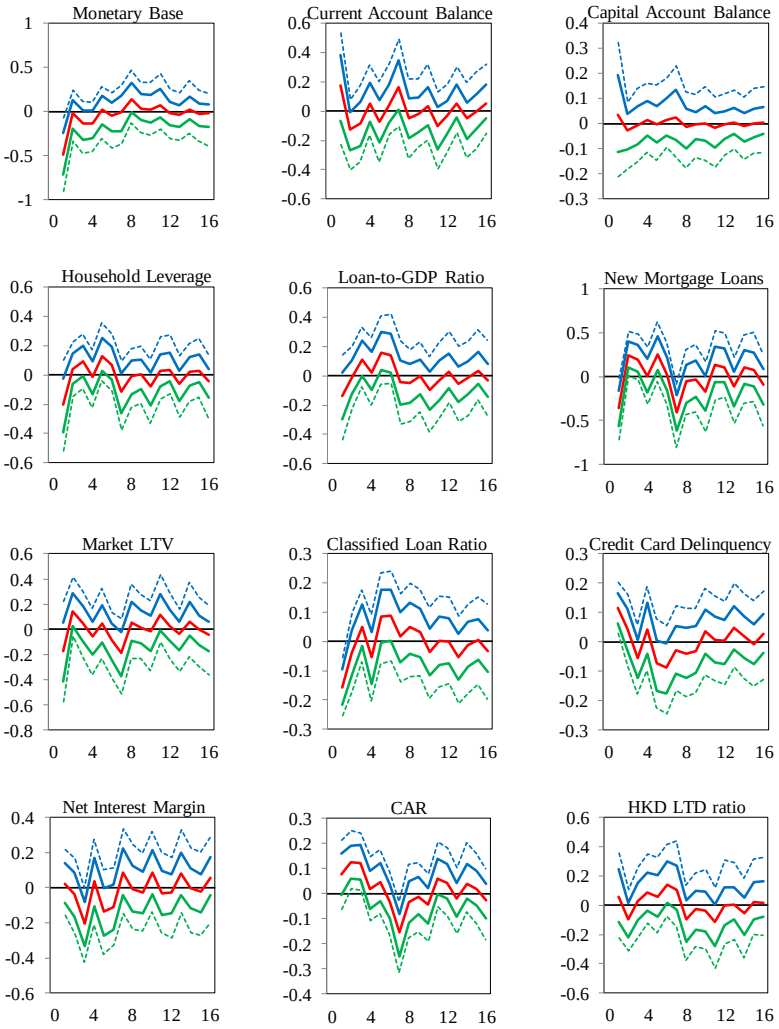
Note: The red line indicates the estimated impulse response based on standard 6-variable VAR model, and the blue line is the estimated impulse response based on 5-factor FAVAR model (same as the corresponding charts in Figure 2). All the charts are in standard deviation units.

Figure 14 Impulse responses for selected Hong Kong variables to the monetary policy shock of the Fed (since 2008)

A: Macroeconomic and financial variables



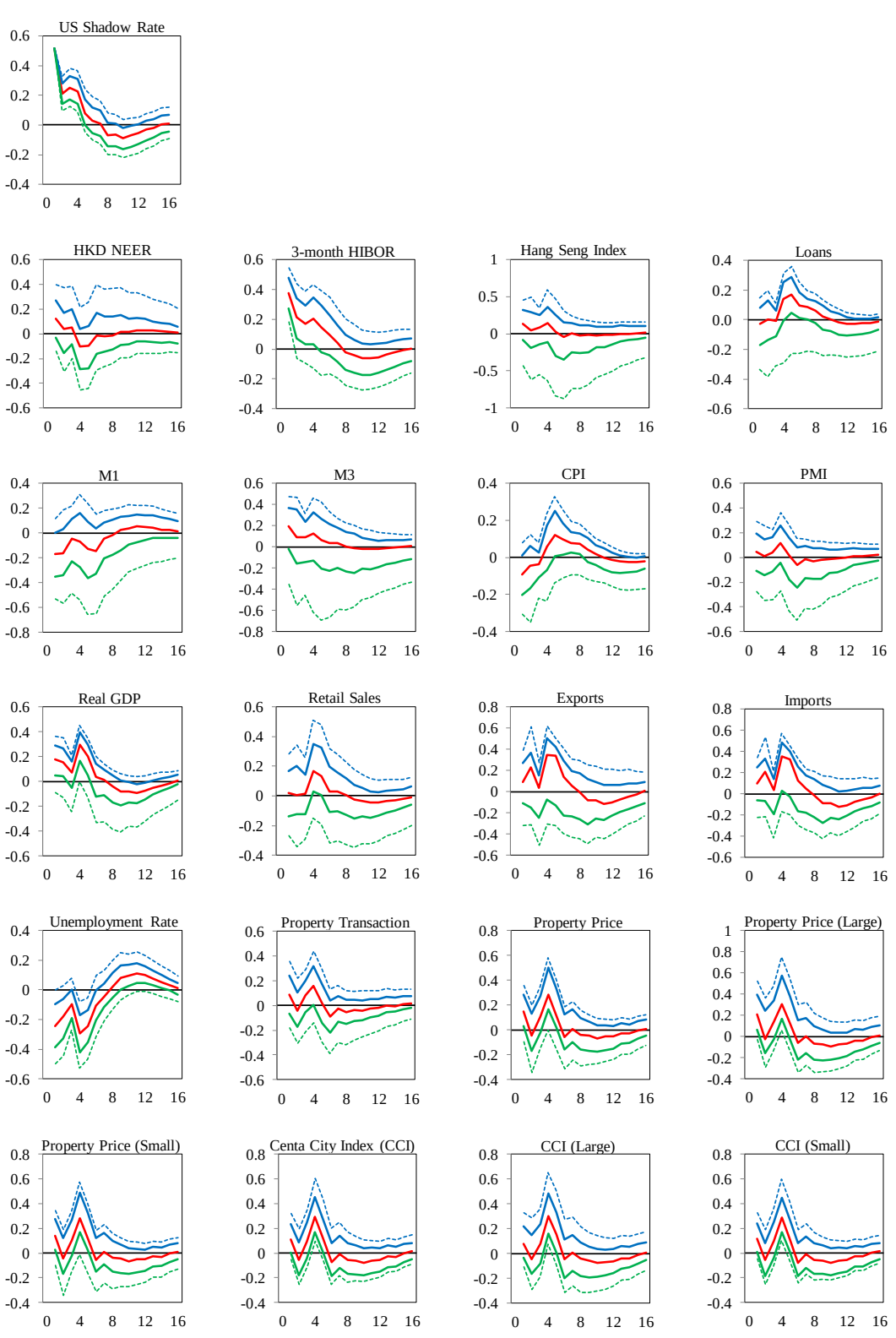
B: Capital flow and financial stability variables



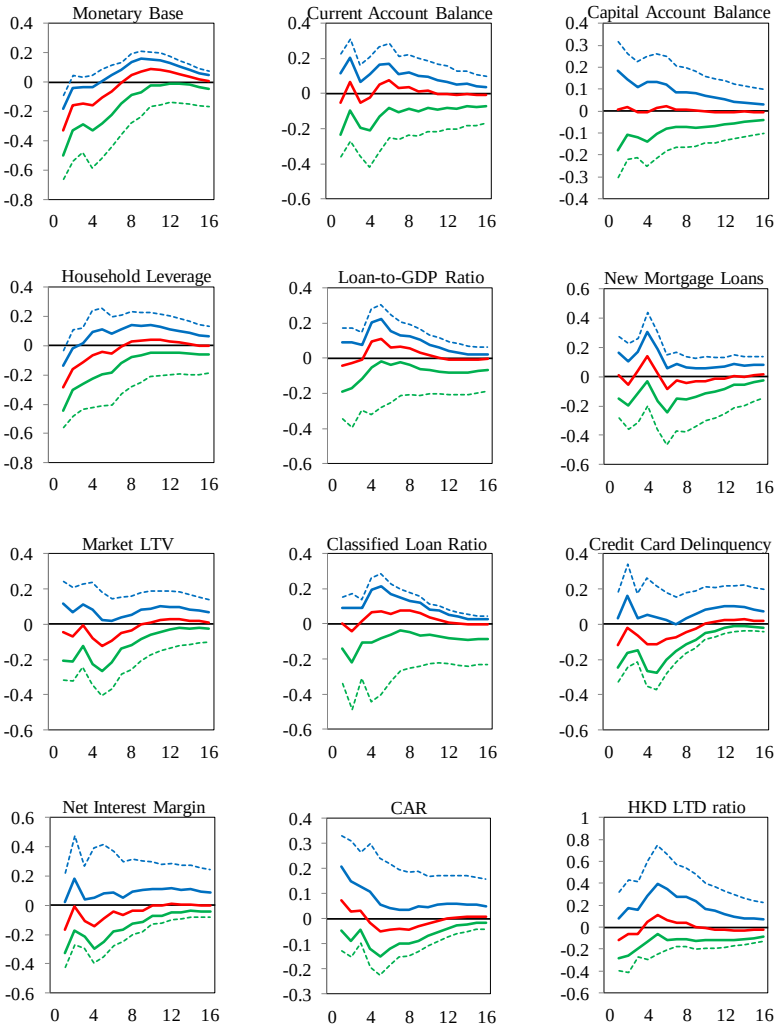
Note: The red line indicates the estimated median response. The solid blue and green lines represent the 68 percent bootstrap confidence interval, and the dashed blue and green lines represent the 90 percent bootstrap confidence interval based on 1,000 bootstrap samples. All the charts are in standard deviation units.

Figure 15 Impulse responses for selected Hong Kong variables to the monetary policy shock of the Fed (estimated by Gibbs Sampling approach)

A: Macroeconomic and financial variables



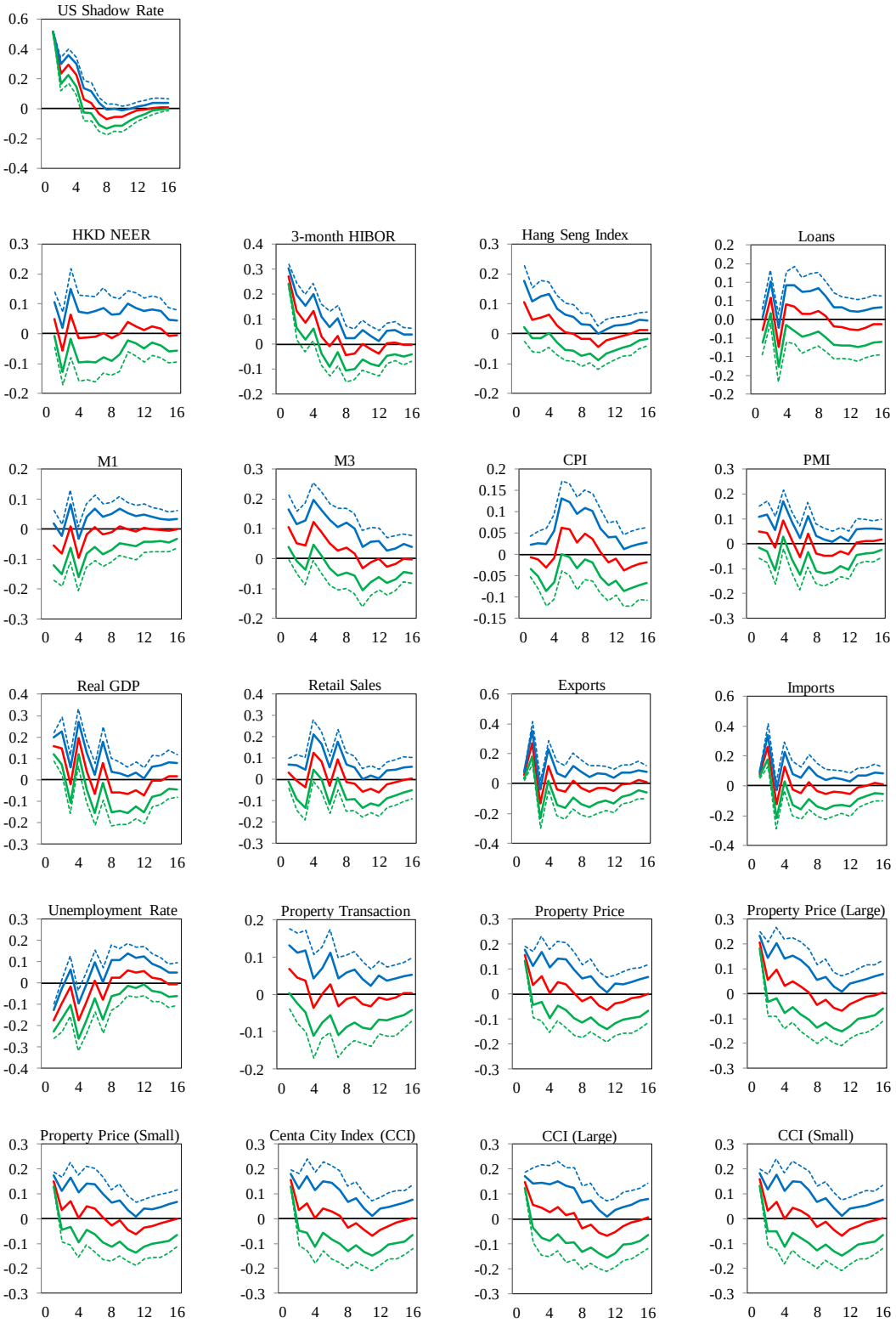
B: Capital flow and financial stability variables



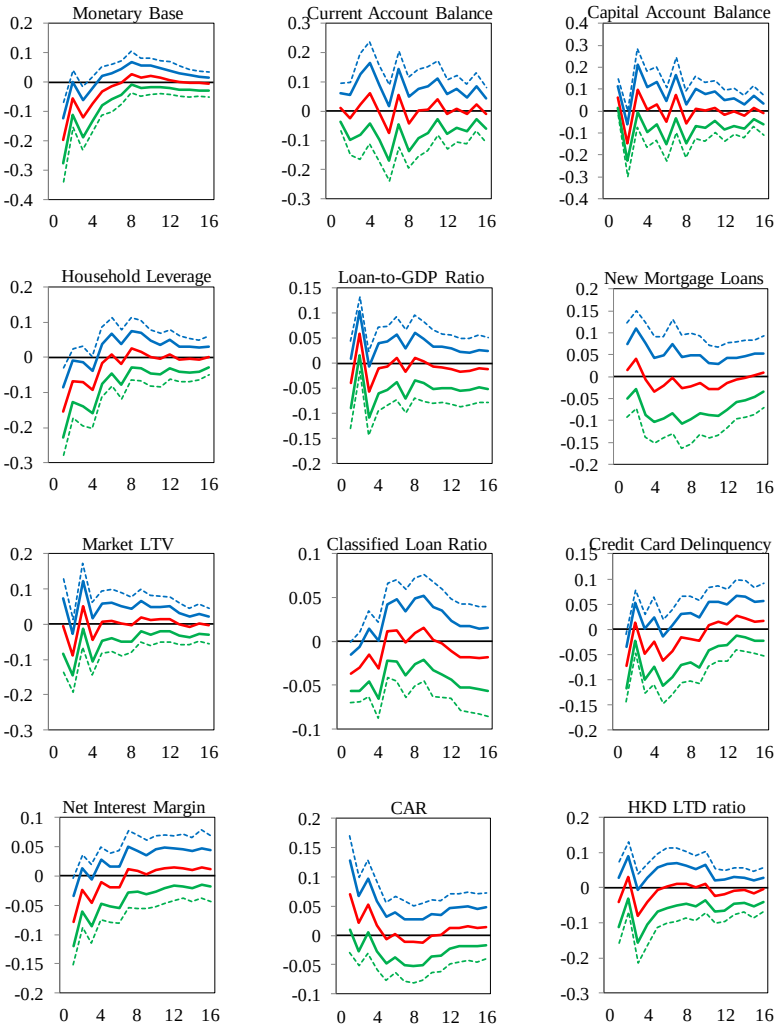
Note: The red line indicates the estimated median response. The solid blue and green lines represent the 68 percent bootstrap confidence interval, and the dashed blue and green lines represent the 90 percent bootstrap confidence interval based on 1,000 bootstrap samples. All the charts are in standard deviation units.

Figure 16 Impulse responses for selected Hong Kong variables to the monetary policy shock of the Fed (estimated by Structual FAVAR, factors extracted from variables by groups)

A: Macroeconomic and financial variables



B: Capital flow and financial stability variables



Note: The red line indicates the estimated median response. The solid blue and green lines represent the 68 percent bootstrap confidence interval, and the dashed blue and green lines represent the 90 percent bootstrap confidence interval based on 1,000 bootstrap samples. All the charts are in standard deviation units.