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The Transmission of Monetary Policy Shocks: Evidence from Japan*

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Abstract

Following Miranda-Agrippino and Ricco (2021), we identify a monetary policy shock in Japan. We construct this shock to be orthogonal to the Bank of Japan's macroeconomic forecasts, as well as a central bank's information shock (Nakamura and Steinsson, 2018). Our findings indicate that a surprise policy tightening is contractionary, leading to a deterioration in output and decline in prices. There are no lagged effects of monetary policy on inflation. In response to a tightening shock, prices fall immediately. Furthermore, we demonstrate that a positive central bank information shock increases both output and prices. An unexpected positive outlook from the Bank of Japan raises stock prices and depreciates the Japanese yen. This evidence suggests that information effects play a crucial role in the Japanese economy, even under the effective lower bound.

JEL Classification: D82; D84; E32; E43; E52; E58

Keywords: expectation; inflation; monetary policy; monetary policy shock; price puzzle; private information

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1 Introduction

The identification of monetary policy (MP) shocks and their effects under the effective lower bound (ELB) has been a major focus for macroeconomic researchers and central bankers. However, the literature provides limited evidence on the macroeconomic effects of unconventional monetary policies in Japan, largely as a result of challenges in identifying these shocks.[1] Notable exceptions include Hanisch (2017), Kimura and Nakajima (2016), Koeda (2019), Nagao et al. (2021), and Morita et al. (forthcoming) who indicate that unconventional MP shocks have a significant impact on the output gap. However, these studies provide mixed evidence regarding whether expansionary unconventional policy shocks raise inflation rates. Furthermore, much of the literature overlooks the information effects of bank economic outlook assessments, limiting our understanding of how monetary policies affect macroeconomic variables in Japan.

Using a simplified approach proposed by Miranda-Agrippino and Ricco (2021), we decompose the BOJ's announcements into information on MP and the CB's assessment of the economic outlook. Following established methods for identifying MP shocks, we use high-frequency data to capture MP surprises, which are defined as changes in financial variables during a half-hour window spanning from 10 min before to 20 min after policy announcement. We then regress these surprises on the CB's economic outlook, thereby isolating both MP shocks and CB information shocks.[2]

The effects of CB information shocks have received increasing attention in MP analysis (Melosi, 2017; Nakamura and Steinsson, 2018; Jarociński and Karadi, 2020; Miranda-Agrippino and Ricco, 2021). The literature indicates that CBs possess private information (Romer and Romer, 2000). For example, when a CB announces a policy rate increase, private agents may interpret it as a signal of the CB's more optimistic outlook compared with their own. In this case, a rate hike could lead to expansionary reactions in macroeconomic variables.

These responses to CB information shocks have two important implications. First, they contrast with conventional responses to MP shocks, which typically depress the economy by reducing output, investment, price levels, and stock prices. Second, MP surprises often contain both CB information shocks and MP shocks. Previous studies have relied on high-frequency data to identify

[1]Existing literature on unconventional monetary policies mainly focuses on their impact on financial markets (Dell'Ariccia et al., 2018; Gagnon et al., 2011; Hamilton and Wu et al., 2012; Kuttner, 2018; D'Amico et al., 2012; Swanson, 2017). Studies by Arai (2017), Kubota and Shin-tani (2022), Eser and Schwaab (2016), Ghysels et al. (2016), and Krishnamurthy (2018) examine how unconventional policies by the Bank of Japan (BOJ) and European Central Bank (CB) affect government bond yields. Additionally, Inoue and Rossi (2019) explores the relationship between MP and exchange rates. There is general consensus among researchers regarding the accommodative effects of unconventional policies on financial markets.

[2]Unlike Jarociński and Karadi (2020), who combine high-frequency asset price responses with sign restrictions to identify MP shocks, our method does not require sign restrictions. Morita et al. (forthcoming) and Tanahara et al. (2019) use the Jarociński and Karadi (2020) approach to examine information effects on the Japanese economy.

MP surprises and treated these surprises as MP shocks. However, recent literature suggests that MP surprises may not fully correspond to MP shocks, as they include CB information shocks. When using MP surprises to analyze the effects of MP, researchers may obtain mixed estimates as a result of this combination of shocks. In other words, accurately assessing the impacts of MP requires disentangling MP shocks from CB information shocks.

We identify these two types of shocks to examine their influence on macroeconomic and financial variables, yielding three key findings. First, we provide evidence that macroeconomic and financial variables respond significantly to MP shocks. Specifically, a contractionary MP shock reduces output and price levels. Regarding financial variables, we find that a contractionary MP shock raises the real effective exchange rate, suggesting that a policy rate increase appreciates the Japanese yen. Second, we observe that price levels respond more strongly and quickly to an MP shock than reported in past studies. We demonstrate that a one-standard-deviation MP shock ($+0.01\%$) reduces price levels by 0.3%. While previous studies on the effects of quantitative and qualitative monetary easing by the BOJ report limited or insignificant effects (Koeda, 2019; Morita et al., forthcoming; Tanahara et al., 2019), our results indicate an immediate price response to an MP shock. This finding suggests that disentangling MP shocks from CB information shocks in CB announcements may resolve the "price puzzle." Third, a CB information shock elicits opposite reactions in macroeconomic and financial variables. A positive CB shock increases output, price levels, and stock prices while depreciating the yen. These reactions align with findings from Nakamura and Steinsson (2018), Jarociński and Karadi (2020), and Miranda-Agrippino and Ricco (2021) in the US. Our results imply that an unexpected policy rate increase is not always contractionary. Instead, a transmission mechanism exists that allows output and inflation to rise, even when policy rates increase unexpectedly. This evidence highlights the crucial role of information effects in the Japanese economy, even under the ELB.

The remainder of this paper is organized as follows. Section 2 outlines our strategy for identifying MP shocks and CB information shocks. Section 3 describes the impulse responses to both types of shocks. Section 4 provides concluding remarks.

2 Identification of information shocks

Following Miranda-Agrippino and Ricco (2021), we identify MP shocks as the residuals estimated in the following equation:

$$\Delta \text{EYF6}_m = \sum_{j=0}^{2} \theta_j F_m^{BOJ} x_{+j} + \sum_{j=0}^{2} \vartheta_j \left(F_m^{BOJ} x_{+j} - F_{m-3}^{BOJ} x_{+j} \right) + c + \text{MPI}_m, \tag{1}$$

where ΔEYF6_m represents intraday changes in six-month-ahead Euroyen futures rates (EYF6) within a half-hour window, starting 10 min before and ending 20 min after the MP announcement.[3] $F_m^{BOJ}x_{+j}$ represents a vector of the BOJ's forecasts for growth and inflation rates through the end of the upcoming fiscal year j, which are released in month m. The BOJ publishes its Outlook for Economic Activity and Prices quarterly (typically in January, April, July, and October) along with the MP announcement.[4] The first term on the right side includes the BOJ's growth and inflation forecasts, while the second term represents forecast revisions from the previous quarter. We refer to these two terms collectively as the CB's information shock, which contains the BOJ's private information.[5] MP shocks (MPI) are identified as the residuals orthogonal to the CB information shocks. By regressing MP surprises on the CB's private information, we decompose MP surprises (ΔEYF6) into MP shocks and CB shocks.

Figure 1 illustrates the development of MP shocks and CB information shocks.[6] This figure indicates that large negative (i.e., expansionary) MP shocks occurred in December of 2008 and January of 2016. December of 2008 coincided with significant turmoil during the Global Financial Crisis. The shock in January of 2016 reflects the launch of the negative-interest-rate policy (NIRP), when the BOJ announced the introduction of "quantitative and qualitative monetary easing with a negative interest rate." Although the Bank's governor, Haruhiko Kuroda, denied that such a policy was under consideration during a Diet session, the bank ultimately decided to implement the NIRP. As the introduction of the NIRP was unexpected, the corresponding shock was significant.

3 Impulse responses

3.1 Effects of MP shocks

We investigate whether MP shocks and CB information shocks significantly impact macroeconomic and financial variables. Our approach is based on the local projections method proposed by Jordà

[3] We use the MP surprise series from Kubota and Shin-tani (2022). We thank Hiroyuki Kubota and Mototsugu Shin-tani for providing data.

[4] We use data from 2008 to 2019, as the BOJ began publishing quarterly macroeconomic forecasts in 2008.

[5] Because the Outlook for Economic Activity and Prices is only available in January, April, July, and October, the CB information shock is zero in other months.

[6] Table 2 presents the results of estimating Equation (1).

(2005). We estimate the following equations:

$$\log y_{m+h} - \log y_{m-1} = \alpha_h \times \text{MPI}_m + \sum_{1}^{k} \gamma_k X_{m-k} + \varepsilon_{m+h}, \tag{2}$$

$$\log y_{m+h} - \log y_{m-1} = \beta_h \times \text{Information}_m + \sum_{1}^{k} \gamma_k X_{m-k} + \varepsilon_{m+h}, \tag{3}$$

where $\log y_m$ includes the logarithm of output, price levels, real effective exchange rates, and the stock index. We use indices of all-industry activity or industrial production as a measure of output and the consumer price index (CPI) as a measure of price levels. We include 12 lags of y as control variables. First, we focus on the α coefficients. We then compare the α coefficients with the β coefficients to illustrate the differing effects of MP shocks and CB information shocks on macroeconomic and financial variables.

Figure 2 presents the impulse responses of macroeconomic variables to one-standard-deviation MP surprises and MP shocks based on data from 2007 to 2019. The dashed line represents responses to MP surprises, while the solid line represents responses to MP shocks.[7] The top panel in Figure 2 illustrates the impulse responses of the indices of all-industry activity, which serve as a proxy for output. These responses suggest that contractionary MP surprises have no significant effect on output, whereas contractionary MP shocks significantly reduce output. Eight months after the occurrence of MP shocks, output falls by -0.4%. Furthermore, MP shocks lead to a more rapid decline in output compared with MP surprises. The bottom panel in Figure 2 presents the impulse responses of the CPI, which is used as a proxy for price levels. The responses indicate that contractionary MP surprises do not significantly affect aggregate prices, whereas contractionary MP shocks significantly reduce aggregate prices. Eighteen months after MP shocks occur, aggregate prices decrease by -0.3%. Additionally, MP shocks exert a relatively fast impact on aggregate prices compared with MP surprises, with prices significantly falling one month after the shock. This finding suggests that decomposing MP surprises into MP shocks helps resolve the price puzzle.

Figure 3 presents the impulse responses of financial variables to one-standard-deviation MP surprises and MP shocks. The top panel in Figure 3 presents the impulse responses of the real effective exchange rate (REER). One can see that contractionary MP surprises have no significant effects, whereas contractionary MP shocks significantly increase the REER. Three months after the occurrence of MP shocks, the REER increases by $+1.0\%$. This result suggests that the Japanese yen appreciates in response to a contractionary MP shock. Additionally, MP shocks lead to a quicker increase in the REER compared with MP surprises. The bottom panel in Figure 3 presents the

[7] We show the impulse response functions with ± 1 standard error confidence intervals. In the literature on estimating impulse response functions, it is common to encounter ± 1 standard error confidence intervals, as shown in Romer and Romer (2010), Ueda (2010), Jarociński and Karadi (2020), and Morita et al. (forthcoming).

impulse responses of the Tokyo price index (TOPIX). One can see that neither MP surprises nor MP shocks have significant effects on stock prices.

3.2 Effects of CB information shocks

We now compare the effects of MP shocks with those of CB information shocks. Figure 4 presents the impulse responses of output to one-standard-deviation MP shocks and CB information shocks. The solid line represents the responses to MP shocks, whereas the dashed line represents the responses to CB information shocks. The top panel in Figure 4 presents the impulse responses of the indices of all-industry activity. One can see that positive MP shocks reduce output. In contrast, positive CB information shocks significantly increase output. One year after the occurrence of CB information shocks, output rises by $+1.0\%$. This result is robust when we estimate the impulse responses of the index of industrial production (IIP). The bottom panel in Figure 4 presents the impulse responses of the IIP. One can see that positive MP shocks significantly reduce the IIP, whereas positive CB information shocks lead to an increase in the IIP of $+1.0\%$ eight months after the shocks occur.

These contrasting responses become increasingly evident when we examine the impulse responses of aggregate prices. Figure 5 presents the impulse responses of the CPI, which includes all goods and services, to MP shocks and CB information shocks. As shown in Figure 2, positive MP shocks significantly reduce aggregate prices. In contrast, positive CB information shocks increase aggregate prices. We observe similar responses for the core CPI (excluding fresh foods). The bottom panel in Figure 5 presents the impulse responses of the core CPI. One can see that positive MP shocks significantly reduce aggregate prices, where positive CB information shocks lead to an increase in aggregate prices. In response to CB information shocks, aggregate prices gradually rise by $+0.3\%$ 18 months after the shocks occur.

The top and bottom panels in Figure 6 present the impulse responses of the REER and TOPIX to one-standard-deviation MP shocks and CB information shocks, respectively. The top panel in Figure 6 reveals that the REER positively responds to MP shocks, whereas it decreases in response to CB information shocks. Specifically, the REER decreases by -2% six months after the occurrence of CB information shocks. We also observe a positive reaction in stock prices. The bottom panel in Figure 6 presents the impulse responses of TOPIX. One can see that MP shocks do not significantly influence TOPIX, whereas CB information shocks lead to a significant increase in TOPIX by up to 6%.

Our results remain robust when we modify the specifications of Equations (2) and (3). We extend the lag length of y to 24 in the equations and estimate the coefficients of α and β. Figure 7 presents the impulse responses of output, prices, the REER, and TOPIX to one-standard-deviation

MP shocks and CB information shocks. The results are similar to those shown in Figures 4 to 6, where positive MP shocks reduce output and prices while increasing the REER, whereas positive CB information shocks increase output, prices, and TOPIX, and reduce the REER. This evidence supports our benchmark results.

4 Conclusion

CB announcements simultaneously convey information regarding MP and the bank's assessment of the economic outlook. In this study, we decomposed these announcements into two components, namely information regarding MP and the CB's assessment of the economic outlook, following the procedure established by Miranda-Agrippino and Ricco (2021). By utilizing high-frequency data alongside the economic outlook provided by the BOJ, we examined whether these two components influence macroeconomic and financial variables, even under the ELB.

We presented empirical evidence that responses to an MP shock are larger and quicker than those reported in the existing literature. We found that a contractionary MP shock significantly reduces both output and price levels, with immediate responses observed in price levels. Additionally, we demonstrated that a contractionary MP shock leads to a significant appreciation of the Japanese yen. This finding suggests that the price puzzle is resolved when we disentangle MP shocks from CB information shocks. We also found that a positive CB information shock significantly increases output and price levels. We observed that a positive CB shock leads to a significant increase in stock prices while depreciating the Japanese yen. These contrasting reactions indicate that an unexpected increase in policy rates is not always contractionary or tight. Instead, a transmission mechanism exists that enables output and inflation rates to rise, even when policy rates increase unexpectedly. Overall, our findings suggests that information effects play a crucial role in the Japanese economy, even under the ELB.

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Table 1: Basic statistics of BOJ forecasts and MP shocks

	Mean	Min	Max	Observations
Forecasts on GDP growth rates (g: %)				
$F_m^{BOJ}[g_{+0}]$	0.957	−3.400	3.300	47
$F_m^{BOJ}[g_{+1}]$	1.377	−2.000	2.900	47
$F_m^{BOJ}[g_{+2}]$	1.132	0.200	2.100	37
Forecasts on year-on-year inflation rates (π: %)				
$F_m^{BOJ}[\pi_{+0}]$	0.600	−1.500	3.300	47
$F_m^{BOJ}[\pi_{+1}]$	1.162	-1.100	3.400	47
$F_m^{BOJ}[\pi_{+2}]$	1.878	−0.400	3.200	37
MP surprise (%)				
ΔEYF6$_m$	0.001	−0.045	0.050	144
MP shock (%)				
MPI$_m$	0.000	−0.045	0.050	144
CB information shock (%)				
CB information shock	0.002	−0.028	0.033	33

Note: We use data from 2008 to 2019, as the BOJ began publishing quarterly macroeconomic forecasts in 2008. $F_m^{BOJ}x_{+j}$ represents a vector of the BOJ's forecasts for growth and inflation rates through the end of the upcoming fiscal year j, which are released in month m.

Table 2: Identification of MP shocks and CB information shocks

		ΔEYF6_m
Forecasts on GDP growth rates (g)		
θ_0^g:	$F_m^{BOJ}[g_{+0}]$	0.003
		(0.003)
θ_1^g:	$F_m^{BOJ}[g_{+1}]$	-0.011^{*}
		(0.006)
θ_2^g:	$F_m^{BOJ}[g_{+2}]$	0.013^{*}
		(0.008)
Forecasts on year-on-year inflation rates (π)		
θ_0^π:	$F_m^{BOJ}[\pi_{+0}]$	-0.000
		(0.002)
θ_1^π:	$F_m^{BOJ}[\pi_{+1}]$	0.000
		(0.004)
θ_2^π:	$F_m^{BOJ}[\pi_{+2}]$	-0.004
		(0.006)
Forecast revisions on GDP growth rates (g)		
ϑ_0^g:	$F_m^{BOJ}[g_{+0}] - F_{m-3}^{BOJ}[g_{+0}]$	-0.013^{*}
		(0.007)
ϑ_1^g:	$F_m^{BOJ}[g_{+1}] - F_{m-3}^{BOJ}[g_{+1}]$	0.030^{***}
		(0.008)
ϑ_2^g:	$F_m^{BOJ}[g_{+2}] - F_{m-3}^{BOJ}[g_{+2}]$	-0.012
		(0.013)
Forecast revisions on year-on-year inflation rates (π)		
ϑ_0^π:	$F_m^{BOJ}[\pi_{+0}] - F_{m-3}^{BOJ}[\pi_{+0}]$	-0.061^{***}
		(0.014)
ϑ_1^π:	$F_m^{BOJ}[\pi_{+1}] - F_{m-3}^{BOJ}[\pi_{+1}]$	0.024^{**}
		(0.010)
ϑ_2^π:	$F_m^{BOJ}[\pi_{+2}] - F_{m-3}^{BOJ}[\pi_{+2}]$	-0.008
		(0.014)
c:	Constant	-0.001
		(0.013)
Observations		33
Adjusted R^2		0.505

Note: Table 2 presents the results of estimating Equation (1). ΔEYF6_m represents intraday changes in six-month-ahead Euroyen futures rates (EYF6) within a half-hour window starting 10 min before and ending 20 min after the MP announcement. $F_m^{BOJ}[x_{+j}]$ represents a vector of the BOJ's forecasts for growth and inflation rates through the end of the upcoming fiscal year j, which are released in month m. We use data from 2008 to 2019, as the BOJ began publishing quarterly macroeconomic forecasts in 2008. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

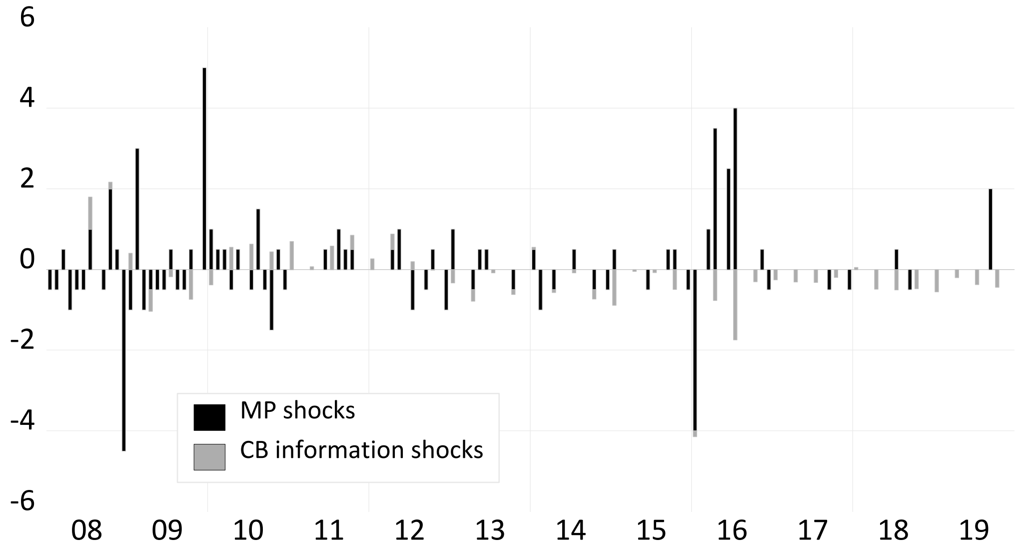


Figure 1: Contributions of MP shocks and CB information shocks (basis points). The shocks are identified by estimating Equation (1).

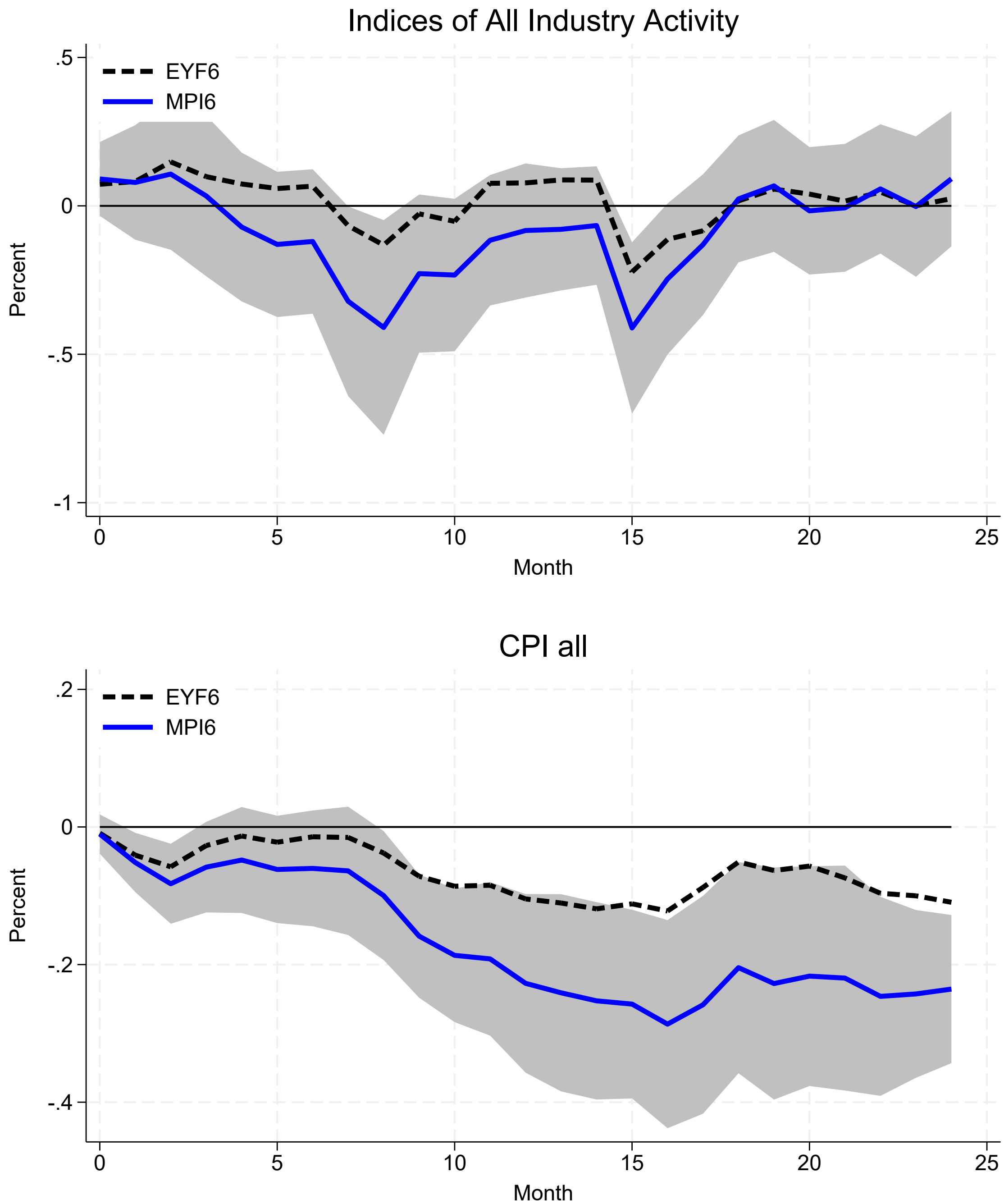


Figure 2: Impulse responses of output and prices to one-standard-deviation MP surprises (ΔEYF6) and shocks (MPI). MP surprises are intraday changes in six-month ahead Euroyen future rates (EYF6) during a half-hour window starting 10 min before and ending 20 min after the MP announcement. MP shocks are identified using Equation (1). The solid line represents the responses to MP surprises, while the dashed line represents the responses to MP shocks. Impulse responses are estimated using Equations (2). The horizontal axis indicates months. The gray bands are the 16- to 84-percentiles for the impulse responses to MP shocks.

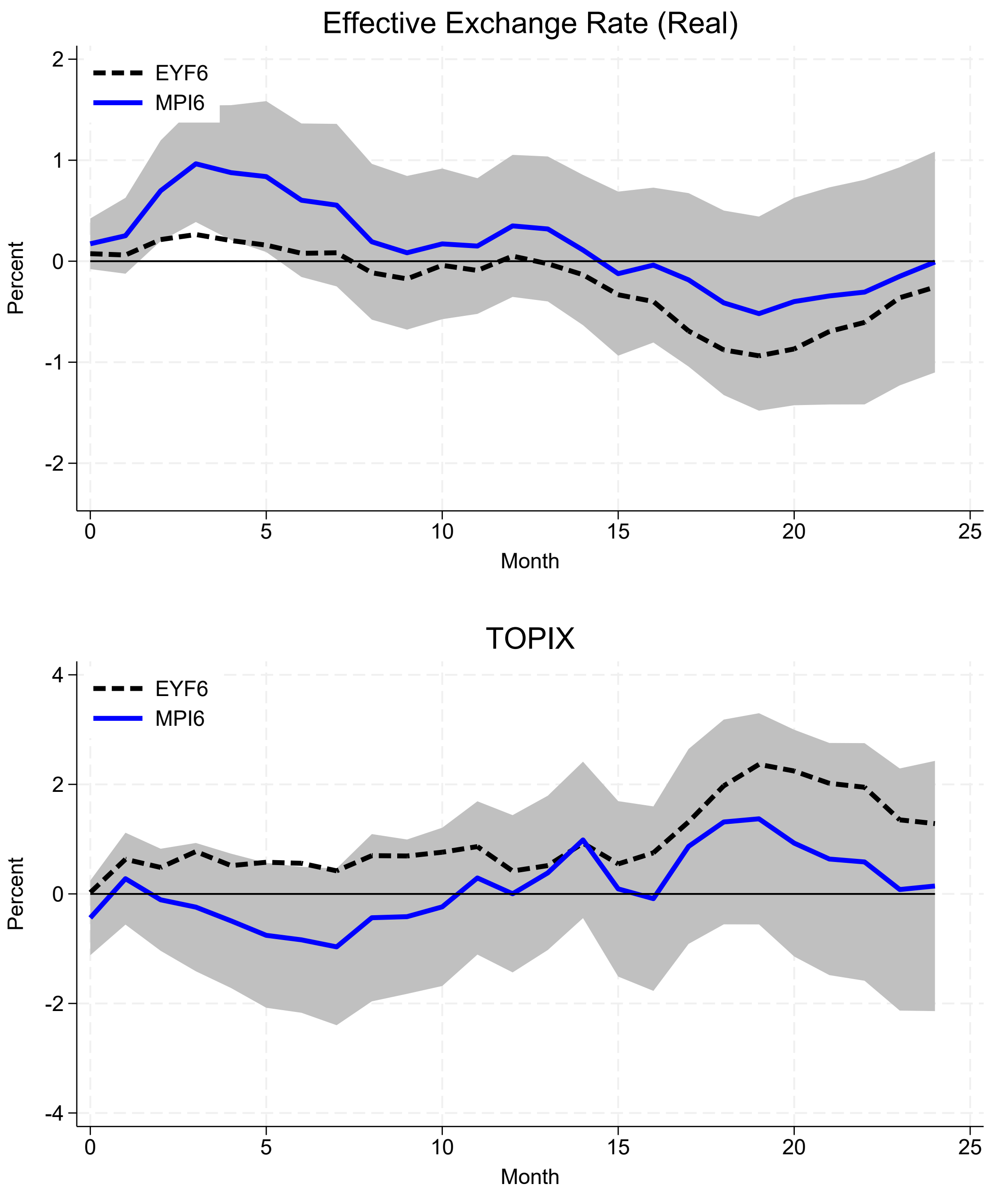
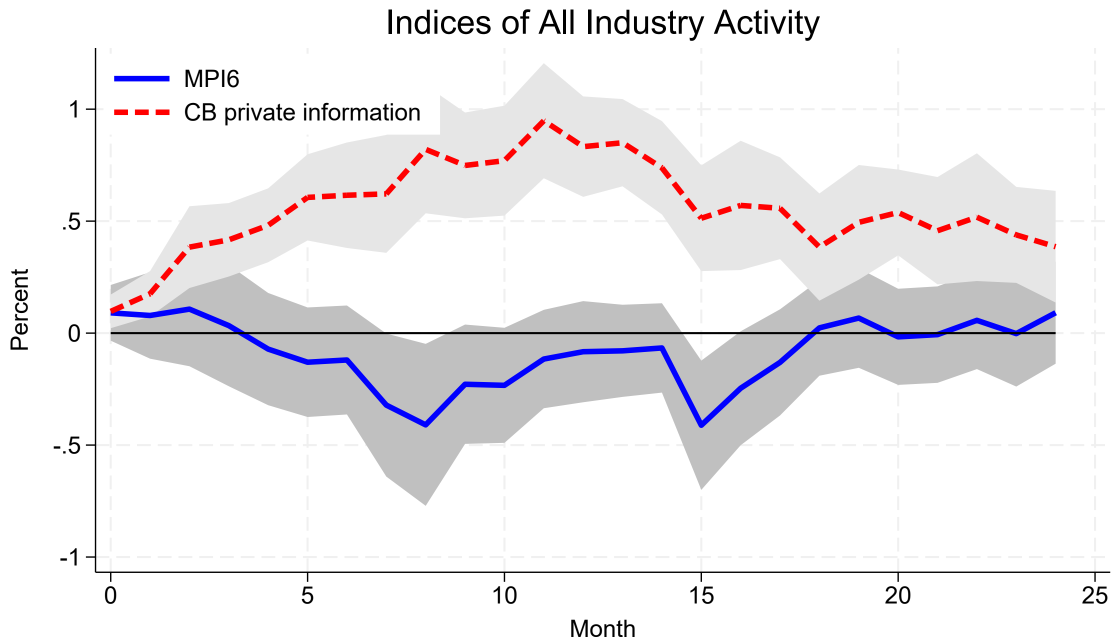


Figure 3: Impulse responses of financial variables to one-standard-deviation MP surprises (ΔEYF6) and shocks (MPI). MP surprises are intraday changes in 6-month ahead Euroyen future rates (EYF6) during a half-hour window starting 10 minitues before and ending 20 minitues after the MP announcement. MP shocks are identified using Equation (1). The solid line represents the responses to MP surprises, while the dashed line represents the responses to MP shocks. Impulse responses are estimated using Equation (2). The horizontal axis is months. The gray bands are the 16- to 84-percentiles for the impulse responses to MP shocks.



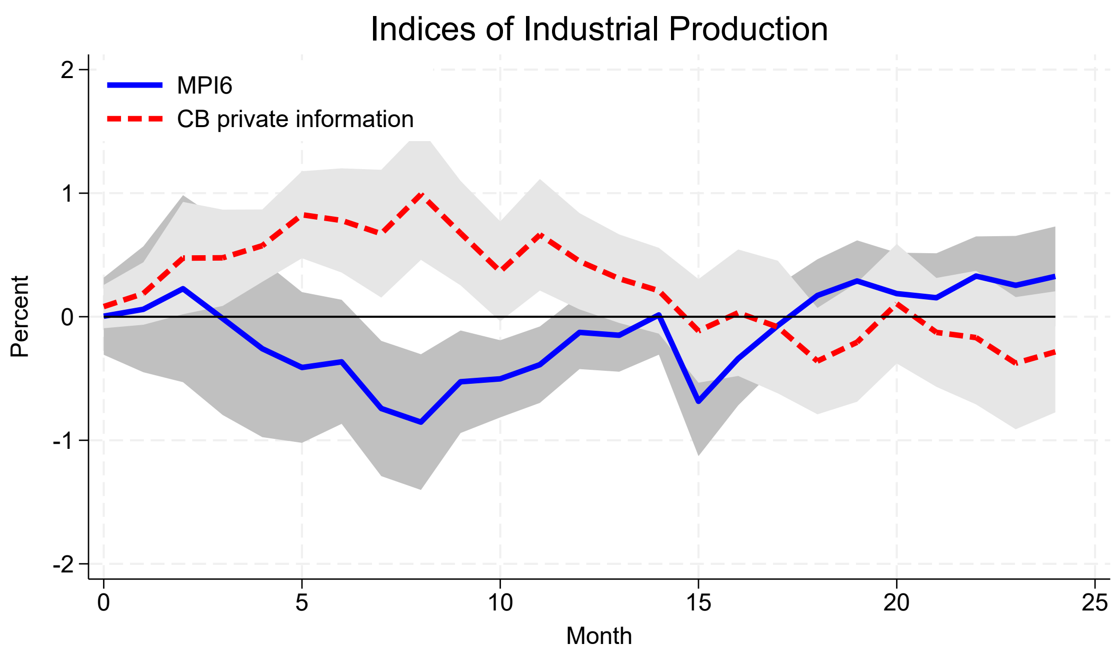
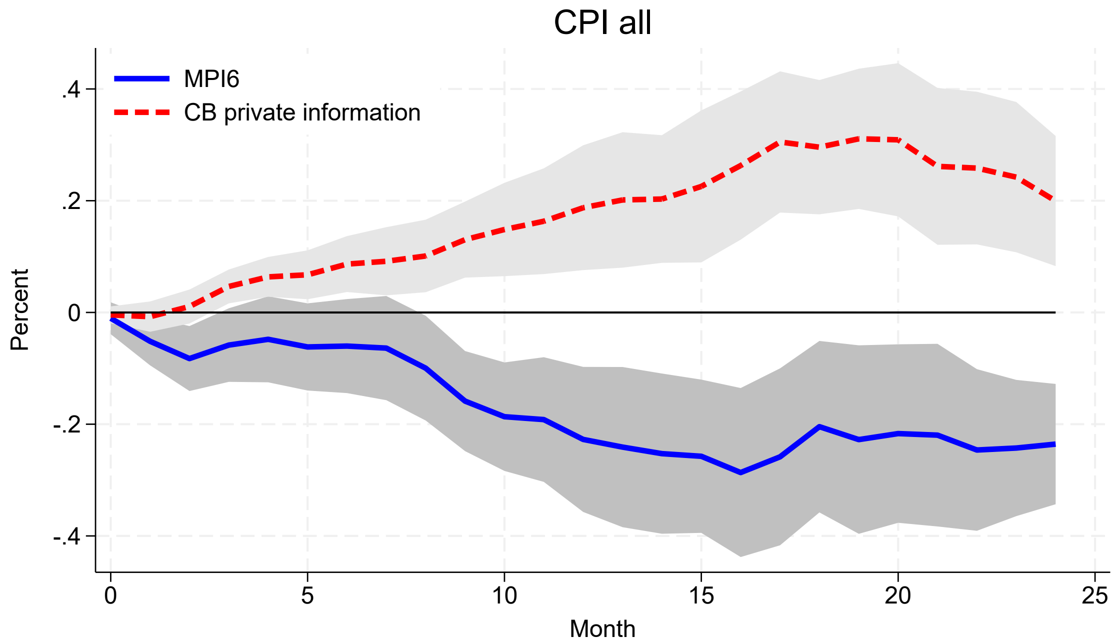


Figure 4: Impulse responses of output to one-standard-deviation MP shocks (MPI) and information shocks (CB private information). MP shocks and information shocks are identified using Equation (1). The solid line represents the responses to MP shocks, while the dashed line represents the responses to CB information shocks. Impulse responses to MP shocks and CB information shocks are estimated using Equations (2) and (3), respectively. The horizontal axis is months. The gray bands are the 16- to 84-percentiles.



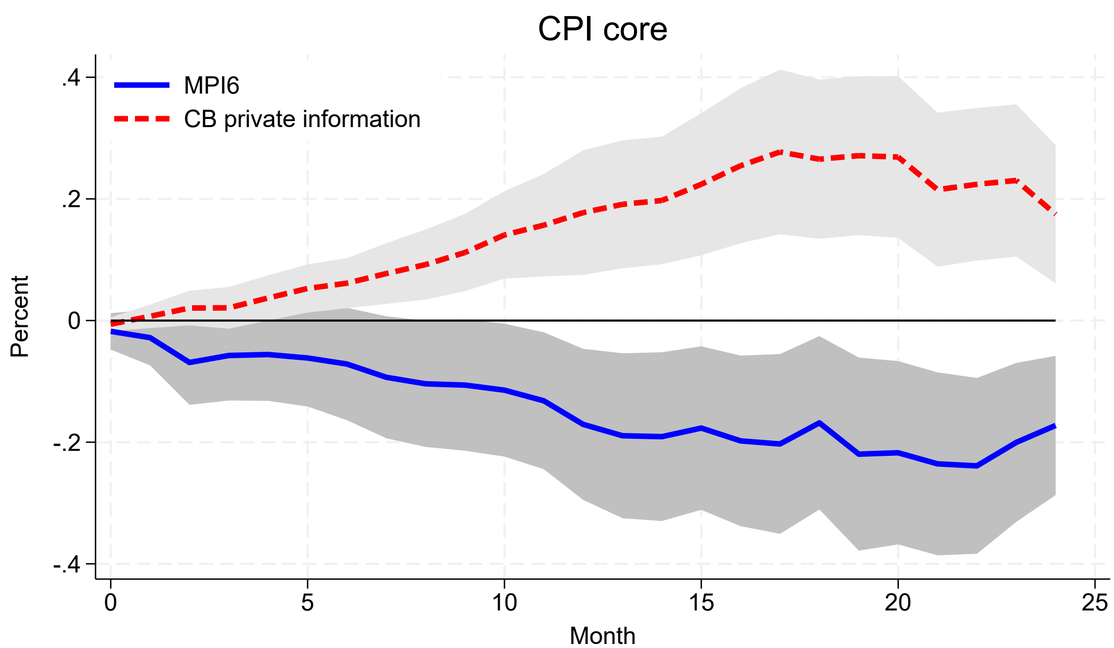
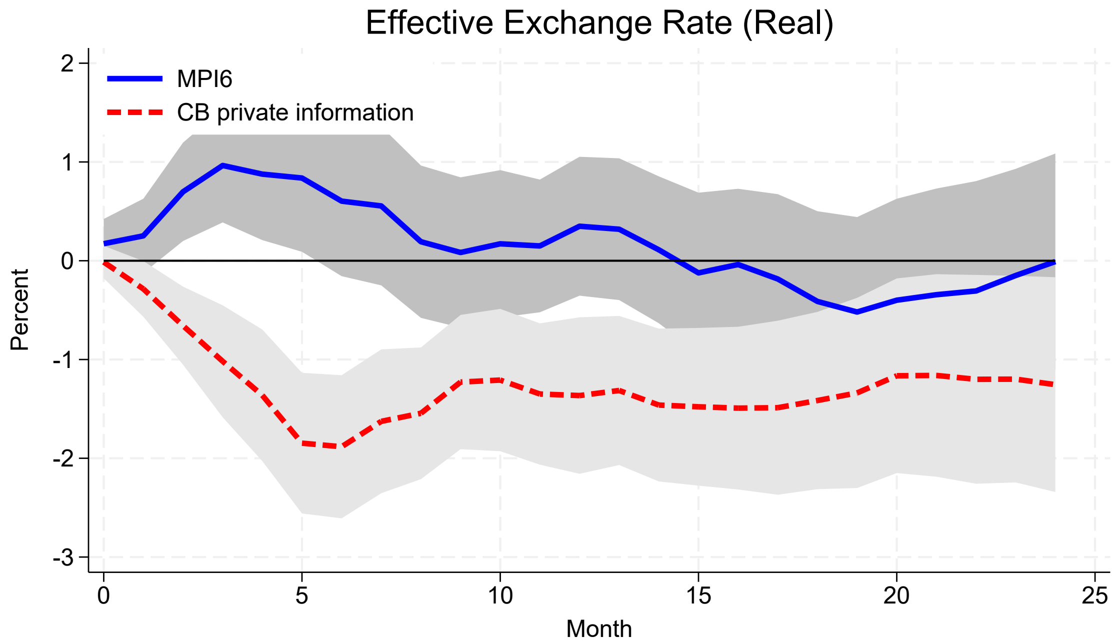


Figure 5: Impulse responses of aggregate prices to one-standard-deviation MP shocks (MPI) and information shocks (CB private information). MP shocks and information shocks are identified using Equation (1). The solid line represents the responses to MP shocks, while the dashed line represents the responses to CB information shocks. Impulse responses to MP shocks and CB information shocks are estimated using Equations (2) and (3), respectively. The horizontal axis is months. The gray bands are the 16- to 84-percentiles.



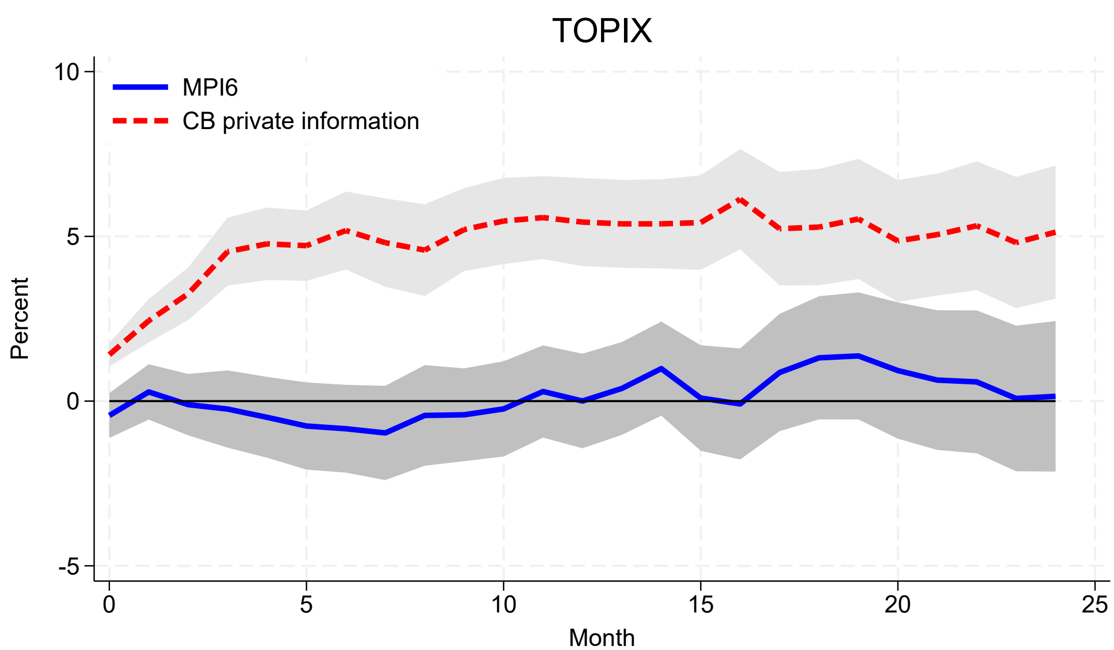


Figure 6: Impulse responses of financial variables to one-standard-deviation MP shocks (MPI) and information shocks (CB private information). MP shocks and information shocks are identified using Equation (1). The solid line represents the responses to MP shocks, while the dashed line represents the responses to CB information shocks. Impulse responses to MP shocks and CB information shocks are estimated using Equations (2) and (3), respectively. The horizontal axis is months. The gray bands are the 16- to 84-percentiles.

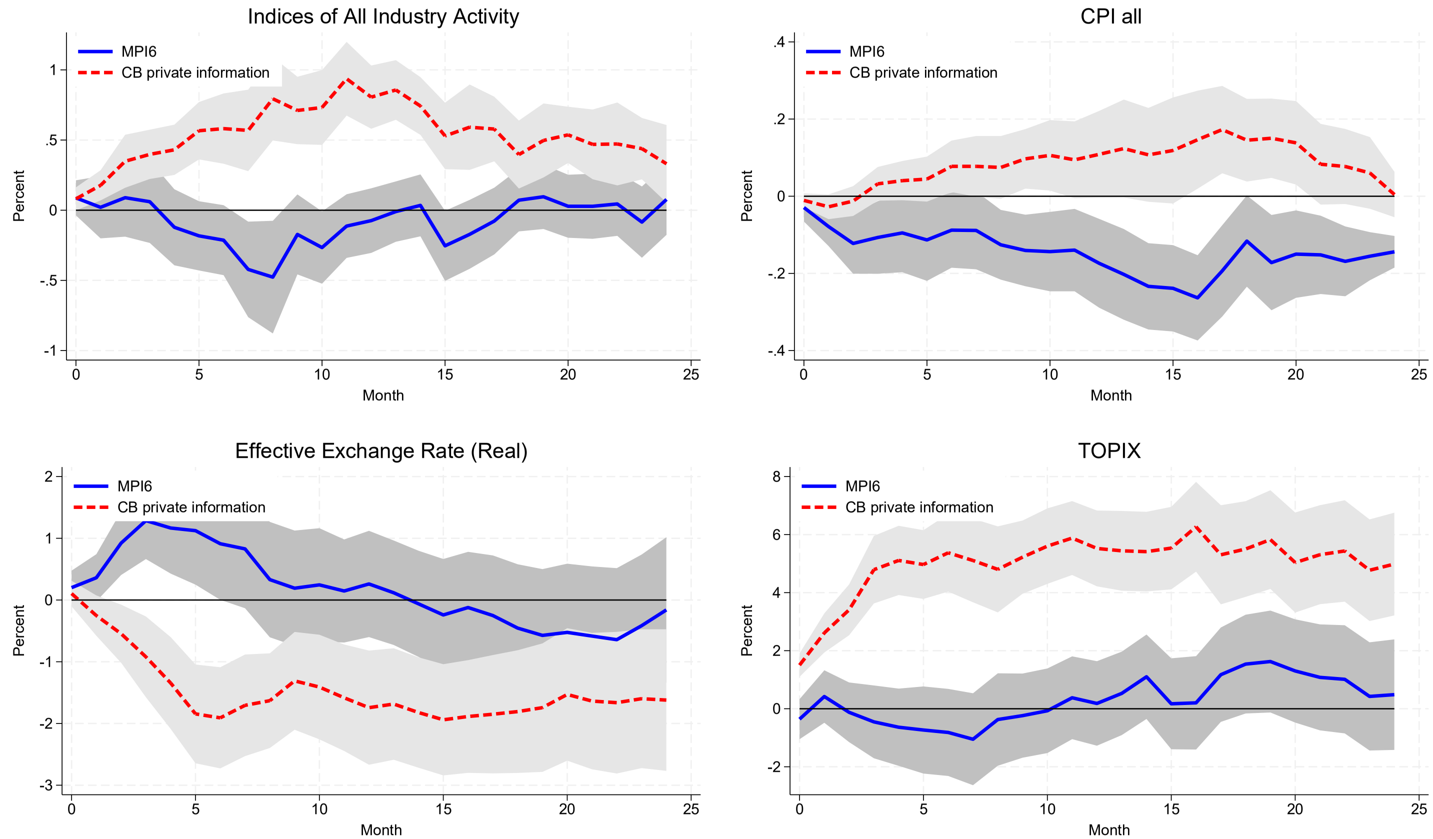


Figure 7: Robustness check using Equations (2) and (3). We show impulse responses to one-standard-deviation MP shocks (MPI) and information shocks (CB private information). MP shocks and information shocks are identified using Equation (1). The solid line represents the responses to MP shocks, while the dashed line represents the responses to CB information shocks. Impulse responses to MP shocks and CB information shocks are estimated using Equations (2) and (3), respectively. We changed the lag length of y to 24 in the corresponding equations. The horizontal axis is months. The gray bands are the 16- to 84-percentiles.