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Abstract

In this paper, we consider the issue of identifying unconventional monetary policy shocks in Japan by using the market-based measure of policy surprises obtained from high-frequency data. First, we investigate the effects of the monetary policy surprises on asset prices changes as an event study, which is based on the date and time of the monetary policy announcement made by the Bank of Japan. Using the methodology developed by Gürkaynak, Sack, and Swanson (2005), we find that the contractionary monetary policy has negative effects on stock returns. Second, we estimate the effects of unconventional monetary policy on real economic activity and inflation. By combining the vector autoregressive approach of Gertler and Karadi (2015) who employ high-frequency policy surprises as external instruments to identify the structural shocks, and that of Debortoli, Galí, and Gambetti (2020), who employ the long rate as the policy indicator during the period when the short rate is constrained by the zero lower bound, we find that unconventional monetary policy has been effective in Japan over the last two decades.

Keywords: unconventional monetary policy, high-frequency event study, structural vector autoregressive models, external instruments, zero lower bound

JEL Classification: E43, E44, E52, E58, G14

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1 Introduction

As a result of a decreasing trend in the natural rate of interest, controlling the short-term interest rate as a policy instrument is more likely to be constrained by the zero lower bound (ZLB) in many advanced countries. When there is no room to lower the policy rate in response to large negative shocks in the economy, such as the global financial crisis in 2008 or the outbreak of COVID-19 in 2020, central banks have no choice but to rely on unconventional policy instruments, including large-scale asset purchases and forward guidance. Among central banks in such an environment, the Bank of Japan (BOJ) is notable in having conducted a series of unconventional monetary policies for nearly two decades, since the time the zero interest rate policy was first introduced in 1999 in the aftermath of the non-performing loans problem. For the period of unconventional monetary policy, however, a traditional identification strategy of monetary policy shocks based on unexpected changes in the short-term interest rate can no longer be valid because the short-term interest rate is constrained at the ZLB.

In this paper, we identify unconventional monetary policy shocks in Japan using information from the intraday data on futures interest rates with various maturities, which reflects the expectations of the market participants on the monetary policy for medium to long horizons. We then use the identified unconventional monetary policy shocks to investigate the effect of unconventional monetary policy on the financial market as well as on real economic activity and inflation. Our identification strategy closely follows that of Gürkaynak, Sack, and Swanson (2005), who measured monetary policy surprises for the US, using changes in federal fund futures and three-month euro-dollar LIBOR futures in a sufficiently narrow window of time around the Federal Open Market Committee (FOMC) announcement. Likewise, we measure monetary policy surprises for Japan using changes in three-month euro-yen TIBOR futures and 10-year Japanese government bond (JGB) futures, around the Monetary Policy Meetings (MPM) announcement. With the use of the same time interval, asset price responses to monetary policy surprises can be appropriately evaluated because effects of other macroeconomic news are likely to be excluded.[1]

[1]According to Altavilla et al. (2019), changes in the policy stance that are orthogonal to the in-

We further combine the approaches of Gertler and Karadi (2015) and Debortoli, Galí, and Gambetti (2020) in evaluating the macroeconomic effect of unconventional monetary shocks. In particular, we follow Gertler and Karadi (2015) and use the high-frequency measure of monetary policy surprises as an external instrumental variable (IV) to identify the monetary policy shocks in the vector autoregressive (VAR) model. As in the case of Debortoli, Galí, and Gambetti (2020), it includes the long-term interest rate as the monetary policy indicator. We utilize the high-frequency data on euro-yen futures and JGB futures from 1999 to 2020, which covers the period in which the BOJ adopted the unconventional monetary policy.

Kuttner (2001) is one of the earliest studies to measure the monetary policy surprises from daily futures market data and examine the instantaneous effects of monetary policy on asset markets. Gürkaynak, Sack, and Swanson (2005) show that using intraday data of futures purifies the measurement of the monetary policy surprises by excluding the possibility of contamination by other shocks. They claim that the monetary policy surprises can be characterized by two factors with structural interpretation: the "target" factor which mainly affects the current short-term rates and the "path" factor which affects the expected path of future short rates. Swanson (2020) further claims the presence of an additional factor representing the effect of the Quantitative Easing (QE) policy, which he calls the "QE" factor. We also investigate whether monetary policy surprises can be summarized by a small number of common factors in Japan. As a result, the two factors, namely, the target and path factors, are found to be useful in describing market surprises in Japan as in the case of Gürkaynak, Sack, and Swanson (2005). Their high-frequency identification approach has now become quite common in the studies on the transmission channels of monetary policy. Other studies using such an approach include Nakamura and Steinsson (2018) and Cieslak and Schrimpf (2019), who focus on the information effect, Gürkaynak, Kara, Kısacıkoğlu, and Lee (2020), who investigate the relation to the foreign exchange rate, and Rogers, Scotti, and Wright (2014), who conduct international comparisons including Japan.

formation set of market participants are called (market-based) policy surprises, while changes that are orthogonal to the state of the economy are called policy shocks.

The method of identifying the structural shocks in the VAR model based on the external IV has been developed by Stock and Watson (2012), Mertens and Ravn (2013), Gertler and Karadi (2015), and Stock and Watson (2018), among others.[2] Gertler and Karadi (2015) have employed the market-based measure of monetary policy surprises as the external IV to identify the monetary policy shocks in the VAR framework.[3] Many studies follow the method of Gertler and Karadi (2015) in investigating the aggregate effect of monetary policy in the VAR framework. Miranda-Agrippino and Ricco (2019) pursues the identification of monetary policy shocks purged from information effects, and Kekre and Lenel (2020) focus on the risk premium channel. Lakdawala (2019) employs two factors of Gürkaynak, Sack, and Swanson (2005). Furthermore, Altavilla et al. (2019) and Kim, Laubach, and Wei (2020) focus on the asset purchases in the Euro area and the US, respectively, and employ the QE factor of Swanson (2020) as the external IVs.

Even if the sample contains the ZLB period in the US, Debortoli, Galí, and Gambetti (2020) identify the monetary policy shocks in the VAR model with the short-term rate replaced by the long-term rate. To be more specific, Debortoli, Galí, and Gambetti (2020) consider the so-called ZLB irrelevance hypothesis that the central bank can conduct effective monetary policy as in a normal time by controlling shadow rates through unconventional monetary policy tools, even if the ZLB is binding. They use a time-varying parameter VAR model with the 10-year bond rates and identify the shocks through a combination of long-run and sign restrictions, claiming that the estimated responses do not differ much between the periods before and after the ZLB is binding. We follow Debortoli, Galí, and Gambetti (2020) in employing the 10-year bond rates in the VAR model and in identifying the unconventional monetary policy shocks. Figure 1 shows the time series of the overnight call rates and the 10-year JGB yields in Japan. Since the long rates are less likely to be constrained by the ZLB after 1999, we do not need to incorporate nonlinear structure in the VAR model, unlike the case when the short-rate is included as a variable. In addition, the BOJ now considers the 10-year JGB yields as the policy target.

[2] See also Ramey (2016) for an extensive survey on identification strategies for monetary policy shocks.

[3] Alternatively, the market-based measure of monetary policy surprises can be directly included as a variable in the VAR model. See Barakchian and Crowe (2013) and Jarociński and Karadi (2020) for such an approach.

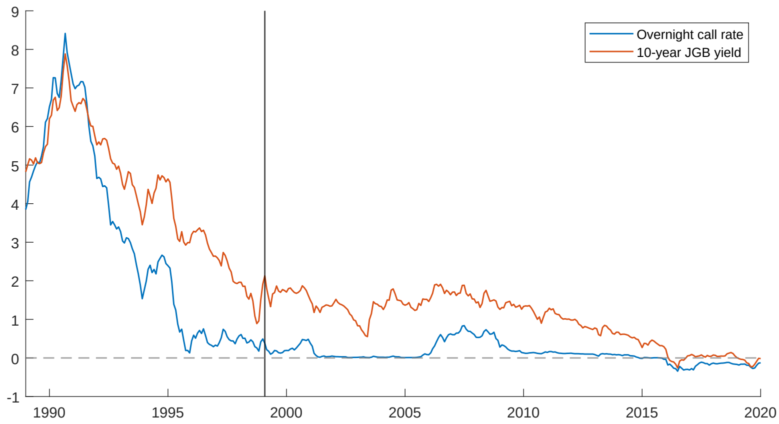


Figure 1. Overnight Call Rates and the 10-year JGB Yields

Note: The monthly averages of the interest rates from 1989 to 2020. The unit of the vertical axis is a percent. The vertical line indicates February 1999 when the zero interest rate policy was first introduced by the BOJ.

In fact, at the time when the the Yield Curve Control (YCC) policy was introduced, the BOJ announced, in the statement released after the MPM on September 21, 2016, that "The Bank will purchase Japanese government bonds (JGBs) so that 10-year JGB yields will remain more or less at the current level."Furthermore, from long before the YCC, the BOJ has been using the long-term rates as its effective policy instrument, in the sense that the long-term government bond purchases and forward guidance policy have been employed throughout our sample period.[4] For these reasons, we believe that employing the 10-year rates in our VAR model helps us to identify the unconventional monetary policy shocks rather then employing the short-term rate or other policy instruments, such as the monetary base.

In earlier VAR studies on conventional monetary policy in Japan, the short-term rate has been often employed as the main policy variable, including Miyao (2000) and Miyao (2002), who use the standard Cholesky decomposition, and Braun and Shioji (2006), who use the sign restriction to identify monetary policy shocks. For the later studies on the ZLB period, other variables are employed in the VAR model as a main policy indicator, which is in line with change of the policy target by the BOJ. Among these studies, Honda,

[4]The BOJ had purchased the long-term government bonds even before adopting the zero interest rate policy in 1999. This fact is explained in the statement released after the MPM on February 12, 1999. The pace of the purchases had been gradually increased and arrived at 80 trillion yen per year in 2014. This pace was maintained at least until early 2020.

Kuroki, and Tachibana (2013) use the BOJ's current account balances, and Iwasaki and Sudo (2017) use the shadow rates in the VAR model to identify the monetary policy shocks. Identification of unconventional monetary policy shocks in nonlinear VAR models has been conducted in several papers, which include Kimura and Nakajima (2016) and Hayashi and Koeda (2019), who use the regime-switching VAR model; Miyao and Okimoto (2020), who use the smooth transition VAR model; and Ikeda, Li, Mavroeidis, and Zanetti (2020), who use a censored and kinked VAR model. For the event studies to measure the monetary policy surprises in Japan, Honda and Kuroki (2006) consider the change in the daily euro-yen futures series from the period before the ZLB period, while their events are different from the MPMs. Arai (2017) investigates the pass-through from the JGB spot yields to asset prices using a daily window around MPMs. For the high-frequency identification of monetary policy surprises from MPM announcements, both Rogers, Scotti, and Wright (2014) and Cieslak and Schrimpf (2019) use the intraday data of JGB futures. In a more recent study, Nakamura, Sudo, and Sugisaki (2020) also use the intraday data of euro-yen futures and emphasize the importance of using a tight window to identify the monetary policy surprises, while they do not consider the presence of multiple factors. For VAR analyses using the market-based surprise measures as external IVs in Japan, Nakashima, Shibamoto, and Takahashi (2019) identify the multiple unconventional monetary policy shocks while their market surprises are constructed from daily data. Our analysis differs from previous VAR studies as we identify the unconventional monetary policy shocks using intraday data for euro-yen futures of various maturities as well as JGB futures.

The remainder of the paper proceeds as follows. In Section 2, we briefly describe our methodology and show the results from the high-frequency event study. In Section 3, we investigate the effectiveness of unconventional monetary policy on aggregate economy using the VAR model. Our remarks conclude in Section 4.

2 High-frequency Event Study

2.1 Monetary Policy Surprise

In this section, we first describe our intraday series and the methodology used to construct our monetary policy surprises and then present the result of event study regressions. We employ the euro-yen futures and the JGB futures to measure the policy surprises. The euro-yen futures rate is a futures contract for the three-month Tokyo Interbank Offered Rates (TIBOR) on a specific future date.[5] Since the euro-yen futures are traded for multiple contract months, we collect four series; three-, six-, nine-, and twelve-month ahead euro-yen futures rates, which will be denoted by EYF3, EYF6, EYF9, and EYF12, respectively. To be more specific, we use only the contract with a remaining maturity of more than 14 days. For example, EYF3 contains information from the euro-yen futures for which a contract can have as little as 14 days to expiration and as much as 3.5 months to expiration, with an average horizon of 2 months.[6] Similarly, EYF6, EYF9, and EYF12 have 5, 8, and 11 months, respectively, to expiration on average. On expiration, euro-yen futures settle based on the spot three-month TIBOR so that EYF3, EYF6, EYF9, and EYF12 represent the current expectation of the three-month interest rate after 2, 5, 8, and 11 months on average, respectively. For simplicity, we refer to surprises obtained from four euro-yen futures data as EYF surprises. Because of the term structure of interest rates, we interpret EYF surprises as containing information on unexpected changes in the medium-term rate.

The JGB futures rate is a futures contract for a hypothetical 10-year JGB. Since we use only JGB futures with a nearby month, policy surprises reflect unexpected changes

[5] TIBOR is the prevailing interest rate in the Japan Offshore Market (JOM). As the futures contract equivalent to the Federal Fund futures in the US, overnight call rate futures can also be used in Japan. It is a futures contract for the uncollateralized overnight call rate, which was the main policy target of the BOJ during the conventional monetary policy period. However, the data for overnight call rate futures are available only in the period from 2007 to 2017. In contrast, high frequency data for euro-yen futures, as well as JGB futures, are available for the past 20 years, which corresponds to the entire period of unconventional monetary policy.

[6] Euro-yen futures have expiration dates that lie about two weeks before the end of each quarter. For this reason, we measure for example the EYF3 surprises for January and February by the March contract, from March to May by the June contract, from June to August by the September contract, from September to November by the December contract, and for December by the next-March contract.

in up to three-month ahead long-term rates.[7] It should be noted that the expected long-term rate, which is reflected in the JGB futures, is also informative regarding the expected path of short-term rates.[8] In what follows, we refer to JGB futures as JGBF.

Monetary policy surprises are measured by the difference between the futures rate ten minutes before and the futures rate twenty minutes after the monetary policy announcement. Here, the monetary policy announcement is referred to as various types of events that are related to releasing the information on the monetary policy officially by the central bank.[9] For the time being, we focus on the press releases of the statements decided in the MPMs called "Statement on Monetary Policy" as the monetary policy announcement. MPMs have been regularly held once or twice a month since the revision of the Bank of Japan Act in January 1998. The frequency of the MPMs is later set at eight times a year from January 2016. After the BOJ decided to hold the MPMs regularly, the schedule of MPMs was made public in advance. The statement is released quickly after every MPM on the website, which reveals the information on the decision for the first time, and the governor's press conference is held within the same day after the press release. In general, the market participants can revise their expectations on the future interest rate in response to any news on the prospects of the economy rather than to the news on the monetary policy conducted by the central bank. By taking a tight thirty-minute window around the policy announcements, we expect to capture the revisions of the market's expectations purely caused by monetary policy.

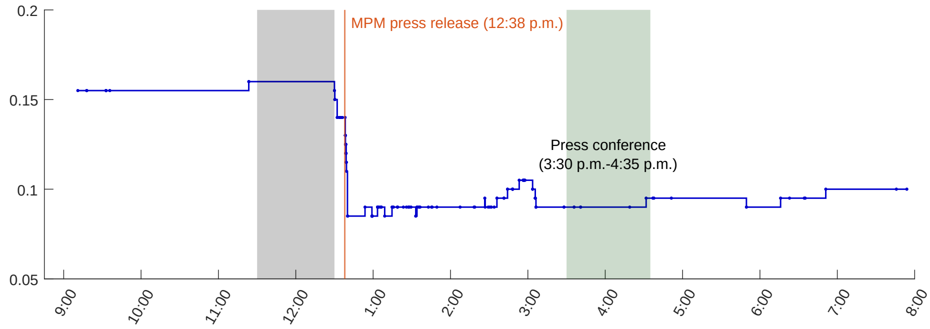
To illustrate the relationship between our monetary policy surprise measure and the discontinuity around the monetary policy announcements, we plot changes in EYF3 in Figure 2 on three selected dates of the MPMs. Note that a decline in EYF3 implies a

[7]While the JGB futures are traded for multiple contract months, most of the trades are concentrated in the leading contract month. They are traded for the quarterly months (March, June, September, and December) and the nearby month has often been the leading month.

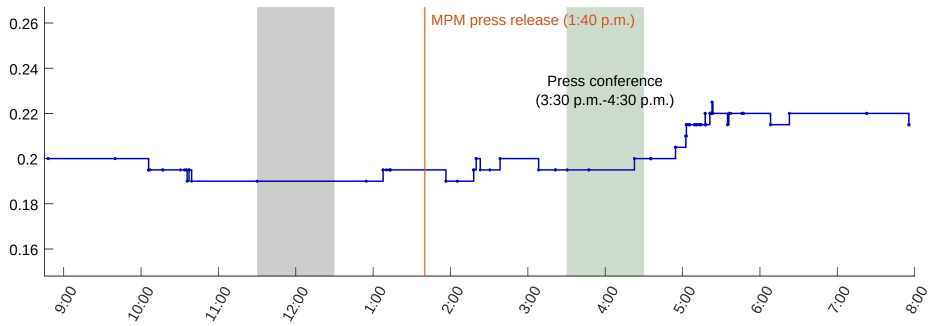
[8]Since the JGB futures are written on a hypothetical 10-year JGB with coupons, to calculate changes in the expected long rates from the JGB futures prices, we approximate the change in the yield of the cheapest-to-deliver with the rate of change in the futures prices. To be specific, we calculate the rate of change in prices divided by the negative of the maturity of the cheapest, which we regard as the duration, similarly to Cieslak and Schrimpf (2019). For simplicity, we also consider the maturity of the cheapest uniformly as seven, as Hattori (2019) points out that the 7-year JGB has been the cheapest in Japan.

[9]According to the terminology used by Gürkaynak, Sack, and Swanson (2005), the announcement refers to "any means by which a policy decision was communicated to financial markets, including open market operations as well as explicit press releases (p. 57)."

(i) January 29, 2016 (March 2016 Contract)



(ii) April 4, 2013 (June 2013 Contract)



(iii) July 29, 2016 (September 2016 Contract)

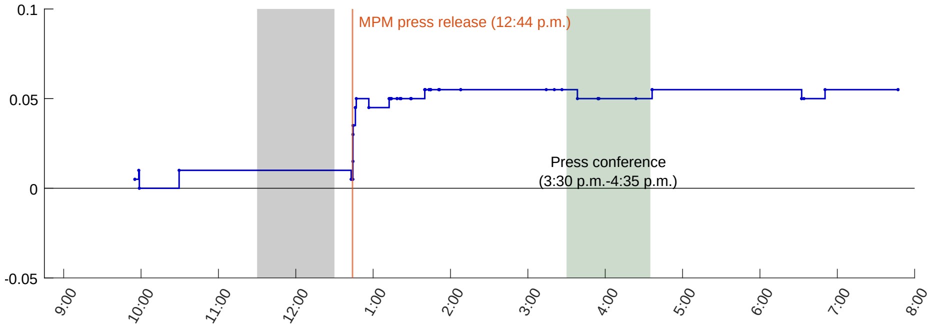


Figure 2. Intraday Changes in the Euro-yen Futures Rate (1)

Note: Each panel shows the three-month ahead euro-yen futures rates (percentage) on the selected MPM date. The times of the press releases are indicated by the vertical lines for every panel. The dark shaded area indicates the lunch break for the euro-yen futures market (11:30 a.m.-12:30 p.m.), and the light shaded area indicates the press conference for the explanation of the policy decisions in the MPM.

decline in the expected future short-term rate. Panel (i) shows the changes in EYF3 on January 29, 2016, when the BOJ introduced a negative interest rate policy. We can observe a sharp drop in EYF3 tight around the press release at 12:38 p.m. This change suggests that the announcement was unanticipated to some extent, and the market participants revised their expectation on the short rates in response to the announcement. Panel (ii) shows the changes in EYF3 on April 4, 2013, when the BOJ introduced the Quantitative and Qualitative Monetary Easing (QQE) policy. The QQE includes (1) the policy target change from the uncollateralized overnight call rate to the monetary base; (2) the long-term bond and exchange-traded fund (ETF) purchases; and (3) the forward guidance. Although it was one of the largest policy actions in the last two decades, the EYF3 surprise was 0.5 basis points. This result implies that the policy action had almost been anticipated prior to the press release at 1:40 p.m.

Panel (iii) shows the changes in EYF3 on July 29, 2016, when the BOJ enhanced the monetary easing by increasing the pace of purchasing ETF twice as fast as before. From a rise in EYF3 shortly after the press release, we know that the monetary decision led to an upward revision of the expected short-term rates. In this case, we can discern that the actual monetary decision was perceived as a disappointment by the market participants, and that the futures rates responded in the opposite direction to the policy decision. This conjecture can be confirmed by the CNBC article explaining that the market had expected further monetary easing actions on that day.[10]

From the three examples above, we can rely on the thirty-minute surprises in the futures rates to capture the unanticipated movements in the market's expectations, even in the periods during which the unconventional monetary policy is employed.[11] Since

[10]The July 29, 2016 CNBC article, "Nikkei whipsaws after BOJ disappointment; yen surges against dollar" reported that "the Bank of Japan threw markets a smaller-than-expected bone in a keenly watched decision on Friday." It also reported that "it didn't change interest rates or increase the monetary base, as analysts had widely expected," while the BOJ decided to increase ETF purchases.

[11]On some occasions, a jump in the futures rate is observed shortly before the timing of the announcement. For instance, on January 29, 2016 in panel (i) in Figure 2, the futures rate began to move a few minutes before the press release. This observation suggests the possibility of information leakage about the decisions in the MPM. Our thirty-minute window can also capture such movements up to ten minutes before the announcements. While there are trade-offs in capturing the information leakage beyond ten minutes by using a wider window and the identification of pure monetary surprises, we later show that a thirty-minute window is a reasonable choice in the event study regressions.

the intraday data of euro-yen futures is available from September 1999 through February 2020, we construct four series of the monetary policy surprises around 280 press releases from the corresponding period. Because the zero-interest policy was first introduced in Japan on February 12, 1999, our sample covers the entire ZLB period when the various unconventional monetary policies were conducted.[12]

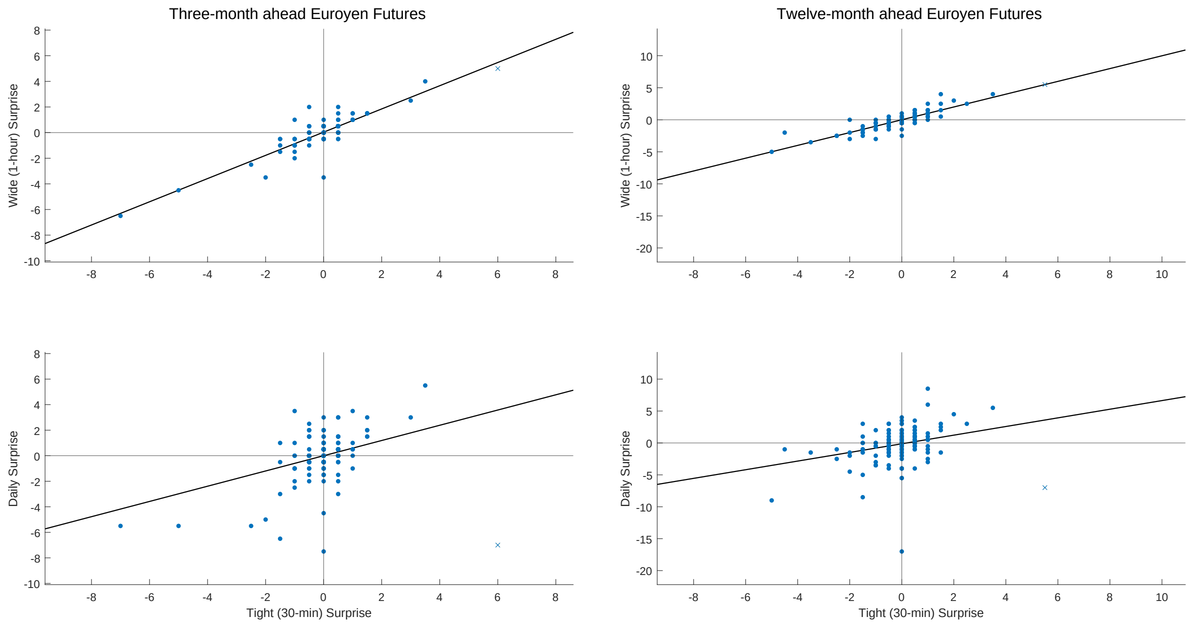


Figure 3. Monetary Policy Surprises: Comparison with Alternative Windows

Note: The left and right panels show the EYF3 and EYF12 surprises around 280 press releases from October 13, 1999 through January 21, 2020, respectively. Crosses indicate the values on December 1, 2009, which we will discuss later. The unit of every axis is a basis point. The least squares fitted lines are also shown.

Let us follow Gürkaynak, Sack, and Swanson (2005) and compare the thirty-minute window to the alternative window sizes on the construction of monetary surprise measures. In addition to the "tight" window surprises within a thirty-minute window, we consider the "wide" window surprises measured within a one-hour window as well as

[12]Although it was not until October 13, 1999 that the term "zero interest rate policy" appeared in the statements, it was February 12 1999 when the interest rate was decreased to effectively zero, and no policy change took place on October 13. According to the minutes of the MPM on February 25, 1999, "on February 17, the weighted average of the overnight call rate declined to a record low of 0.08 percent in response to the governor's statement at a press conference on the previous day that the Bank would allow the overnight call rate to fall to zero percent if possible." The overnight call rate indeed declined close to zero in March, and consequently, the market perceived that the BOJ allowed the short-term interest rate to be virtually zero as of February 12 1999. Accordingly, we set the ZLB period to begin in February 1999.

the "daily" window surprises.[13] Figure 3 compares the surprise measures using three alternative windows, in which the left panel and the right panel show the comparison for EYF3 and EYF12 surprises, respectively. The top two panels compare the tight window surprises and the wide window surprises, and the bottom two panels compare the tight window surprises and the daily window surprises. The figure shows that all three surprises are positively correlated. The tight window surprises and the wide window surprises move closely to each other but there seems to be deviations between the daily window surprises and the tight surprise. This situation suggests that the daily window surprises are likely to be influenced by news unrelated to the monetary policy announcements.

	ZLB Period (1999-2020)			Pre-ZLB Period (1989-1999)	
	Tight	Wide	Daily	Daily	Honda and Kuroki (2006)
Mean	-0.013	0.025	-0.009	-3.243	-1.618
	(0.050)	(0.052)	(0.084)	(1.401)	(2.205)
Standard dev.	0.842	0.873	1.401	8.519	16.353
Obs.	280	280	280	37	55

Table 1. Monetary Policy Surprises: Descriptive Statistics

Note: All the surprises other than in the last column are measured with EYF3. The means and the standard errors are expressed by basis points. For the ZLB period, the sample consists of 280 press releases from October 13, 1999 through January 21, 2020. For the pre-ZLB period, the sample of the daily surprises consists of 37 policy announcements from October 11, 1989 through January 21, 1999), while the sample of the series of Honda and Kuroki (2006) consists of 55 events from August 7, 1989 through March 1, 2001. Since the MPMs were not held until 1997 and the statements were released only on the timing of the policy changes, the surprises are measured when the policy changes were made for that period. The second row in the parentheses show the standard errors.

The first three columns of Table 1 show the descriptive statistics of EYF3 surprises, expressed in the unit of basis points, using alternative windows around press releases. We observe that the surprises are unbiased around mean zero and the standard deviation is the smallest for the tight window surprises. While not shown in the table, the F-statistic of 2.768 suggests that the null hypotheses of the same standard deviations for the daily window surprises and tight window surprises is rejected in favor of a larger

[13] The wide window surprise is the difference between the futures rate 15 minutes before and the futures rate 45 minutes after the announcement, and the daily window surprise is the difference between the closing rate before and the closing rate after the announcement.

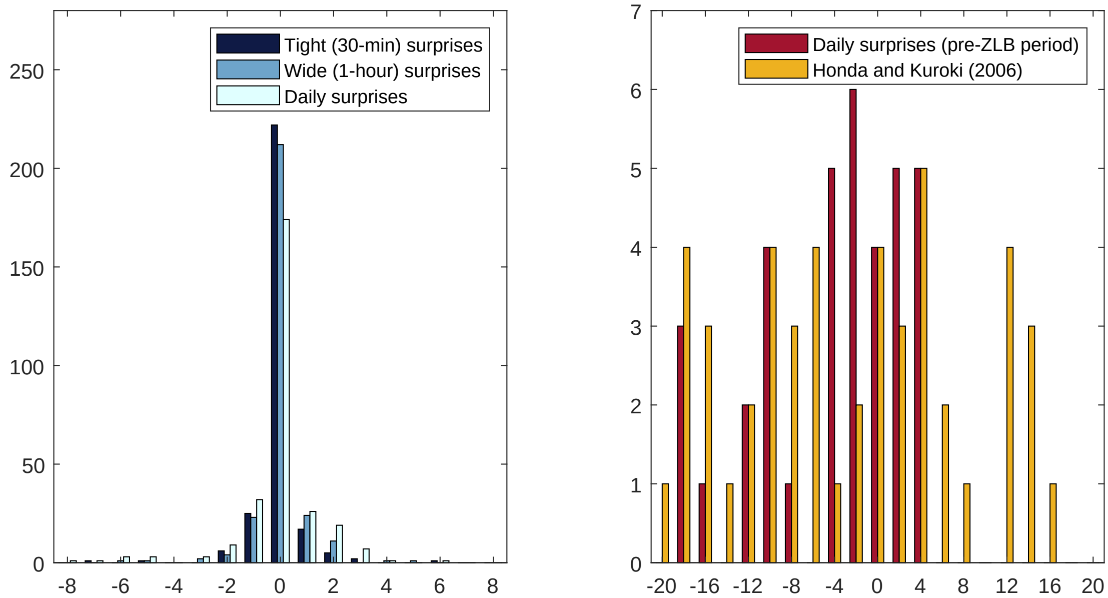


Figure 4. Monetary Policy Surprises: Empirical Distribution

Note: The left panel shows the distributions of the tight, wide, and daily EYF3 surprises around 280 press releases after 1999. The right panel shows the histogram of the daily surprises around press releases before 1999 and the series of Honda and Kuroki (2006). For the details of each series, refer to texts and the footnotes in Table 1. The unit of the horizontal axis is a basis point.

standard deviation for the daily windows surprises at the 1 percent significance level.[14] This outcome implies that daily window surprises contains additional news surprises.

In the fourth and fifth columns of Table 1, we show the summary statistics of two measures of EYF3 surprises for the period before 1999, which we refer to as the pre-ZLB period. The first surprise measure is the daily window surprises that can be directly compared with the daily windows surprises from the ZLB period.[15] The second surprise measure, proposed by Honda and Kuroki (2006), uses windows wider than the daily window. Honda and Kuroki (2006) claim that the information on the policy changes had been transmitted gradually in Japan. Their window sizes vary among events that are determined on the basis of past news articles. Figure 4 shows the empirical distribution of each surprise series. Those for the ZLB period are shown in the left panel, while those for the pre-ZLB period are shown in the right panel. We observe that the daily window surprises for the pre-ZLB period are negatively biased, as the null hypothesis of

[14] At the same time, the null of same standard deviations between the wide window surprises and the tight window surprises is not rejected at the 10 percent level with the F-statistic of 1.076.

[15] The tight window surprises and wide window surprises for this period are not shown because high-frequency data for euro-yen futures is not available before September 1999.

zero mean is rejected at the 5 percent significance level. In contrast, the unbiasedness hypothesis is not rejected for the series of Honda and Kuroki (2006). It is also clear that the standard deviation of daily window surprises has become much smaller in the ZLB period. Based on the F-test statistic of 37.003, we reject the null hypotheses that the standard deviations of daily window surprises are the same between the pre-ZLB and ZLB periods, in favor of a larger standard deviation in the pre-ZLB period at the 1 percent significance level. The same is true when we compare the standard deviation of daily window surprises in the ZLB period and that of the series of Honda and Kuroki (2006) with the F-statistic of 136.345. This result suggests that the expectations on the short rates fluctuate more during the time when the short-term rate is not constrained by the ZLB.

Using the time series plot is also useful in understanding the effect of choosing the window size on the measure of the monetary policy surprises. Figure 5 plots the tight window and the daily window EYF3 surprise series in the top and bottom panel, respectively. In the figure, we observe three events when the difference between the two surprise series is larger than 5 basis points. These three dates, shown as (a), (b), and (c) in the figure, provide useful case studies for understanding the source of the difference between the tight window surprises and daily window surprises. Figure 6 shows the intraday changes in EYF3 for the corresponding three events.

For December 19, 2006 in panel (a) and January 22, 2008 in panel (b), the tight window surprises are smaller than the daily window surprises. First, for December 19, 2006, both tight window surprise and the daily window surprise is negative but the latter is much larger in size. In fact, the change at the time of the end of the press conference accounts for a large fraction of the daily window surprise. Second, for January 22, 2008, the euro-yen futures rate hardly changed within the thirty-minute window around the MPM press release.[16] However, the daily window surprise is large and negative because the euro-yen futures rate varied through the day due to drastic falls in stock prices,

[16] If we simply measure the thirty-minute surprise on this day, it will be zero, since the thirty-minute window around the MPM press release is within the lunch break in the euro-yen futures market. To avoid this situation, we set the thirty-minute windows excluding the trade breaks. We describe this point in the Appendix.

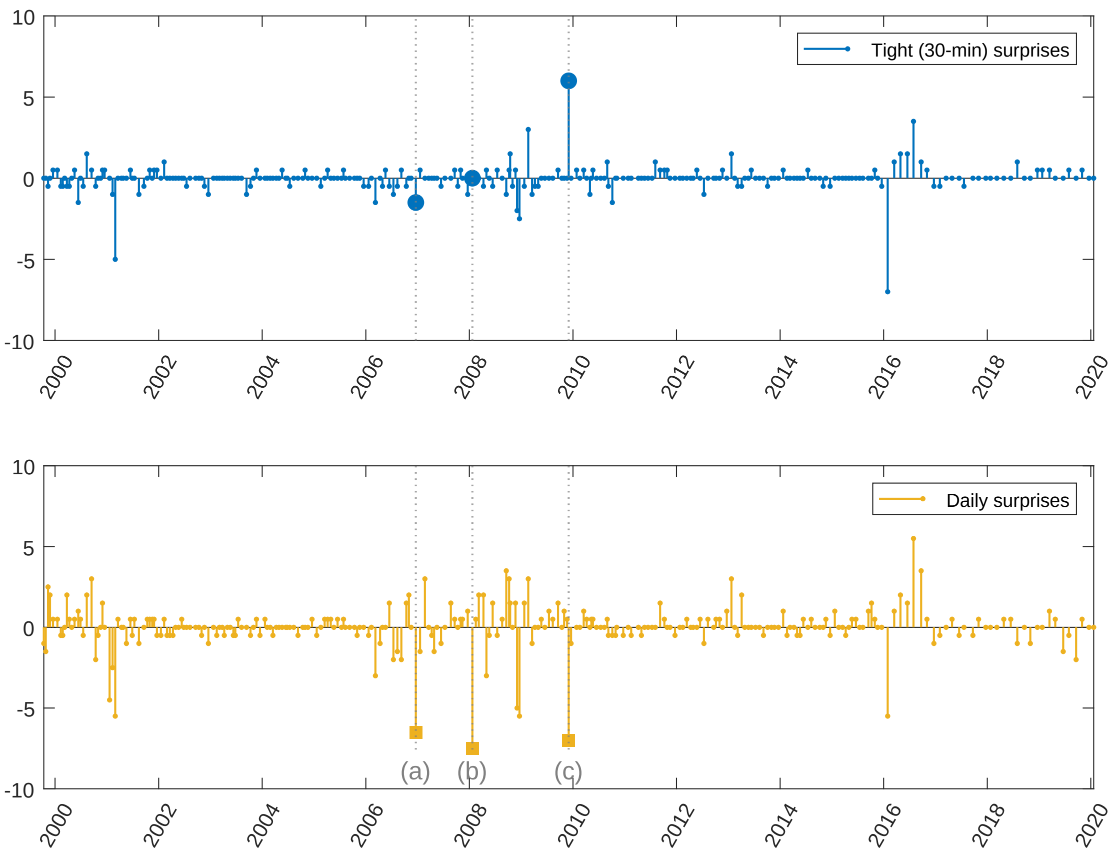
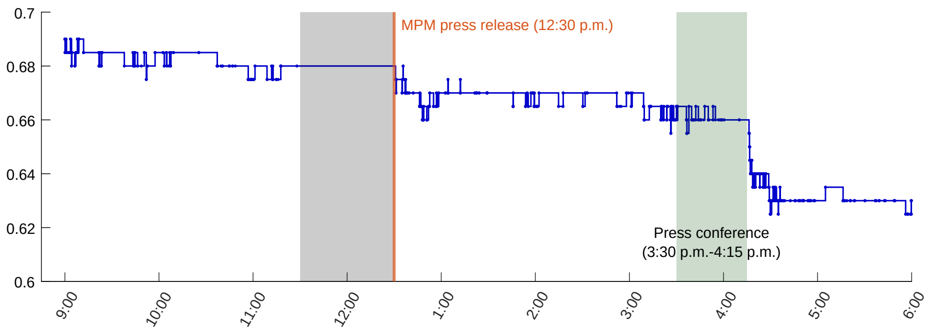


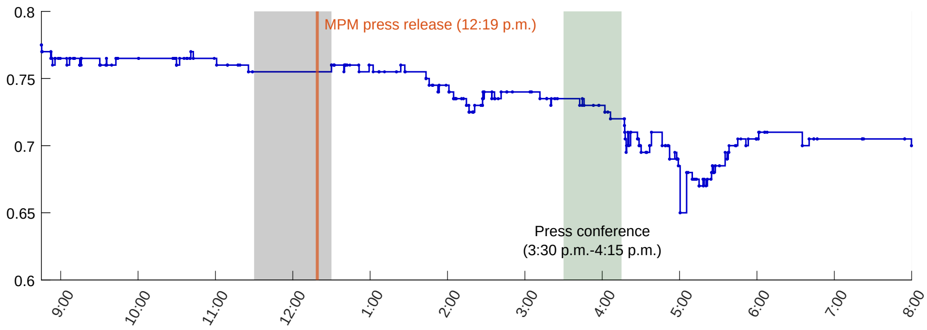
Figure 5. Monetary Policy Surprises: Time Series Plot

Note: The top panel and the bottom panel show the values of tight surprises and those of daily surprises for the three-month ahead euro-yen futures rate (basis points), respectively. Each of (a), (b), and (c) marked in the figure indicates December 19, 2006, January 22, 2008, and December 1, 2009, respectively. The sizes of surprises on the three dates are indicated by the circles in the top panel and the squares in the bottom panel.

(a) December 19, 2006 (March 2007 Contract)



(b) January 22, 2008 (March 2008 Contract)



(c) December 1, 2009 (March 2010 Contract)

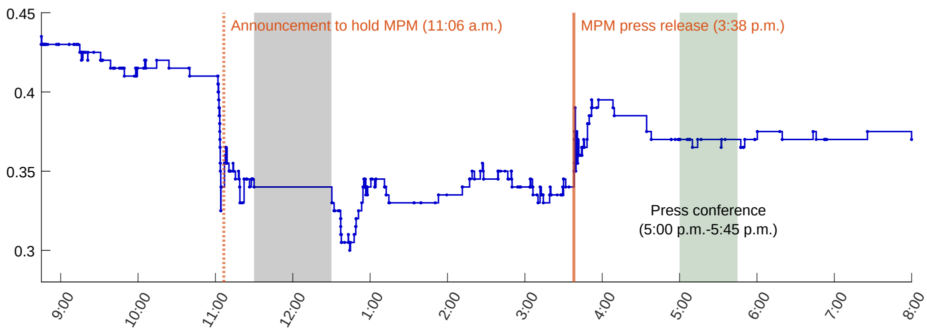


Figure 6. Intraday Changes in Euro-yen Futures Rate (2)

Note: Each panel shows the three-month ahead euro-yen futures rates (percentage) on the selected MPM date. The times of the press releases are indicated by the vertical lines for every panel, and the time of the announcement to hold the unscheduled MPM is indicated by the dotted vertical line only for panel (c), which is the date of the unscheduled MPM. The dark shaded area indicates the lunch break for the euro-yen futures market (11:30 a.m.-12:30 p.m.), and the light shaded area indicates the press conference for the explanation of the policy decisions in the MPM. Since the precise times of the announcements to hold the unscheduled MPMs are not made public by the BOJ, the time at which the first news flash bulletin about holding the unscheduled MPMs was released in Bloomberg is indicated.

the speech in the governor's press conference after the MPM, and a speculation on an emergency rate cut in the US.[17] These two examples imply that the effects from events other than the press release are likely to be excluded from the thirty-minute window surprises.

For December 1, 2009, in panel (c), both the tight and daily surprises are large in size but they are in the opposite directions.[18] On that day, the BOJ held an unscheduled MPM and announced the resumption of the QE for the first time in four years.[19] Despite the BOJ's decision, the tight surprise indicates the largely positive, i.e., contractionary surprise. It is considered to be a similar case to what we have observed for July 29, 2016 in panel (i) of Figure 2. Specifically speaking, the market had anticipated a further monetary easing in response to the announcement to hold the unscheduled MPM, which was released in the morning on this day. It is reasonable to conclude that the market expected that the situation was urgent and some policy actions would be decided. We can make this conclusion from a striking decline around the announcement to hold the unscheduled MPM, which is larger than a rise around the press release. Accordingly, the fact that the tight surprise on that day was positive should imply that the policy action actually decided was not as strong as the market had expected ten minutes before the press release of the statement. They felt disappointed with the actual decision once it was revealed.

As we see in the three examples, we confirm that thirty-minute windows successfully capture the surprises only from the press releases, excluding the other sources of surprises. At the same time, however, the press conferences and the announcements to hold the unscheduled meetings can be considered as other types of monetary policy announcements.

[17]A speculation that the Fed would hold an unscheduled meeting (FOMC) and decide a rate cut had been spreading through the day, according to the news articles. The Fed actually held a meeting and announced a drastic rate cut around 10 p.m., which was after the euro-yen futures market had closed. We also note that the difference between the closing price on the day and the opening price on the next business day for the euro-yen futures was very small. This observation implies that the decisions of FOMC had been almost anticipated by the time the market closed.

[18]The values on this date are plotted as crosses in Figure 3 and we can see that the daily surprise is quite different from the tight surprise for this day.

[19]Although the statement itself refers to the enhancement of the monetary easing by introducing a new funds-supplying operation, at the press conference after the MPM, the governor expressed the policy as a quantitative easing in a broad sense.

Meanwhile, we focus on surprises from the MPM press releases using thirty-minute windows. Later in the section, we also consider the possibility of incorporating other types of announcement in the analysis.

2.2 The Responses of the Asset Prices to the Monetary Policy Surprises

In this subsection, we evaluate the instantaneous effects of the monetary policy surprises on the asset market by applying the method of Gürkaynak, Sack, and Swanson (2005). We follow Gürkaynak, Sack, and Swanson (2005) in running the regression of the form

$$\Delta y_t = \alpha + \beta \Delta x_t + \varepsilon_t \tag{1}$$

where Δy_t is the asset price change within some intervals; Δx_t is the unanticipated change in the futures rate within the same interval; α and β are a constant and a coefficient, respectively; and ε_t is an error term. When the length of the interval is long, Δx_t in (1) is likely to be endogenous, because (i) the monetary policy can react to movements in the financial market or (ii) there may be a possible confounding variable affecting both monetary policy and the financial market. However, as discussed in Gürkaynak, Sack, and Swanson (2005), Δx_t can be treated as an exogenous variable when the interval is sufficiently short, because the monetary policy decision is less likely to respond to asset price movements and the possibility of the confounder can be excluded. We use high-frequency data for stock price indexes and the government bond rates to construct dependent variables Δy_t, namely, changes in asset prices within the same windows as those used to construct Δx_t. For the stock price index, we measure percent changes in the Tokyo Stock Price Index (TOPIX) and Nikkei 225. For the government bonds, we take differences in the one-, two-, five-, ten-, and twenty-year Japanese government bond (JGB) yields.

Our sample contains 280 MPMs held in the period from October 13, 1999 through January 21, 2020, during which the intraday data of euro-yen futures is available. It should be noted that we follow Nakashima, Shibamoto, and Takahashi (2019) and exclude four MPMs from the sample. In Nakashima, Shibamoto, and Takahashi (2019), September 18, 2008, September 29, 2008, and November 30, 2011 are excluded because multiple central banks announced coordinated actions at the same time, and therefore, identification of monetary policy surprises from MPM press release is difficult. In addition, March 14, 2011 is excluded for the possibility of confounders, because the market was highly volatile on the day, due to a number of news bulletins regarding damages caused by the East Japan Earthquake.

	EYF3		EYF6		EYF9		EYF12		JGBF	
	Coefficient	R^2	Coefficient	R^2	Coefficient	R^2	Coefficient	R^2	Coefficient	R^2
Nikkei 225	-14.693*	0.049	-19.241**	0.077	-15.822**	0.057	-16.15**	0.063	-4.057	0.009
	(8.018)		(8.895)		(6.776)		(6.622)		(3.648)	
TOPIX	-9.949*	0.027	-14.371*	0.052	-11.191**	0.035	-11.159**	0.036	-2.036	0.003
	(5.979)		(7.951)		(5.592)		(5.315)		(3.604)	
JGB1Y	0.118**	0.051	0.141**	0.066	0.133**	0.065	0.129**	0.064	0.104***	0.095
	(0.057)		(0.064)		(0.057)		(0.056)		(0.035)	
JGB2Y	0.229**	0.089	0.274***	0.115	0.265***	0.118	0.290***	0.149	0.249***	0.251
	(0.090)		(0.100)		(0.090)		(0.087)		(0.049)	
JGB5Y	0.391***	0.187	0.424***	0.200	0.372***	0.169	0.440***	0.248	0.360***	0.380
	(0.096)		(0.108)		(0.099)		(0.089)		(0.047)	
JGB10Y	0.430***	0.192	0.458***	0.200	0.445***	0.206	0.454***	0.226	0.469***	0.550
	(0.090)		(0.100)		(0.095)		(0.081)		(0.059)	
JGB20Y	0.285***	0.079	0.335***	0.100	0.335***	0.110	0.263***	0.071	0.364***	0.309
	(0.083)		(0.076)		(0.081)		(0.070)		(0.070)	

Table 2. Response of Asset Prices to the Monetary Policy Surprises: Euro-yen Futures and JGB Futures

Note: Each entry of JGB1Y, JGB2Y, JGB5Y, JGB10Y, and JGB20Y in the first column refers to the changes in the one-, two-, five-, ten-, and twenty-year JGB yields, respectively. The sample consists of 280 press releases from October 13, 1999 through January 21, 2020. Heteroskedasticity-consistent standard errors are reported in parentheses. *, **, and *** denote significance at 10 percent, 5 percent, and 1 percent, respectively. See the text for details.

Table 2 reports the simple regression results when our tight window surprise series, namely, EYF3, EYF6, EYF9, EYF12, and JGBF are used as regressor Δx_t. For each regression, the estimate of β, its standard error, and R^2 are reported. When two stock price indexes, namely, Nikkei 225 and TOPIX, are used as Δy_t, and regressed on EYF surprises, all the coefficients are negative and statistically significant. For the regression on JGBF surprises, the coefficients are also negative while not statistically significant.

As we expect a surprise in a positive direction, namely a contractionary shock, to lead to a decline in the stock prices, our results are consistent with the standard theoretical prediction. When five JGB yields, namely, JGB1Y, JGB2Y, JGB5Y, JGB10Y, and JGB20Y, are used as Δy_t, coefficients are positive and statistically significant for all the cases. These observations are also consistent with the theoretical prediction, because a contractionary shock raises the various maturities of interest rates.

In the case of EYF3, for example, the Nikkei 225 and TOPIX decline by approximately 15 and 10 percent, respectively, in response to an unanticipated 1 percent point monetary policy tightening. Both estimates are much larger than those of Gürkaynak, Sack, and Swanson (2005), who estimate a 4 percent decline. In our view, this outcome partly reflects the fact that the size of EYF surprises becomes much smaller for the ZLB period, compared to the pre-ZLB period as we observed in table 1. When the government bond yield is used as a dependent variable, JGB1Y instantly increases by 12.4 basis points in response to a EYF3 surprise. From one- to ten-year JGB yields, the size of the coefficient increases monotonically. This outcome differs from the US results obtained in Gürkaynak, Sack, and Swanson (2005), where the size of the coefficient is decreasing with the maturity.

The results of the estimated coefficients are similar for the other EYF surprise series. These findings suggest that expectations at horizons longer than three months are as important as the three-month ahead expectations contained in EYF3, at least up to a one-year horizon. This interpretation motivates us to extract the information efficiently from all the four EYF surprise series by using factor analysis in the next subsections. Since coefficients on the JGBF surprises are not statistically significant in stock price regression, we first focus on the EYF surprises and then examine the effect of adding the JGBF surprises in the subsequent analyses.

Before we move on to the factor analysis, we also run the same regression using different windows. Table 3 shows the results from the regression with the EYF3 surprises using the tight (thirty-minute) window, along with the wide (one-hour) and daily windows. It should be noted that the surprises measured with the wider window cannot accurately capture the effects on the asset prices, in particular for the stock prices. The

	Tight (30-min) window		Wide (1-hour) window		Daily window	
	Coefficient	R^2	Coefficient	R^2	Coefficient	R^2
Nikkei 225	-14.693*	0.049	-6.123	0.007	15.339	0.023
	(8.018)		(5.483)		(9.904)	
TOPIX	-9.949*	0.027	-2.617	0.002	15.044	0.028
	(5.979)		(5.209)		(9.222)	
JGB1Y	0.118**	0.051	0.146	0.050	0.462***	0.262
	(0.057)		(0.104)		(0.103)	
JGB2Y	0.229**	0.089	0.426**	0.135	0.560***	0.272
	(0.090)		(0.166)		(0.100)	
JGB5Y	0.391***	0.187	0.385**	0.111	0.724***	0.237
	(0.096)		(0.183)		(0.121)	
JGB10Y	0.430***	0.192	0.639***	0.209	0.737***	0.153
	(0.090)		(0.211)		(0.144)	
JGB20Y	0.285***	0.079	0.516***	0.138	0.625***	0.056
	(0.083)		(0.161)		(0.157)	

Table 3. Response of Asset Prices to the Monetary Policy Surprises: Alternative Windows

Note: The dependent variable is the EYF3 surprises within each window. The sample consists of 280 press releases from October 13, 1999 through January 21, 2020. Heteroskedasticity-consistent standard errors are reported in parentheses. *, **, and *** denote significance at 10 percent, 5 percent, and 1 percent, respectively. See the text for details.

estimated coefficients are not significantly different from zero even with the 10 percent significance level for a wide window. Furthermore, for a daily window regression, the estimated coefficient becomes positive, which is opposed to the standard theoretical predictions. These results support the claim by Gürkaynak, Sack, and Swanson (2005) that the thirty-minute window is useful for the purpose of identifying the pure monetary policy surprises by eliminating the effects of other shocks.

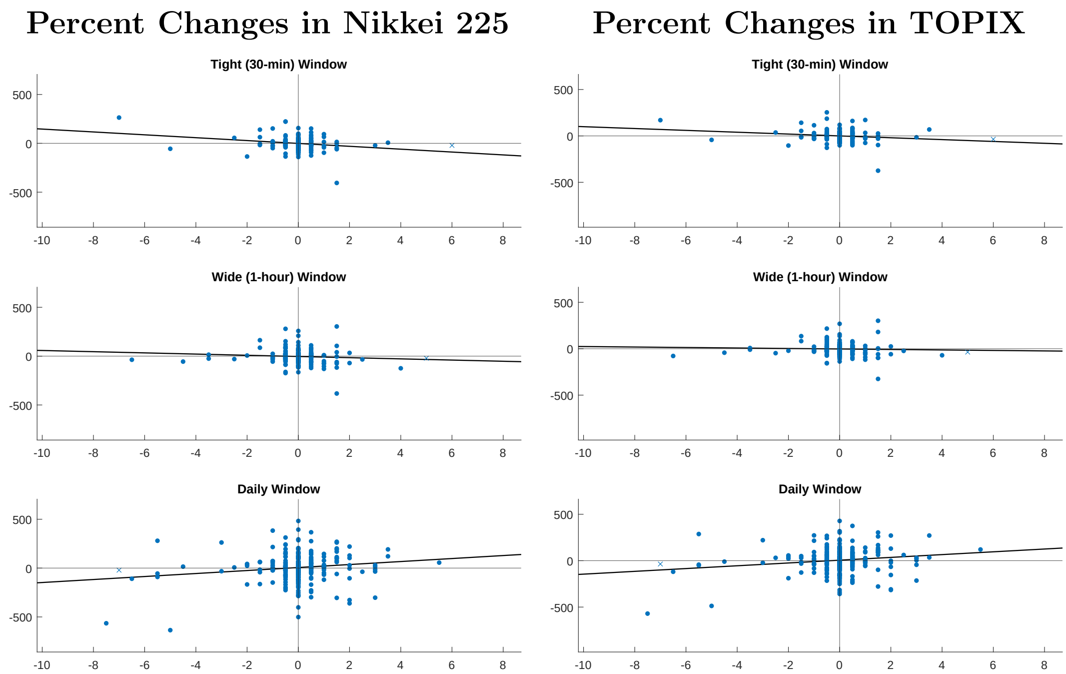


Figure 7. Responses of the Stock Prices to the Monetary Policy Surprises: Euro-yen Futures

Note: The top two panels, the middle two panels, and the bottom two panels plot the relation between the EYF3 surprises (horizontal axes) and the percent changes in the stock prices (vertical axes) within a tight window, a wide window, and a daily window, respectively. The left side panels the relation to the percent changes in Nikkei 225, and the right side panels show the relation to the percent changes in the TOPIX. The unit of the axes is a basis point. Each point represents the surprise for each MPM date. Crosses indicate the values on December 1, 2009. The least squares fitted lines are also shown.

In Figures 7 and 8, we also show the scatterplots for selected regression results to visualize the effect of choosing different windows. In the top panel of Figure 7, the relation between the monetary policy surprises and the stock prices within a tight window is negative and the fitted line is downward sloping as expected. The middle and bottom panels of the figure suggest that, for the wide and daily windows, regression fails to capture the negative relationship. In particular, the fitted line is almost flat in the case

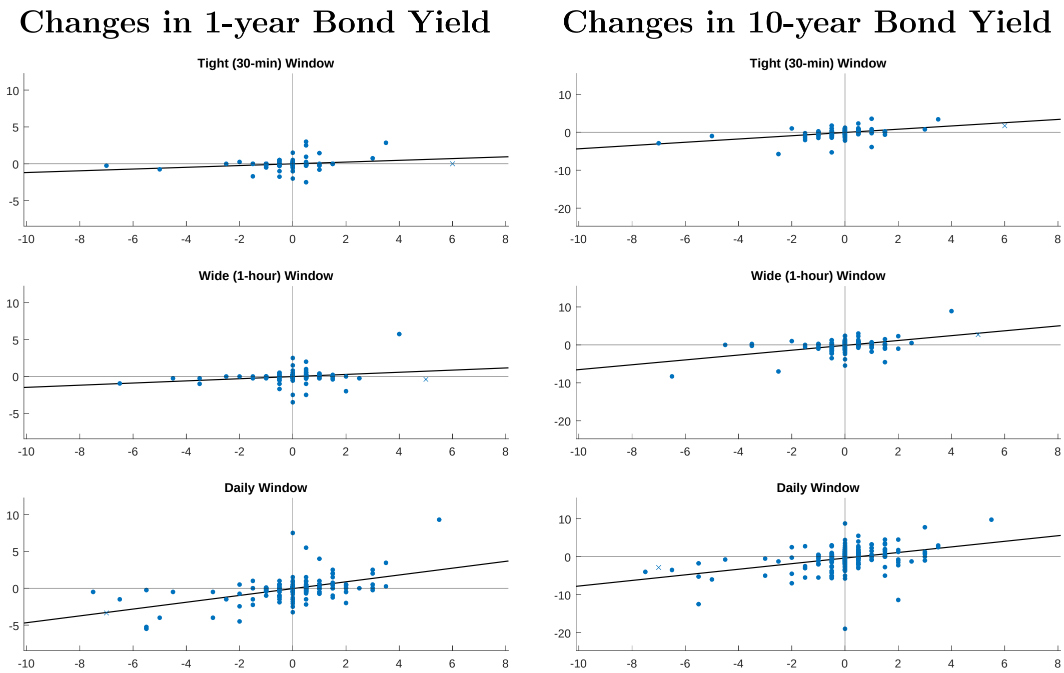


Figure 8. Responses of the JGB Yields to the Monetary Policy Surprises: Euro-yen Futures

Note: The top two panels, the middle two panels, and the bottom two panels plot the relation between the EYF3 surprises (horizontal axes) and the JGB yield changes (vertical axes) within a tight window, a wide window, and a daily window, respectively. The left side panels show the relation to the 1-year JGB yield changes and the right side panels show the relation to the 10-year JGB yield changes. The unit of the axes is a basis point. Each point represents the surprise for each MPM date. Crosses indicate the values on December 1, 2009. The least squares fitted lines are also shown.

of the wide window, and the fitted line is upward sloping in the case of the daily window. For the the relation between the monetary policy surprises and the JGB yields shown in Figure 8, all the fitted lines are upward sloping, which is consistent with the theoretical prediction.

2.3 Factor Estimation

When multiple series of surprise measures are available, it is often convenient to summarize the information in terms of the common factors in the factor model framework. For example, for the US monetary policy surprises, Gürkaynak, Sack, and Swanson (2005) find the presence of two important common factors, while Swanson (2020) claim three common factors. In the case of Japan, Nakashima, Shibamoto, and Takahashi (2019) identify three common factors in monetary policy surprises.

Let T denote the number of observations. The common factor model can be given by

$$X = F\Lambda + \eta$$

where X is $T \times n$ matrix for n observed variables (surprise series), F is $T \times k$ matrix for k latent factors, which are orthogonal to each other, Λ is $k \times n$ matrix of factor loadings, and η is $T \times n$ matrix for error terms. The factors F and the factor loadings Λ are estimated by the principal components method.

H_0	H_1	Wald statistic	d.f.	p-value
$k = 0$	$k > 0$	28.480	6	0.000
$k = 1$	$k > 1$	6.397	1	0.041

Table 4. Tests of Number of Factors: EYF Surprises

Note: The factors are estimated from the four euro-yen futures surprise series. The sample consists of 280 press releases from October 13, 1999 through January 21, 2020. k denotes the number of factors tested. See the text for details.

We begin our factor analysis based on EYF surprises, because negative and statistically significant coefficients on the EYF surprises in the stock price regression are consistent with a standard theory (see Table 2). To determine the number of the factors, we employ the rank tests of Cragg and Donald (1997), which is also used in Gürkaynak, Sack, and Swanson (2005). As reported in Table 4, the null hypotheses of zero and one factors are rejected at the 5 percent level in favor of two (or more) factors.[20] For this reason, we proceed with our analysis, assuming the presence of two common factors in the four EYF surprises ($k = 2$).

To interpret the two factors, we follow the strategy of Gürkaynak, Sack, and Swanson (2005) and assume one factor has zero impact on the nearest futures rate, EYF3 surprises. The rotated factor is given by

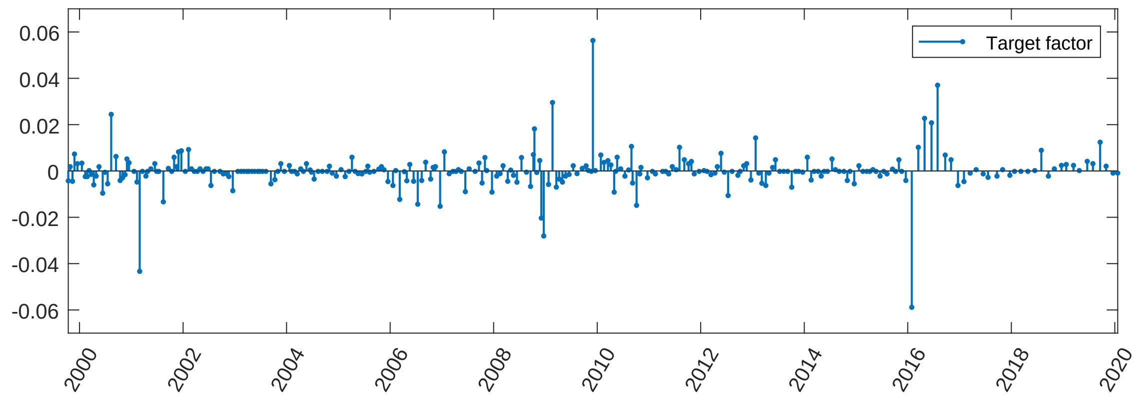
$$Z = FU$$

where $Z = [Z_1, Z_2]$ is $T \times 2$ matrix, $F = [F_1, F_2]$ is $T \times 2$ matrix and U is an orthogonal 2×2 matrix. Since we impose the restriction so that the second factor Z_2 has zero effect on EYF3 surprises, Z_1 will be the only factor that explains the variation in the EYF3 surprises. Accordingly, Z_1 is our target factor that mainly affects the short horizon expectations, while Z_2 is our path factor that mainly affects the longer horizon expectations.[21]

Figure 9 plots our estimated target factor and path factor from four EYF surprise series from October 13, 1999 to January 21, 2020. For instance, on Janurary 29, 2016, the target factor takes a large and negative value of -0.059, while the path factor is nearly zero. This observation implies that the introduction of the negative interest rate policy on that day mainly affects the short horizon expectations, rather than the longer horizon expectations.

[20]Here, unlike Gürkaynak, Sack, and Swanson (2005), we cannot test for the null hypothesis of two factors because the corresponding test statistic degenerates when $n = 4$.

[21]The notion of the target factor in our study slightly differs from that in Gürkaynak, Sack, and Swanson (2005) for the following reasons. In Gürkaynak, Sack, and Swanson (2005), the target factor is defined as a factor orthogonal to the path factor, which has zero impact on federal fund futures. In contrast, our path factor has zero impact on euro-yen futures. The former uses futures contracts for the overnight rate, while the latter uses futures contracts for the three-month interest rate. In addition, the longest remaining maturity is one month for the former, but is three months for the latter. In this sense, our target factor contains information on surprises in the longer-horizon expectation regarding the longer-term interest rate than the target factor of Gürkaynak, Sack, and Swanson (2005).



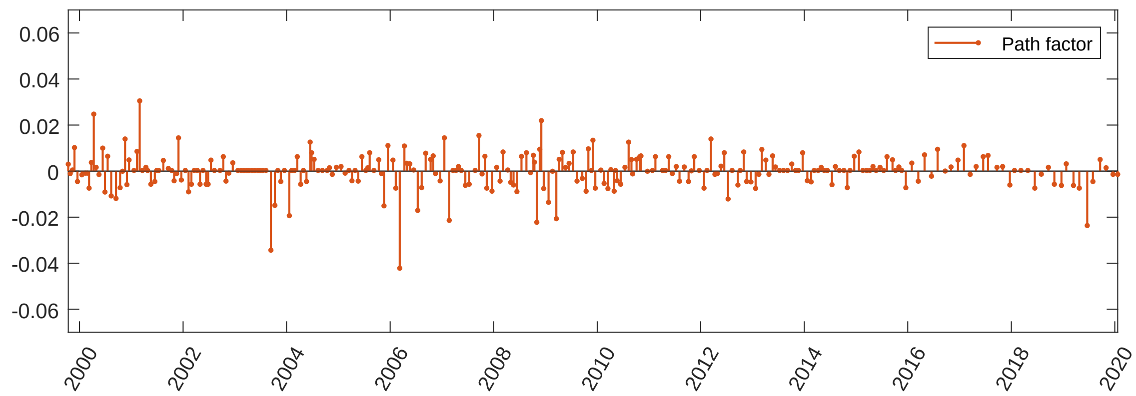


Figure 9. Target Factor and Path Factor: Time Series Plot

Note: The top panel plots the target factor and the bottom panel plots the path factor. The factors are estimated from the four euro-yen futures surprise series. The sample consists of 280 press releases from October 13, 1999 through January 21, 2020. See the text for details.

2.4 The Responses of the Asset Prices to the Factors

We now turn to investigate the effects of the estimated factors on stock prices and the bond yields. We now replace a single surprise measure Δx_t in regression (1) by the two factors, namely, the target factor $Z_{1,t}$ and path factor $Z_{2,t}$ and run the regression of the form,

$$\Delta y_t = \alpha + \beta Z_{1,t} + \gamma Z_{2,t} + \varepsilon_t. \quad (2)$$

The sample period and the dependent variables are the same as those used in regression (1).

	One Factor			Two Factors			
	Constant	Target Factor	R^2	Constant	Target Factor	Path Factor	R^2
EYF3	0.000	1.000***	0.932	0.000	1.000***	0.000	0.932
	(0.000)	(0.046)		(0.000)	(0.046)	(0.025)	
EYF12	0.000	0.761***	0.515	0.000***	0.761***	0.761***	0.949
	(0.000)	(0.077)		(0.000)	(0.034)	(0.023)	
Nikkei 225	-0.01	-16.73*	0.060	-0.01	-16.73**	-8.579*	0.073
	(0.032)	(8.581)		(0.032)	(8.492)	(4.570)	
TOPIX	0.000	-11.886*	0.036	0.000	-11.886*	-5.948	0.044
	(0.030)	(6.863)		(0.029)	(6.784)	(3.848)	
JGB1Y	0.000	0.130**	0.058	0.000	0.130**	0.074**	0.074
	(0.000)	(0.061)		(0.000)	(0.061)	(0.037)	
JGB2Y	-0.001	0.244**	0.094	-0.001*	0.244**	0.211***	0.152
	(0.000)	(0.098)		(0.000)	(0.098)	(0.080)	
JGB5Y	0.000	0.400***	0.182	0.000	0.400***	0.250***	0.242
	(0.000)	(0.106)		(0.000)	(0.108)	(0.081)	
JGB10Y	-0.001	0.449***	0.196	-0.001	0.449***	0.247***	0.246
	(0.000)	(0.096)		(0.000)	(0.092)	(0.065)	
JGB20Y	-0.001	0.326***	0.097	-0.001	0.326***	0.110*	0.106
	(0.000)	(0.085)		(0.000)	(0.085)	(0.067)	

Table 5. Response of the Asset Prices to the Factors: EYF Surprises

Note: The factors are estimated from the four euro-yen futures surprise series. The sample consists of 280 press releases from October 13, 1999 through January 21, 2020. Heteroskedasticity-consistent standard errors are reported in parentheses. *, **, and *** denote significance at 10 percent, 5 percent, and 1 percent, respectively. See the text for details.

Table 5 shows the results of the regression (2). The main result using two factors is provided in the right panel. We also show the results when only the target factor is used as a regressor in the left panel. We normalized the factor so that the positive sign corresponds to tightening surprises based on the EYF surprise series.[22] The table shows that both target and path factors have significant effects on asset prices in almost all the cases. In response to a 1 percent point increase in the target factor, the Nikkei 225 declines by more than 16 percent and the 1-year JGB yield increases by 13.0 basis points. On the other hand, in response to a 1 percent point increase in the path factor, the Nikkei 225 declines by about 8.6 percent and the 1-year JGB yield rises by 7.4 basis points. These results are consistent with the theoretical prediction and with US results obtained by Gürkaynak, Sack, and Swanson (2005). These findings suggest that the two factors jointly summarize the monetary policy surprises well. In particular, the significant effects of the path factor imply the important role of the longer-term horizon expectations.

In terms of the coefficient of determination, the two factors can explain many more of the variations of JGB yields than the target factor alone, while the size of the improvement is not as large as those obtained by Gürkaynak, Sack, and Swanson (2005). It should also be noted that both coefficients on the target and path factors tend to increase with the maturity of JGB yields, which is similar to the case we observed in Table 2. In general, a shift of the yield curve can be caused by monetary policy surprises. However, since shorter-term rates are likely to be constrained at near zero in Japan, there is more room for the long end of the yield curve to shift. Thus, our results suggest that the BOJ was successful in controlling the long-run expectations by MPM announcements.

2.5 Unscheduled Meetings and Press Conferences

So far, we have focused on the thirty-minute window surprises around the press releases of the MPM statements. However, it is also possible to consider other events associated with the MPMs; the announcement to hold the unscheduled meetings and the post-MPM

[22]Specifically, the scales of the factors are normalized so that the coefficient on the target factor in the regression of EYF3 is one, and the coefficient on the path factor in the regression of EYF12 is the same as that on the target factor.

press conferences. For example, as shown in panel (c) of Figure 6, on December 1, 2009, there were three types of events in a single day, namely, the announcement to hold the unscheduled MPM at 11:06 a.m., the MPM press release at 3:38 p.m., and the post-MPM press conference from 5:00 p.m. It can clearly be seen from the figure that, in addition to the press release, the market's expectations were largely affected by the announcement to hold the unscheduled MPM. This observation implies that it may be more appropriate to incorporate the latter in capturing the overall effects of policy announcements.

In what follows, we provide two reasons why we believe the two announcements can be combined and viewed as a single event. First, the news of holding the unscheduled meeting affects expectations of the market participants on the monetary policy. From such an announcement, the market participants are likely to expect that a decision on some policy change will be made in the meeting. This effect can be captured by the change in the EYF around the time of the announcement to hold the meeting. Second, the expectations on the monetary policy stance vary over several hours between the announcement to hold the meeting and the press release. On December 1, 2009, for instance, a series of bulletin reports about speculations on the policy decisions are circulated during the interval between the announcement to hold the meeting and the press release. Such continuously updated information caused the fluctuations in the EYF during the interval. If we use only the thirty-minute window around the MPM press release, surprise measures will fail to capture such movements in expectations.

Based on the above discussion, we modify the monetary policy surprises caused by some of the unscheduled MPMs, using a wider window covering both the announcement to hold them and the press release.[23] The dates and times of the announcements to hold and the press releases of the statements for all the unscheduled MPMs are summarized in Table 6. There are total of nine unscheduled meetings within our sample period. As shown in the table, three unscheduled meetings were held without the announcement and only the statement of decision is made public after the meeting. In these cases, we simply use the thirty-minute window around the press release. In the other six cases, the

[23]The extended window starts from ten minutes before the announcement to hold the unscheduled meeting and ends at twenty minutes after the press release.

Date	Announcement to hold	Press release	Window extension
March 25, 2003	3:40 p.m. on 24th	11:55 a.m.	No
September 18, 2008	NA	4:00 p.m.	No
September 29, 2008	NA	11:00 p.m.	No
October 14, 2008	4:04 p.m.	9:38 p.m.	Yes
December 2, 2008	5:30 p.m. on 1st	2:34 p.m.	No
December 1, 2009	11:06 a.m.	3:38 p.m.	Yes
May 10, 2010	10:40 a.m.	12:11 p.m.	Yes
August 30, 2010	7:02 a.m.	12:11 p.m.	Yes
November 30, 2011	NA	10:00 p.m.	No

Table 6. Unscheduled MPMs between October 1999 and January 2020

Note: The list of unscheduled MPMs derives from the BOJ's past statements and minutes. As in Figure 6, the precise times of the announcements to hold the unscheduled MPM refer to the news flash bulletins in Bloomberg. For the unscheduled MPMs on September 18, 2008, September 29, 2008, and November 30, 2011, the announcements to hold the meeting were not released. Also note that these three dates are excluded from our sample. See the text for details.

H_0	H_1	Wald statistic	d.f.	p-value
$k = 0$	$k > 0$	33.453	6	0.000
$k = 1$	$k > 1$	7.669	1	0.0216

Table 7. Tests of Number of Factors: EYF Surprises with Extended Windows for Unscheduled MPMs

Note: The factors are estimated from the four euro-yen futures surprise series. The sample consists of 280 press releases from October 13, 1999 through January 21, 2020. The windows for the four unscheduled MPMs which are accompanied by the announcements to hold the meeting on the same day, are extended. See the text for details.

timing of the announcement varies from a few hours before the meeting to a day before the meeting. We extend the windows only if the announcement was made on the day of the meetings because the changes in the futures rate can be caused by news unrelated to the monetary policy during the night. These qualifications result in a total of four unscheduled meetings with extended windows, which is shown in the far right column of Table 6. It should be noted that the longest length of the extended window is about six hours, which is still much shorter than the daily window.[24]

	One Factor			Two Factors			
	Constant	Target Factor	R^2	Constant	Target Factor	Path Factor	R^2
EYF3	0.000***	1.000***	0.930	0.000***	1.000***	0.000	0.930
	(0.000)	(0.050)		(0.000)	(0.050)	(0.023)	
EYF12	-0.001**	0.708***	0.427	-0.001***	0.708***	0.708***	0.924
	(0.000)	(0.082)		(0.000)	(0.043)	(0.026)	
Nikkei 225	0.014	-21.156**	0.067	0.014	-21.156**	-9.428**	0.082
	(0.035)	(10.391)		(0.034)	(10.03)	(4.718)	
TOPIX	0.021	-14.181	0.037	0.021	-14.181*	-6.472	0.046
	(0.032)	(8.746)		(0.032)	(8.558)	(4.042)	
JGB1Y	0.000	0.188**	0.077	0.000	0.188**	0.081**	0.094
	(0.000)	(0.085)		(0.000)	(0.081)	(0.040)	
JGB2Y	-0.001*	0.298**	0.102	-0.001*	0.298***	0.214***	0.164
	(0.000)	(0.119)		(0.000)	(0.106)	(0.078)	
JGB5Y	0.000	0.421***	0.149	0.000	0.421***	0.266***	0.219
	(0.000)	(0.137)		(0.000)	(0.120)	(0.078)	
JGB10Y	-0.001	0.499***	0.153	-0.001	0.499***	0.241***	0.194
	(0.001)	(0.133)		(0.001)	(0.118)	(0.073)	
JGB20Y	0.000	0.350***	0.049	0.000	0.350***	0.099	0.054
	(0.001)	(0.126)		(0.001)	(0.121)	(0.077)	

Table 8. Response of the Asset Prices to the Factors: EYF Surprises with Extended Windows for Unscheduled MPMs

Note: The factors are estimated from the four euro-yen futures surprise series. The sample consists of 280 press releases from October 13, 1999 through January 21, 2020. The windows for the four unscheduled MPMs, which are accompanied by the announcements to hold the meeting on the same day, are extended. Heteroskedasticity-consistent standard errors are reported in parentheses. *, **, and *** denote significance at 10 percent, 5 percent, and 1 percent, respectively. See the text for details.

[24] Instead of extending the window for the unscheduled MPMs, we can alternatively remove all the unscheduled meetings from the sample in the event study. However, since unscheduled MPMs are informative events in evaluating the policy surprise by the market, such an alternative approach may lose efficiency in the regression.

Table 7 reports the results of the Cragg and Donald (1997) test regarding the number of factors from the EYF surprises, when extended windows are used for the selected unscheduled MPMs. The table suggests that the null hypotheses of zero factor and one factor are rejected at the 5 percent level in favor of two factors as before. For this reason, we proceed and compute the target and path factors and run regression (2). We report the results of the event study regressions in Table 8. The estimated coefficients are very similar to those in Table 5. The signs of the coefficients are consistent with the theoretical prediction.[25]

Finally, we discuss another type of event associated with the MPM statements; the post-MPM press conferences. After every MPM, the governor of the BOJ explains the policy decision along with prospects of the policy stance and the economy.[26] That is, the post-MPM press conferences are directly associated with the MPM and can affect the market expectations, as we saw in the example on December 19, 2006 in panel (a) of Figure 6. We also estimate the factors and the same regressions, including the MPM press releases and the post-MPM press conferences, and obtain qualitatively similar results.[27] It should also be noted that Altavilla et al. (2019) conduct the event study for the press conferences as well as the press releases, treating each of the two events as representing a different type of policy announcement.

2.6 Surprises in the 10-year JGB Futures

We now add the JGBF surprises in estimating factors to take the longer-term horizon expectations into account. Table 9 reports the results of the tests regarding the number of factors when both EYF and JGBF surprises are included. The rank test of Cragg and Donald (1997) suggests that the null hypothesis of one factor is not rejected at the 10 percent level. On the other hand, if we use the rule of thumb, we need two factors to

[25]Since we use this factor in the VAR analysis in the next section, the estimated factor series is provided in Table A3 in the Appendix.

[26]The governor's press conference has been held after every MPM within the same day from October 10, 2003. Before then, it was held once a month, two days after the first MPM in the month.

[27]The results are presented in Table A2 in the Appendix.

H_0	H_1	Wald statistic	d.f.	p-value
$k = 0$	$k > 0$	32.571	10	0.00032
$k = 1$	$k > 1$	9.086	5	0.106
$k = 2$	$k > 2$	0.201	1	0.654

Table 9. Tests of Number of Factors: EYF and JGBF Surprises

Note: The factors are estimated from the four euro-yen futures surprise series and the JGB futures surprise series. The sample consists of 280 press releases from October 13, 1999 through January 21, 2020. See the text for details.

account for more than 80 percent of the total variations.[28] For this reason, we proceed with the analysis, assuming the presence of two factors.[29]

We report the results of the event study regression in Table 10.[30] The effects of the target factor are consistent with the theoretical predictions and also statistically significant. Compared to the case when we use only the EYF surprises, we now have stronger evidence in the regression of the 20-year JGB yields, since the positive coefficient on the path factor becomes statistically significant at the 1 percent level. This outcome may reflect the fact that JGBF contains the information on the longer horizon expectations. On the other hand, in the stock price regression, the coefficients on the path factor become positive, while they are not statistically significant. The positive sign may suggest that the market participants learned the central bank's view on economic conditions in the long-run, from the policy announcements.[31]

[28] A threshold of 80 percent has been typically employed in the principal components analysis. The relative contribution of the first and the second principal components are 76.6 percent and 11.2 percent, respectively.

[29] In this subsection we focus on the thirty-minute window and do not report the results for the extended windows for the selected unscheduled MPMs. When we apply the Cragg and Donald (1997) test to the EYF and JGBF surprises with extended unscheduled MPM windows, the null hypothesis of one factor is significantly rejected and that of two factors cannot be rejected. We also run the stock price regressions using the two factors computed from the EYF and JGBF surprises with extended unscheduled MPM windows and find that the coefficient on the target factor is negative and statistically significant.

[30] We normalize the factors using a procedure similar to the one used in the previous subsection. The scales of the factors are normalized so that the coefficient on the target factor in the regression of EYF3 is one, and the coefficient on the path factor in the regression of JGBF (not EYF12) is the same as that on the target factor.

[31] This channel is often referred to in the literature as the information effect. In Gürkaynak, Sack, and Swanson (2005), the coefficient on the path factor in their stock price regression was negative but statistically insignificant. They argued that this result could be explained by the information effect. Nakamura and Steinsson (2018) find the positive response of the one-year-ahead output growth forecast in the private sector to a tightening monetary policy surprise and explain this finding by the information effect. To construct instruments for monetary policy shocks in the VAR analysis, Miranda-Agrippino

	One Factor			Two Factors			
	Constant	Target Factor	R^2	Constant	Target Factor	Path Factor	R^2
EYF3	0.000	1.000***	0.833	0.000	1.000***	0.000	0.833
	(0.000)	(0.076)		(0.000)	(0.076)	(0.020)	
JGBF	-0.001*	0.927***	0.298	-0.001***	0.927***	0.927***	0.995
	(0.001)	(0.129)		(0.000)	(0.016)	(0.005)	
Nikkei 225	-0.01	-19.879**	0.075	-0.01	-19.879**	2.947	0.079
	(0.032)	(8.689)		(0.032)	(8.674)	(3.874)	
TOPIX	0.000	-14.212**	0.047	0.000	-14.212**	3.247	0.052
	(0.029)	(7.082)		(0.029)	(7.037)	(4.056)	
JGB1Y	0.000	0.145**	0.064	0.000	0.145**	0.076***	0.105
	(0.000)	(0.067)		(0.000)	(0.065)	(0.028)	
JGB2Y	-0.001	0.288***	0.117	-0.001*	0.288***	0.210***	0.262
	(0.000)	(0.103)		(0.000)	(0.086)	(0.046)	
JGB5Y	0.000	0.448***	0.204	0.000	0.448***	0.287***	0.399
	(0.000)	(0.109)		(0.000)	(0.090)	(0.046)	
JGB10Y	-0.001	0.481***	0.201	-0.001**	0.481***	0.414***	0.549
	(0.000)	(0.097)		(0.000)	(0.058)	(0.068)	
JGB20Y	-0.001	0.322***	0.084	-0.001	0.322***	0.339***	0.303
	(0.000)	(0.085)		(0.000)	(0.057)	(0.085)	

Table 10. Response of the Asset Prices to the Factors: EYF and JGBF Surprises

Note: The factors are estimated from the four euro-yen futures surprise series and the JGB futures surprise series. The sample consists of 280 press releases from October 13, 1999 through January 21, 2020. Heteroskedasticity-consistent standard errors are reported in parentheses. *, **, and *** denote significance at 10 percent, 5 percent, and 1 percent, respectively. See the text for details.

3 VAR Analysis

3.1 Methodology

In this section, we identify the unconventional monetary policy shocks using the factors estimated in the previous section as the external IV, and evaluate the dynamic responses of aggregate variables to the monetary policy shock in the VAR model. While Gertler and Karadi (2015) employ the original series of monetary policy surprises in federal fund futures rates as the external IV, we also consider the factors as candidates for IV, as in the analysis of Lakdawala (2019). By using either the original surprise series or factors as external IVs, we can extract the monthly monetary policy shocks from the error term of the interest rate equation in the reduced-form VAR model. Unlike the traditional approach of using Cholesky decomposition to identify shocks in the VAR, the external IV approach does not need to impose zero restrictions on the impact matrix.

Here we briefly review how the external IV method can be applied in identifying the monetary policy shock. Let $\boldsymbol{Z}_t$ denote a vector of the external instruments and $\boldsymbol{\varepsilon}_t$ denote a vector of the structural shocks. Furthermore, let ε_t^p and $\boldsymbol{\varepsilon}_t^q$ denote the monetary policy shock and a vector of other structural shocks, respectively, as elements of $\boldsymbol{\varepsilon}_t' \left(= \left[\varepsilon_t^p, \boldsymbol{\varepsilon}_t^{q\prime}\right]\right)$. For the instruments to be relevant and exogenous, they must be correlated with the monetary policy shock ε_t^p and uncorrelated with the other structural shocks $\boldsymbol{\varepsilon}_t^q$.

$$\mathrm{E}\left[\boldsymbol{Z}_t \varepsilon_t^p\right] = \phi, \quad \mathrm{E}\left[\boldsymbol{Z}_t \boldsymbol{\varepsilon}_t^{q\prime}\right] = 0 \tag{3}$$

In our context, we use the monetary policy surprises or factors as $\boldsymbol{Z}_t$. If the surprise measures using the thirty-minute window around the monetary policy announcements reflect only the exogenous shock to the monetary policy, using such measures as an instrument satisfies both requirements in equation (3).

The identification with the external IV proceeds as follows. Among the reduced-form

and Ricco (2019) remove information effects by using the Fed's Greenbook forecasts. Jarociński and Karadi (2020) decompose the monetary policy surprises into monetary policy shocks and information shocks using a sign restriction of positive co-movements between the information shocks and changes in stock prices.

shocks $\boldsymbol{u}_t$, let u_t^p and $\boldsymbol{u}_t^q$ denote the reduced-form shocks of the policy indicator and the others. The relationship between the reduced-form shock in the VAR model and the structural shocks are given by $\boldsymbol{u}_t = \boldsymbol{S}\boldsymbol{\varepsilon}_t$ or

$$\begin{pmatrix} u_t^p \\ \boldsymbol{u}_t^q \end{pmatrix} = \begin{pmatrix} s^p & \boldsymbol{s}_{12} \\ \boldsymbol{s}^q & \boldsymbol{s}_{22} \end{pmatrix} \begin{pmatrix} \varepsilon_t^p \\ \boldsymbol{\varepsilon}_t^q \end{pmatrix}. \tag{4}$$

Since the first column of $\boldsymbol{S}$, namely, s^p and $\boldsymbol{s}^q$, represents the contemporaneous effect of the monetary policy shock ε_t^p on the reduced-form shock $\boldsymbol{u}_t$ as well as on the observed aggregate variables, the monetary policy shock can be identified by obtaining s^p and $\boldsymbol{s}^q$. From (4), we obtain the following expression.

$$u_t^p = s^p \varepsilon_t^p + \boldsymbol{s}_{12}\boldsymbol{\varepsilon}_t^q \tag{5}$$

$$\boldsymbol{u}_t^q = \frac{\boldsymbol{s}^q}{s^p} u_t^p + \left(\boldsymbol{s}_{22} - \frac{\boldsymbol{s}^q}{s^p}\boldsymbol{s}_{12} \right) \boldsymbol{\varepsilon}_t^q \tag{6}$$

We cannot directly estimate $\boldsymbol{s}^q/s^p$ in (6) by running a regression of $\boldsymbol{u}_t^q$ on u_t^p because (5) implies that the regressor u_t^p is correlated with the error term $(\boldsymbol{s}_{22} - (\boldsymbol{s}^q/s^p)\boldsymbol{s}_{12})\boldsymbol{\varepsilon}_t^q$. If $\boldsymbol{Z}_t$ is available, we can isolate the monetary policy shock $\boldsymbol{\varepsilon}_t^p$ from the reduced-form shock u_t^p and estimate $\boldsymbol{s}^q/s^p$. Since the reduced-form shocks $\boldsymbol{u}_t = [u_t^p, \boldsymbol{u}_t^{q\prime}]'$ are unobservable, we use the reduced-form VAR residuals $\widehat{\boldsymbol{u}}_t = [\widehat{u}_t^p, \widehat{\boldsymbol{u}}_t^{q\prime}]'$ and the instrument $\boldsymbol{Z}_t$ to run the IV regression. Finally, using the estimated value of $\boldsymbol{s}^q/s^p$ and the sample covariance matrix of the reduced-form residuals, we obtain the estimates of $\boldsymbol{s}^q$ and s^p.[32]

3.2 Choice of the Policy Indicator and the Instruments

We estimate the VAR model using the monthly data and identify the unconventional monetary policy shock. To be specific, the sample period is from February 1999 to January 2020, so that the data starts at the time when the BOJ first introduced the zero-interest policy in Japan on February 12, 1999. Therefore, our sample covers the whole period in which the BOJ has conducted a number of unconventional monetary policies,

[32] For the derivation in detail, see Gertler and Karadi (2015).

including forward guidance, QE, comprehensive monetary easing, QQE, negative interest rate, and the YCC.

Our baseline specification includes five variables: the output growth rate (Index of Industrial Production, IIP); the inflation rate (Consumer Price Index, CPI); the long-term interest rate (10-year JGB yield); the stock price (Nikkei 225); and the corporate bond index (A-rated, 1-year). As suggested in Debortoli, Galí, and Gambetti (2020), we adopt the long-term interest rate as the policy indicator for the purpose of avoiding the issue of nonlinearity caused by the ZLB constraint on the short-term interest rate. In addition, we expect to capture the transmission channels of unconventional monetary policy through the long-term rate, represented by the long-term government bond purchases and the explicit target of the 10-year rate in the YCC.

We also follow their specification in using the output growth and inflation rate. At the same time, we added two financial variables, the stock price and the corporate bond index in the VAR. We employ the stock price following Miyao (2002) and other previous studies of VAR analysis of Japan. The corporate bond index is introduced as an alternative to the excess bond premium employed by Gertler and Karadi (2015). We expect adding these two financial variables helps to capture the transmission mechanism of unconventional monetary shocks through financial markets to the aggregate economic activities. The lag of the VAR model is selected using the AIC and set at seven.

As a preliminary analysis, we look for the valid instruments for the reduced-form VAR shock in the policy indicator, namely, the 10-year JGB yield. It is known that the possibility of weak instruments is low when the F-statistic in the first-stage regression is above 10 (Stock, Wright, and Yogo, 2002). For this reason, we run the first-stage regression using several candidates of instruments based on the policy surprises around the MPM press releases and report F-statistics. For the unscheduled MPMs, we use extended windows which we discussed in Section 2.5. We convert all the surprise measures into the monthly frequency using the method explained in Gertler and Karadi (2015, footnote 11). Accordingly, our instrument set spans from October 1999 through January 2020. The candidates of the instruments are EYF3 surprises, JGBF surprises, the first and second principal components, and the target and path factors.

The upper panel of Table 11 shows the results of the first-stage regressions of VAR residuals on each candidates of the instruments. Each column represents the results for a particular choice of the instruments. The robust F-statistics are above 10 only in the cases of the EYF3 surprise and the target factor from the EYF surprises. Since the target factor is more likely than the EYF3 surprise to contain information on the longer horizons, in what follows, we use the target factor from the EYF surprises as the main IV for the baseline specification.

For the choice of the policy indicator, we also examine the possibility of using 20-year JGB yields in place of the 10-year JGB yields in the VAR specification. The lower panel of Table 11 reports the results when the 20-year JGB yields is used as a policy indicator in the VAR model. The results of the first-stage regressions are very similar to the case of the 10-year JGB yields. For this reason, we also consider an alternative specification of the VAR model using 20-year JGB yields as a policy indicator in the following analysis.

3.3 Macroeconomic Effects of the Unconventional Monetary Policy

In the baseline specification, we use the target factor from the EYF surprises. Figure 10 shows the impulse response of each variable to the one standard error contractionary unconventional monetary policy shock. For the purpose of comparison, the figure also includes the impulse responses using the Cholesky decomposition in the right panel, in addition to those based on external IVs in the left panel. The Cholesky ordering is the same as the order presented in the figure, which is similar to the ordering employed by Gertler and Karadi (2015) and Debortoli, Galí, and Gambetti (2020). The dotted lines indicate the 68 percent confidence bands obtained by the wild bootstrap method.

On the whole, our impulse responses are consistent with the prediction of standard macroeconomic theory. A one standard deviation monetary policy shock induces an approximately 6.3 basis point increase in the 10-year JGB rate on impact. In response to a one standard deviation contractionary monetary policy shock, the output growth

Policy indicator: 10-year JGB yield												
					EYF					EYF+JGBF		
EYF3	2.037***											
	(0.561)											
JGBF		0.471										
		(0.311)										
PC1			0.013**					-0.005				
			(0.006)					(0.005)				
PC2				0.013**					0.013**			
				(0.006)					(0.006)			
TARGET					2.071***		1.991***			1.829**		1.805*
					(0.634)		(0.628)			(0.920)		(0.931)
PATH						-3.096	-2.439				0.027	0.025
						(2.831)	(2.649)				(0.022)	(0.021)
Obs	244	244	244	244	244	244	244	244	244	244	244	244
R^2	0.036	0.007	0.023	0.021	0.034	0.008	0.039	0.003	0.022	0.020	0.005	0.024
Robust F-stat.	13.180	2.295	4.483	4.193	10.683	1.196	6.542	0.907	4.340	3.950	1.471	2.636

Policy indicator: 20-year JGB yield												
					EYF					EYF+JGBF		
EYF3	2.171***											
	(0.600)											
JGBF		0.861**										
		(0.395)										
PC1			0.012*					-0.010*				
			(0.006)					0.006				
PC2				0.014***					0.015***			
				(0.005)					(0.005)			
TARGET					2.202***		2.151***			2.038**		1.989**
					(0.671)		(0.639)			(0.822)		(0.818)
PATH						-2.281	-1.571				0.052*	0.050*
						(2.607)	(2.105)				(0.027)	(0.026)
Obs	244	244	244	244	244	244	244	244	244	244	244	244
R^2	0.036	0.021	0.017	0.024	0.034	0.004	0.035	0.013	0.025	0.022	0.016	0.037
Robust F-stat.	13.095	4.749	3.626	6.805	10.785	0.765	5.898	2.746	7.197	6.151	3.552	4.500

Table 11. The First-stage Regression of VAR Residuals on Instruments

Note: The sample period for the reduced-form VAR is from February 1999 through January 2020, and the sample period for the first-stage regression is from October 1999 through January 2020. PC1 and PC2 denote the first and second principal components, respectively. Heteroskedasticity-consistent standard errors are reported in parentheses. *, **, and *** denote significance at 10 percent, 5 percent, and 1 percent, respectively. See the text for details.

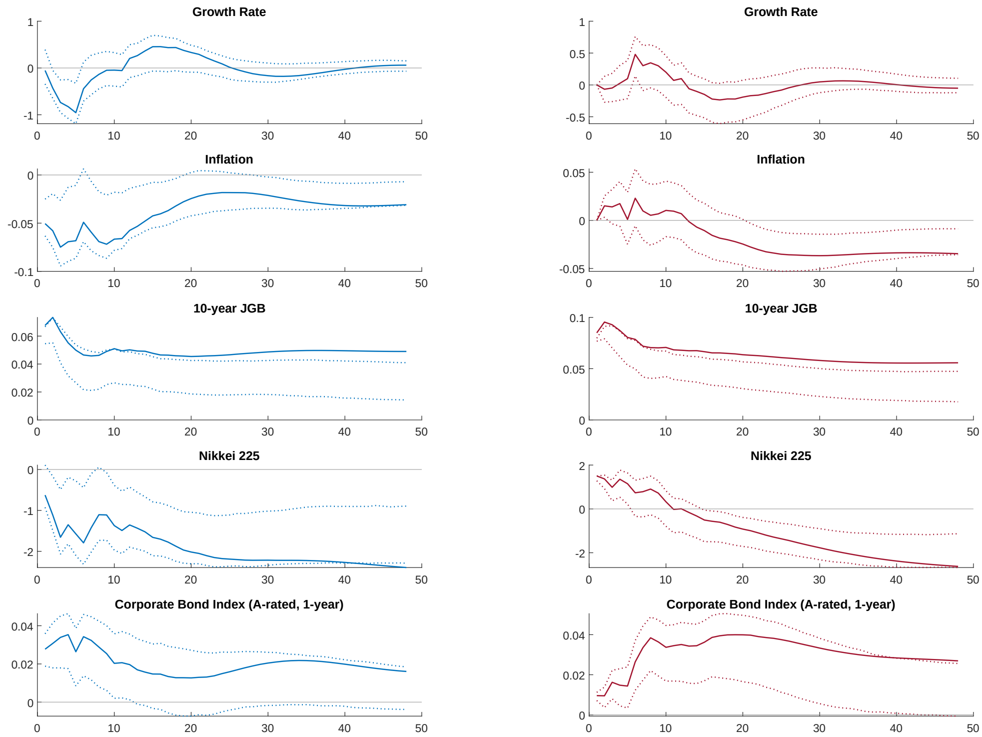


Figure 10. Responses to the Monetary Policy Shocks: Target Factor as IV

Note: The factors are estimated from the four euro-yen futures surprise series. The sample period for estimating VAR is from February 1999 through January 2020, and the sample period for the first-stage regression is from October 1999 through January 2020. The left panel shows the result with the external IVs and the right panel shows the result with the Cholesky decomposition. The unit of the vertical axes is a basis point, and the dotted lines indicate the 68 percent confidence band. The first-stage robust F-statistic is 10.683. See the text for details.

becomes slower and declines by 1 percent point and reverts to the mean growth within a year. The inflation rate declines by 0.1 percent points and it takes more than two years for returning to the mean. The effect of the monetary policy shock is nearly permanent for the stock price. The stock price declines by 1 to 2 percent and seems to stay at this level for a very long time. In contrast, both output growth and stock price increase in response to a contractionary monetary policy shock for the Cholesky decomposition, which contradicts the standard theoretical prediction. In addition, a weak price puzzle can be observed in the response of inflation. These anomalies are also observed in the US by Gertler and Karadi (2015). They conjecture that the Cholesky identification fails to capture the simultaneity between the monetary policy and the financial variables. They argue that the external IV method can be used in the presence of such a simultaneous relationship and thus appropriately capture the transmission channel through the financial market. For both external IV and Cholesky methods, the corporate bond yields responds positively to a contractionary monetary policy shock, which is also consistent with the theoretical prediction.[33]

We now turn to the alternative specification using the 20-year JGB yields as the policy indicator. Figure 11 shows the impulse responses using the external IV and the Cholesky decomposition. For the external IV, we keep using the target factor which is shown to be a valid instrument from Table 11. On the whole, the shape of the impulse responses are similar to the ones in the baseline specification with the 10-year JGB yields. The variables respond to the monetary policy shock in the direction consistent with theory, while puzzling responses are obtained with the Cholesky decomposition.

It should be noted that the robust F-statistic in the first-stage regression suggest EYF3 is also a valid instrument along with the target factor. Figure 12 presents the impulse response functions when EYF3 is used as an instrument instead of the target factor. The left panel shows the case when the 10-year JGB yields is used as a policy

[33]Using two factors may help identifying the unconventional monetary policy shock because the additional information on the longer horizon expectations is contained in the path factor (see Lakdawala, 2019). For this reason, we also examine the case in which both the target and path factors are used as instruments. In Figure A1 in the Appendix, we report the result using both factors as instruments. The variables respond to monetary policy shock in the direction consistent with theoretical predictions, while the first-stage F-statistic is low.

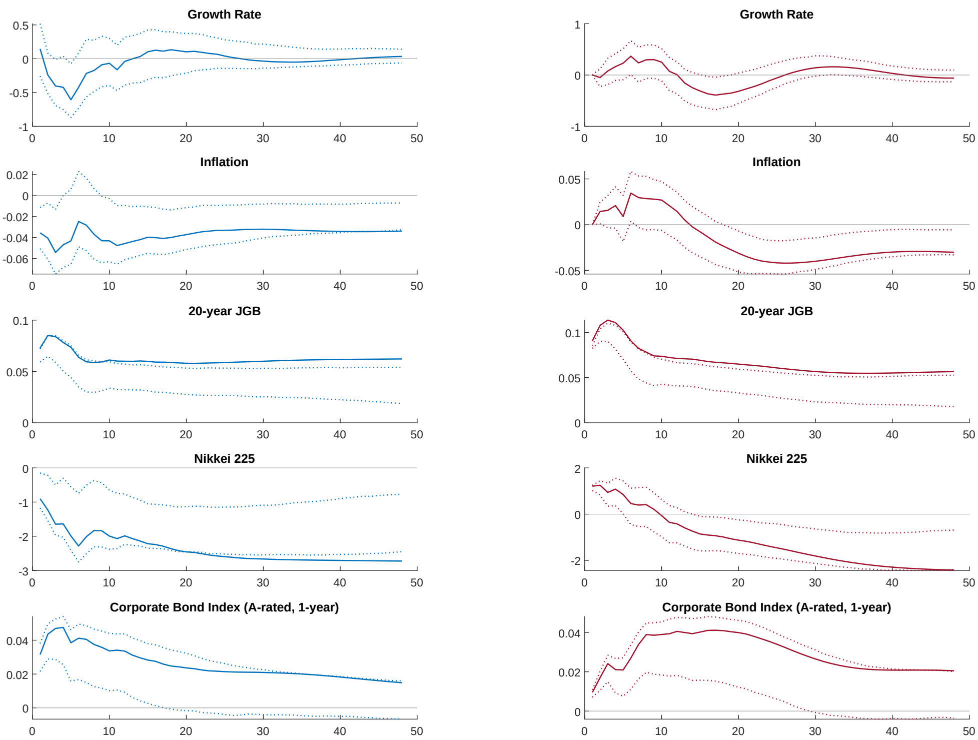


Figure 11. Responses to the Monetary Policy Shocks: 20-year Bond Rate as the Policy Indicator

Note: The factors are estimated from the four euro-yen futures surprise series around. The first-stage robust F-statistic is 10.785. The remaining details are essentially the same as in Figure 10.

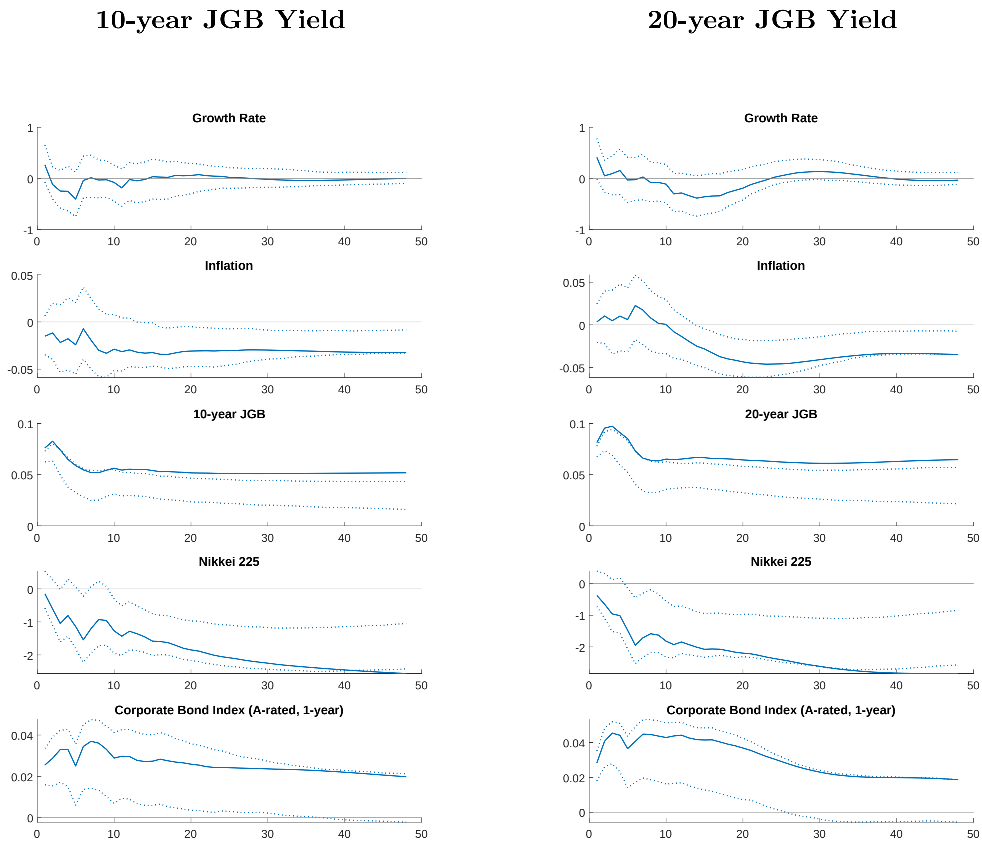


Figure 12. Responses to the Monetary Policy Shocks: the EYF3 Surprises as IV

Note: The left panel shows the case in which the EYF3 surprise is used as the instrument to the baseline model. The first-stage robust F-statistic is 13.180. The right panel shows the case in which the policy indicator is replaced with the 20-year bond rate. The first-stage robust F-statistic is 13.095. The remaining details are essentially the same as in Figure 10.

indicator, and the right panel shows the case when it is replaced by the 20-year JGB yields. While all the signs of the impulse responses seem to be consistent with the theory, the magnitude of the responses of the growth rate and inflation becomes much smaller than the specifications using the target factor as an instrument. In either case, a decline in the growth rate is, at most, 0.3 to 0.4 percent points, which is less than half the estimates obtained with identification through the target factor. In addition, responses are statistically insignificant. The responses of the inflation are also weaker than in the previous cases and the response on impact is almost zero. It should be noted that the monetary policy shocks identified only through the EYF3 surprise do not contain information on horizons longer than three months. In contrast, the target factor reflects surprises in EYF6, EYF9 and EYF12 and thus contains information on longer horizon expectations. We conjecture that stronger results are obtained in the baseline specification with the target factor because including the expectations for a longer horizon is important for the appropriate identification of unconventional monetary policy shocks. This VAR result is also consistent with our finding in event study regressions in Table 3, which shows that the longer-horizon expectations are as important as the three-month ahead expectations contained in EYF3.

Let us recall that, in the last part of the event study section, we discuss the possibilities of measuring the surprises using post-MPM press conferences and JGBF. As a robustness check, we also examine some other choices of instruments based on different surprise measures. First, we estimate the impulse responses to the monetary policy shocks identified with the target factor estimated from the surprises around the post-MPM press conferences as well as the MPM press releases. Second, we estimate the impulse responses to the shocks identified with the target factor estimated from both the EYF and JGBF surprises around the MPM press releases. While the F-statistics do not exclude the possibility of weak instruments, the variables respond to the monetary policy shock in the direction consistent with the theoretical prediction. The growth rate and inflation decline quickly after the contractionary monetary policy shock, and the depreciation of stock prices is highly persistent.[34]

4 Conclusion

We investigate the effect of unconventional monetary policy shocks on the Japanese asset market and macroeconomy by measuring revisions of the market expectation with high-frequency data of futures rates.

First, we estimate the instantaneous effects of the monetary policy surprises on asset prices using the timing of the MPM press releases by the Bank of Japan. Following the high-frequency event study regression approach developed by Gürkaynak, Sack, and Swanson (2005), we find that the contractionary unconventional monetary policy has negative effects on the stock returns and positive effects on the yield curve, which are outcomes consistent with the theoretical predictions. Furthermore, both the target and path factors we construct are useful in evaluating the unconventional monetary policy surprises.

Second, we estimate the dynamic effects of the unconventional monetary policy in the VAR framework. To this end, we follow the external IV method of Gertler and Karadi (2015) and use the high-frequency policy surprises as an instrument to the monetary policy shock in the VAR model. Furthermore, we employ the 10-year JGB rate as the policy indicator rather than the short-term interest rates following Debortoli, Galí, and Gambetti (2020), since the short rate is constrained by the zero lower bound for our sample period. We find that the shape of the impulse response is consistent with the standard macroeconomic theory, which implies that unconventional monetary policy has been effective over the last two decades in Japan.

There are several directions in which this study could be extended. For example, our event study regression results using JGBF surprises indicate the possibility of the information effect. A further analysis can be conducted by taking into account the presence of information effects based on the methods suggested by Miranda-Agrippino and Ricco (2019) and Jarociński and Karadi (2020). Another direction of extension is to incorporate

[34] The estimated impulse responses are presented in Figures A2 and A3 in the Appendix.

the nonlinearity in the VAR analysis combined with the high-frequency surprise variable. These extensions remain for future work.

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Appendix A Data Sources

Event study regression (intraday series)

- EYF3, EYF6, EYF9, EYF12 (Three-month Euro-yen futures): the CQG Data Factory (September 23, 1999-April 27, 2003) and the Tokyo Financial Exchange (April 28, 2003-).[35]
- JGBF (10-year JGB futures): the Japan Exchange.
- TOPIX: the Japan Exchange.
- Nikkei 225: Nikkei NEEDS Tick Data (-2019) and CQG Data Factory (2020-).
- JGB1Y, JGB2Y, JGB5Y, JGB10Y, JGB20Y (the 1-, 2-, 5-, 10-, and 20-year JGB yields): REFINITIV.

VAR model (monthly series)

- Output growth (12-month log differences of the seasonally adjusted Index of Industrial Production, IIP): the Ministry of Economy, Trade and Industry.
- Inflation (12-month log differences of seasonally adjusted and tax-adjusted Consumer Price Index, CPI): the Ministry of Internal Affairs and Communications.
- Government bond rates (the monthly average of the 10- and 20-year JGB yields): the Ministry of Finance.
- Stock price index (the monthly average of Nikkei 225 in log): Bloomberg.
- Corporate bond index (the monthly average): Bloomberg.

[35] The intraday data of euro-yen futures with the contract month of March 2000 are missing in our dataset. Therefore, the following surprises related to futures for March 2000 are replaced with the corresponding daily surprises. First, for EYF3 surprises from December 1999 through February 2000, there are 4 MPMs (December 17, 1999, January 17, 2000, February 10, 2000, and February 24, 2000) and 3 press conferences (December 21, 1999, January 19, 2000, and February 15, 2000). Second, for EYF6 surprises from September 1999 through November 1999, there are 4 MPMs (October 13, 1999, October 27, 1999, November 12, 1999, and November 26, 1999) and 5 press conferences (September 26, 1999, September 28, 1999, October 13, 1999, October 15, 1999, and November 16, 1999).

Appendix B Details on Measuring Monetary Policy Surprises

Market	Trading Hours
Euro-yen futures	8:45 a.m.-11:30 a.m., 12:30 p.m.-8:00 p.m.
	(8:45 a.m.-11:30 a.m., 12:30 p.m.-6:00 p.m. until February 4, 2007)
JGB futures	8:45 a.m.-11:02 a.m., 12:30 p.m.-3:02 p.m., 3:30 p.m.-5:30 a.m.
	(9:00 a.m.-11:00 a.m., 12:30 p.m.-3:00 p.m., 3:30 p.m.-6:00 p.m. until November 20, 2011[36])
Stocks (TOPIX, Nikkei 225)	9:00 a.m.-11:30 a.m., 12:30 p.m.-3:00 p.m.
	(9:00 a.m.-11:00 a.m., 12:30 p.m.-3:00 p.m. until November 20, 2011)

Table A1. Trading Hours in Euro-yen Futures, JGB Futures, and Stock Markets

This appendix describes the procedure in computing the policy surprises and high-frequency changes in asset prices around the monetary policy announcements from the intraday data in detail. Table A1 shows the trading hours for euro-yen futures, JGB futures, and stocks (TOPIX and Nikkei 225).[37] When we construct the thirty-minute windows, the following three issues need to be taken into consideration: (1) trade breaks; (2) closing time; and (3) the event with an interval.

First, Table A1 shows that there are breaks in trading assets in Japanese market. For example, there is a trade break between 11:30 a.m. and 12:30 p.m. in the euro-yen futures market. If the thirty-minute window around the time of the policy announcement overlaps with a trade break, changes in prices may not fully reflect the market surprises. In an extreme case, if the entire thirty-minute window is included in a trade break, no market surprise can be detected at all. To avoid this issue, we modify the windows so that thirty minutes of trading hours will certainly be included to evaluate the change in prices. For instance, when the MPM statement is released at 12:20 p.m., we take the difference between the price at 12:50 p.m. and the price at 11:20 a.m in calculating the

[36]The trading hours of the day session were extended to 8:45 a.m.-11:02 a.m., 12:30 p.m.-3:02 p.m. from November 21, 2011 onward. The closing time of the night session has been extended several times. It was first extended on November 21, 2011 from 6:00 p.m. to 11:30 p.m., then extended to 3:00 a.m. on March 24, 2014, and finally extended to 5:30 a.m. on July 19, 2016 ("Celebrating 30 Years of JGB Futures," Osaka Exchange, Inc).

[37]Note that JGBs are not included in the table because they are traded through over-the-counter without trading hours and breaks.

EYF surprises.

Second, a monetary policy event occurs in some cases after financial markets close. For example, on November 30, 2011, the press release was at 10:00 p.m. when the euro-yen futures and the Tokyo stock market closed. In some dates when the MPM is held, the euro-yen futures market extends the closing time to wait for the MPM press release, and the exact closing time for each date is not publicly available. In such a case, we modify the surprise by taking the difference between the closing price on the day and the opening price on the next business day. Moreover, it is also possibly the case that while the event itself occurs before the market closed, the end of the window falls after the closing time. In such a case, we take the difference in the price at the beginning of the window and the opening price on the next business day.

Third, some events associated with the MPM involve an interval rather than a point in time. For example, on January 21, 2020, the governor's post-MPM press conference began at 3:30 p.m. and ended at 4:20 p.m. so that the total time of the press conference was 50 minutes. In such cases, we set the surprise window as an interval from ten minutes before the event begins until twenty minutes after the event finishes. In the example above, the window is from 3:20 p.m. to 4:40 p.m.

Appendix C Additional Estimation Results Using Other Specifications

	One Factor			Two Factors			
	Constant	Target Factor	R^2	Constant	Target Factor	Path Factor	R^2
EYF3	0.000***	1.000***	0.936	0.000***	1.000***	0.000	0.936
	(0.000)	(0.033)		(0.000)	(0.033)	(0.014)	
EYF12	-0.001**	0.735***	0.342	-0.001***	0.735***	0.735***	0.903
	(0.000)	(0.064)		(0.000)	(0.032)	(0.022)	
Nikkei 225	0.033	-14.891**	0.020	0.033	-14.891**	-5.049	0.024
	(0.031)	(7.544)		(0.031)	(7.481)	(3.794)	
TOPIX	0.041	-9.769	0.010	0.041	-9.769	-4.36	0.013
	(0.029)	(6.366)		(0.029)	(6.323)	(3.622)	
JGB1Y	0.000	0.214**	0.024	0.000	0.214**	0.209*	0.062
	(0.000)	(0.094)		(0.000)	(0.091)	(0.120)	
JGB2Y	0.000	0.222**	0.043	0.000	0.222**	0.118*	0.063
	(0.000)	(0.099)		(0.000)	(0.098)	(0.067)	
JGB5Y	0.000	0.393***	0.109	0.000	0.393***	0.188***	0.150
	(0.000)	(0.105)		(0.000)	(0.102)	(0.065)	
JGB10Y	0.000	0.323***	0.077	0.000	0.323***	0.157***	0.107
	(0.000)	(0.096)		(0.000)	(0.093)	(0.054)	
JGB20Y	-0.001**	0.247***	0.030	-0.001**	0.247***	0.071*	0.035
	(0.000)	(0.078)		(0.000)	(0.077)	(0.039)	

Table A2. Response of the Asset Prices to the Factors: EYF Surprises with Extended Windows for the Unscheduled MPM and Post-MPM Press Conferences as an Additional Event

Note: The factors are estimated from the four euro-yen futures surprise series. The sample consists of 280 press releases and 230 post-MPM press conferences from September 26, 1999 through February 23, 2020. Heteroskedasticity-consistent standard errors are reported in parentheses. *, **, and *** denote significance at 10 percent, 5 percent, and 1 percent, respectively. See the text for details.

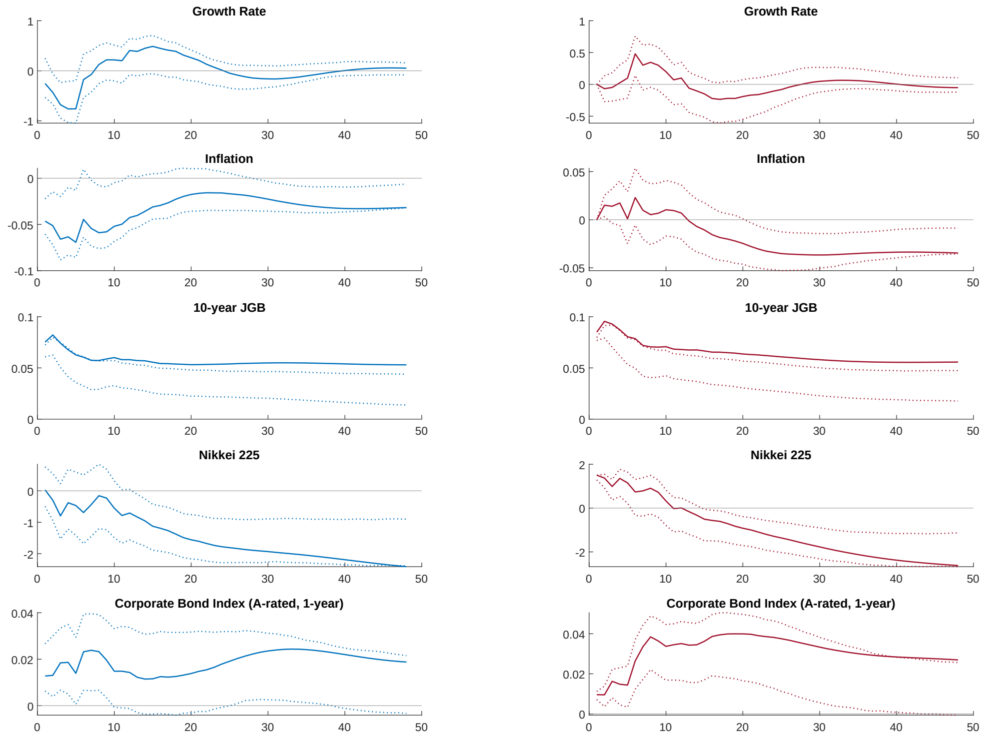

Figure A1. Responses to the Monetary Policy Shocks: Target and Path Factors as IV

Note: The factors are estimated from the four euro-yen futures surprise series. The first-stage robust F-statistic is 6.542. The remaining details are essentially the same as in Figure 10.

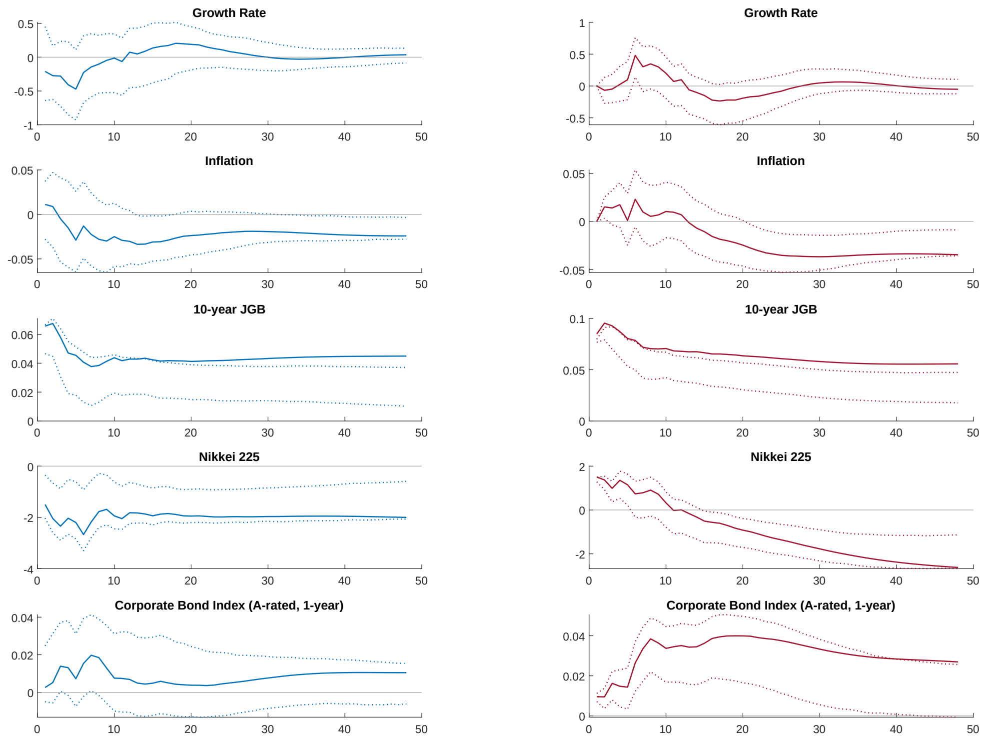

Figure A2. Responses to the Monetary Policy Shocks: MPMs and Post-MPM Press Conferences

Note: The factors are estimated from the four euro-yen futures surprise series around the press releases and the post-MPM press conferences. The first-stage robust F-statistic is 7.257. The remaining details are essentially the same as in Figure 10.

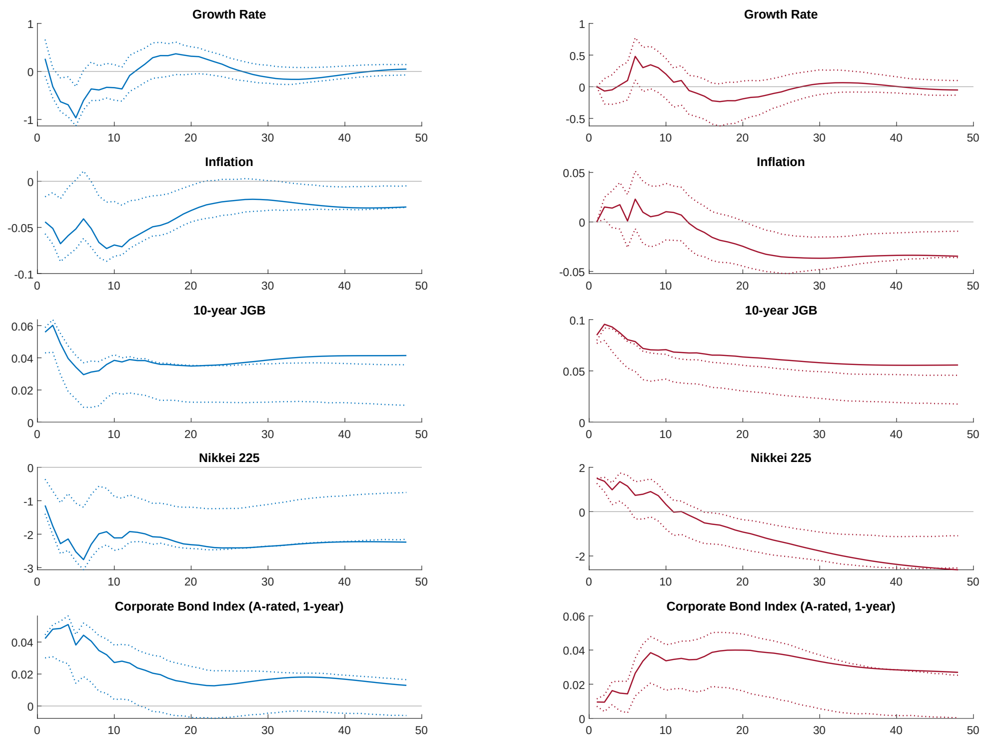

Figure A3. Responses to the Monetary Policy Shocks: Factors from EYF and JGBF as IV

Note: The factors are estimated from the four euro-yen futures surprise series and the JGB futures surprise series. The first left panel shows the result with the target factor as an IV, the second left panel shows the result with the target and path factors used as IVs, and the last panel shows the result with the Cholesky decomposition. In the case with the target factor, the first-stage robust F-statistic is 3.950. In the case with the target and path factors, the first-stage robust F-statistic is 2.636. The remaining details are essentially the same as in Figure 10.

Appendix D Target Factor and Path Factor

Datetime	Target	Path
10/13/1999 5:22 PM	-0.370	0.245
10/27/1999 12:42 PM	0.215	-0.077
11/12/1999 2:47 PM	-0.421	0.059
11/26/1999 12:48 PM	0.696	1.251
12/17/1999 3:44 PM	0.372	-0.484
1/17/2000 3:50 PM	0.409	-0.229
2/10/2000 4:15 PM	-0.227	-0.048
2/24/2000 1:20 PM	-0.227	-0.048
3/8/2000 3:50 PM	0.072	-0.794
3/24/2000 1:25 PM	-0.137	0.438
4/10/2000 3:45 PM	-0.594	2.556
4/27/2000 1:35 PM	-0.175	0.138
5/17/2000 3:40 PM	0.230	-0.145
6/12/2000 4:00 PM	-0.947	1.004
6/28/2000 1:10 PM	0.019	-1.025
7/17/2000 4:15 PM	-0.527	0.652
8/11/2000 5:30 PM (1)	2.370	-0.662
9/14/2000 2:50 PM	0.672	-1.184
10/13/2000 3:45 PM	-0.369	-0.765
10/30/2000 2:40 PM	-0.228	-0.093
11/17/2000 2:55 PM	-0.137	1.448
11/30/2000 12:40 PM	0.567	-0.591
12/15/2000 2:45 PM	0.373	0.572
1/19/2001 4:20 PM	0.020	0.031
2/9/2001 5:25 PM	-0.489	0.952
2/28/2001 4:00 PM	-4.372	3.007
3/19/2001 5:40 PM (2)	0.020	0.031
4/13/2001 12:30 PM	-0.175	0.138
4/25/2001 1:00 PM	0.020	0.031
5/18/2001 12:30 PM	0.125	-0.563
6/15/2001 12:25 PM	0.372	-0.484
6/28/2001 12:55 PM	0.020	0.031
7/13/2001 1:10 PM	0.020	0.031
8/14/2001 1:15 PM	-1.270	0.326
9/18/2001 7:00 PM	0.075	0.307
10/12/2001 1:15 PM	0.020	0.031
10/29/2001 2:10 PM	0.620	-0.360
11/16/2001 12:45 PM	0.215	-0.077
11/29/2001 12:35 PM	0.801	1.668
12/19/2001 3:05 PM	0.869	-0.236
1/16/2002 12:50 PM	0.020	0.031
2/8/2002 12:30 PM	0.972	-0.874
2/28/2002 2:05 PM	0.125	-0.563
3/20/2002 1:35 PM	0.020	0.031
4/11/2002 12:25 PM	0.020	0.031
4/30/2002 1:10 PM	0.125	-0.563
5/21/2002 1:10 PM	0.020	0.031

Datetime	Target	Path
6/12/2002 12:25 PM	0.125	-0.563
6/26/2002 12:55 PM	0.125	-0.563
7/16/2002 12:30 PM	-0.580	0.421
8/9/2002 12:50 PM	0.020	0.031
9/18/2002 1:20 PM	0.020	0.031
10/11/2002 1:00 PM	-0.085	0.624
10/30/2002 2:45 PM	-0.070	-0.455
11/19/2002 1:05 PM	-0.227	-0.048
12/17/2002 1:25 PM	-0.827	0.342
1/22/2003 12:35 PM	0.020	0.031
2/14/2003 1:25 PM	0.020	0.031
3/5/2003 12:45 PM	0.020	0.031
3/25/2003 11:55 AM	0.020	0.031
4/8/2003 1:30 PM	0.020	0.031
4/30/2003 1:40 PM	0.020	0.031
5/20/2003 1:10 PM	0.020	0.031
6/11/2003 1:20 PM	0.020	0.031
6/25/2003 12:05 PM	0.020	0.031
7/15/2003 11:30 AM	0.020	0.031
8/8/2003 11:50 AM	0.020	0.031
9/12/2003 1:35 PM	-0.497	-3.572
10/10/2003 2:05 PM	-0.317	-1.590
10/31/2003 12:25 PM	0.020	0.031
11/21/2003 12:20 PM	0.372	-0.484
12/16/2003 11:30 AM	0.020	0.031
1/20/2004 12:50 PM	0.283	-1.980
2/5/2004 12:05 PM	0.020	0.031
2/26/2004 12:10 PM	0.020	0.031
3/16/2004 12:00 PM	-0.085	0.624
4/9/2004 12:45 PM	0.125	-0.563
4/28/2004 1:05 PM	0.020	0.031
5/20/2004 12:10 PM	0.372	-0.484
6/15/2004 11:40 AM	0.058	1.341
6/25/2004 11:30 AM	-0.032	0.855
7/13/2004 12:30 PM	-0.332	0.545
8/10/2004 11:50 AM	0.020	0.031
9/9/2004 11:40 AM	0.020	0.031
10/13/2004 12:10 PM	0.020	0.031
10/29/2004 1:15 PM	0.267	0.110
11/18/2004 12:10 PM	-0.033	-0.200
12/17/2004 12:45 PM	-0.175	0.138
1/19/2005 12:40 PM	0.073	0.262
2/17/2005 12:10 PM	-0.227	-0.048
3/16/2005 12:50 PM	0.020	0.031
4/6/2005 1:15 PM	0.620	-0.360
4/28/2005 1:15 PM	0.020	0.031
5/20/2005 12:55 PM	-0.070	-0.455

Datetime	Target	Path
6/15/2005 1:10 PM	-0.085	0.624
7/13/2005 1:00 PM	0.020	0.031
7/27/2005 11:45 AM	0.267	0.110
8/9/2005 11:55 AM	-0.032	0.855
9/8/2005 12:40 PM	0.020	0.031
10/12/2005 12:30 PM	0.110	0.517
10/31/2005 1:00 PM	0.215	-0.077
11/18/2005 12:55 PM	0.124	-1.618
12/16/2005 12:40 PM	-0.437	1.138
1/20/2006 1:00 PM	-0.580	0.421
2/9/2006 12:25 PM	0.072	-0.794
3/9/2006 2:20 PM (3)	-1.135	-4.492
4/11/2006 12:55 PM	0.005	1.110
4/28/2006 12:50 PM	-0.385	0.314
5/19/2006 12:15 PM	0.320	0.341
6/15/2006 12:20 PM	-0.421	0.059
7/14/2006 1:40 PM	-1.309	-2.041
8/11/2006 12:20 PM	-0.369	-0.765
9/8/2006 12:40 PM	0.410	0.827
10/13/2006 12:50 PM	-0.332	0.545
10/31/2006 12:50 PM	0.163	0.748
11/16/2006 12:25 PM	0.215	-0.077
12/19/2006 12:30 PM	-1.465	-0.578
1/18/2007 1:05 PM	0.801	1.668
2/21/2007 2:19 PM	-0.019	-2.335
3/20/2007 12:40 PM	0.020	0.031
4/10/2007 12:48 PM	0.020	0.031
4/27/2007 2:07 PM	0.073	0.262
5/17/2007 12:41 PM	0.020	0.031
6/15/2007 12:18 PM	-0.813	-0.782
7/12/2007 12:55 PM	0.125	-0.563
8/23/2007 12:35 PM	0.020	0.031
9/19/2007 1:21 PM	0.358	1.651
10/11/2007 1:32 PM	-0.475	-0.172
10/31/2007 12:42 PM	0.605	0.720
11/13/2007 12:29 PM	0.072	-0.794
12/20/2007 12:51 PM	-0.864	-0.968
1/22/2008 12:19 PM	-0.175	0.138
2/15/2008 12:51 PM	-0.070	-0.455
3/7/2008 12:52 PM	0.216	0.979
4/9/2008 12:24 PM	-0.421	0.059
4/30/2008 1:28 PM	0.124	-0.608
5/20/2008 12:04 PM	-0.123	-0.687
6/13/2008 12:23 PM	-0.423	-0.997
7/15/2008 1:34 PM	0.605	0.720
8/19/2008 12:30 PM	-0.032	0.855
9/17/2008 12:47 PM	-0.668	-0.020

Table A3. Target Factor and Path Factor

Note: The factors are estimated from the four euro-yen futures surprise series with the extended windows for the selected unscheduled MPMs, which are used in Table 8 and Figure 10. The unit is a basis point. Notable events: (1) exit from the zero interest rate policy, (2) the introduction of QE, (3) exit from QE,

Datetime	Target	Path
10/7/2008 12:58 PM	0.675	0.927
10/14/2008 9:38 PM	0.233	0.955
10/31/2008 1:58 PM	-0.017	-2.290
11/21/2008 12:34 PM	0.463	1.058
12/2/2008 2:34 PM	-2.026	2.179
12/19/2008 2:05 PM	-2.703	-1.107
1/22/2009 1:43 PM	-0.512	-1.483
2/19/2009 1:52 PM	2.989	0.192
3/18/2009 12:27 PM	-0.654	-2.155
4/7/2009 12:22 PM	-0.332	0.545
4/30/2009 1:37 PM	-0.474	0.884
5/22/2009 12:33 PM	-0.175	0.138
6/16/2009 12:34 PM	-0.122	0.369
7/15/2009 1:35 PM	0.216	0.979
8/11/2009 11:51 AM	-0.070	-0.455
9/17/2009 12:39 PM	0.177	-0.377
10/14/2009 1:14 PM	0.267	-0.901
10/30/2009 1:05 PM	0.021	1.086
11/20/2009 12:35 PM	0.020	0.031
12/1/2009 3:38 PM (4)	-1.765	0.123
12/18/2009 12:13 PM	0.072	-0.794
1/26/2010 12:26 PM	0.710	0.126
2/18/2010 11:45 AM	0.374	-0.439
3/17/2010 12:49 PM	0.514	-0.822
4/7/2010 12:03 PM	0.268	0.155
4/30/2010 1:18 PM	-0.864	-0.968
5/10/2010 12:11 PM	-0.475	-0.172
5/21/2010 12:42 PM	0.620	-0.360
6/15/2010 12:56 PM	0.125	-0.563
7/15/2010 12:45 PM	-0.175	0.138
8/10/2010 12:28 PM	0.058	1.341
8/30/2010 12:11 PM	0.620	-0.360
9/7/2010 12:39 PM	-0.475	-0.172
10/5/2010 1:38 PM (5)	-1.463	0.478
10/28/2010 1:31 PM	-0.085	0.624
11/5/2010 11:36 AM	0.163	0.748
12/21/2010 12:55 PM	-0.228	-0.093
1/25/2011 12:29 PM	0.020	0.031
2/15/2011 12:37 PM	-0.085	0.624
4/7/2011 1:10 PM	0.020	0.031
4/28/2011 1:31 PM	0.020	0.031
5/20/2011 12:14 PM	-0.085	0.624
6/14/2011 12:42 PM	0.215	-0.077
7/12/2011 1:20 PM	0.073	0.262
8/4/2011 2:00 PM	1.062	-0.388
9/7/2011 12:21 PM	0.515	0.233
10/7/2011 12:37 PM	0.372	-0.484

Datetime	Target	Path
10/27/2011 1:31 PM	0.462	0.002
11/16/2011 12:49 PM	-0.085	0.624
12/21/2011 12:16 PM	0.020	0.031
1/24/2012 12:31 PM	0.072	-0.794
2/14/2012 12:43 PM (6)	0.020	0.031
3/13/2012 2:07 PM	-0.137	1.448
4/10/2012 12:09 PM	-0.033	-0.200
4/27/2012 12:46 PM	0.215	-0.077
5/23/2012 11:37 AM	0.763	0.357
6/15/2012 11:52 AM	-0.032	0.855
7/12/2012 12:51 PM	-0.971	-1.431
8/9/2012 12:19 PM	0.020	0.031
9/19/2012 12:44 PM	-0.123	-0.687
10/5/2012 12:14 PM	0.020	0.031
10/30/2012 2:46 PM	0.216	0.979
11/20/2012 12:14 PM	0.372	-0.484
12/20/2012 1:01 PM	-0.318	-0.579
1/22/2013 12:47 PM (7)	1.467	-0.671
2/14/2013 12:39 PM	-0.033	-0.200
3/7/2013 12:24 PM	-0.490	0.907
4/4/2013 1:40 PM (8)	-0.580	0.421
4/26/2013 1:35 PM	-0.033	-0.200
5/22/2013 12:07 PM	0.163	0.748
6/11/2013 11:48 AM	0.515	0.233
7/11/2013 11:47 AM	0.020	0.031
8/8/2013 11:59 AM	0.020	0.031
9/5/2013 11:42 AM	0.020	0.031
10/4/2013 11:49 AM	-0.633	0.190
10/31/2013 1:14 PM	0.020	0.031
11/21/2013 12:15 PM	0.020	0.031
12/20/2013 11:57 AM	-0.032	0.855
1/22/2014 12:20 PM	0.620	-0.360
2/18/2014 12:28 PM	-0.318	-0.579
3/11/2014 12:00 PM	0.020	0.031
4/8/2014 11:50 AM	0.020	0.031
4/30/2014 12:51 PM	-0.175	0.138
5/21/2014 11:41 AM	0.020	0.031
6/13/2014 11:41 AM	0.020	0.031
7/15/2014 11:58 AM	0.567	-0.591
8/8/2014 12:08 PM	0.073	0.262
9/4/2014 12:07 PM	0.020	0.031
10/7/2014 1:54 PM	0.020	0.031
10/31/2014 1:44 PM (9)	-0.369	-0.765
11/19/2014 12:24 PM	0.020	0.031
12/19/2014 12:28 PM	-0.527	0.652
1/21/2015 12:29 PM	0.216	0.979
2/18/2015 11:49 AM	0.020	0.031

Datetime	Target	Path
3/17/2015 12:04 PM	0.020	0.031
4/8/2015 12:36 PM	0.020	0.031
4/30/2015 1:04 PM	0.073	0.262
5/22/2015 11:49 AM	0.020	0.031
6/19/2015 12:04 PM	-0.175	0.138
7/15/2015 12:18 PM	0.020	0.031
8/7/2015 12:18 PM	-0.085	0.624
9/15/2015 12:07 PM	0.110	0.517
10/7/2015 12:00 PM	0.020	0.031
10/30/2015 12:22 PM	0.515	0.233
11/19/2015 12:17 PM	0.020	0.031
12/18/2015 12:50 PM	-0.369	-0.765
1/29/2016 12:38 PM (10)	-5.894	0.077
3/15/2016 12:35 PM	1.062	-0.388
4/28/2016 12:01 PM	2.233	1.035
6/16/2016 11:45 AM	2.054	0.063
7/29/2016 12:44 PM	3.680	1.343
9/21/2016 1:18 PM (11)	0.725	0.057
11/1/2016 11:55 AM	0.515	0.233
12/20/2016 11:51 AM	-0.580	0.421
1/31/2017 11:56 AM	-0.437	1.138
3/16/2017 11:54 AM	-0.033	-0.200
4/27/2017 12:14 PM	0.073	0.262
6/16/2017 11:54 AM	-0.085	0.624
7/20/2017 12:10 PM	-0.279	0.776
9/21/2017 12:15 PM	-0.175	0.138
10/31/2017 12:05 PM	0.073	0.262
12/21/2017 11:46 AM	-0.123	-0.687
1/23/2018 12:14 PM	0.020	0.031
3/9/2018 11:46 AM	0.020	0.031
4/27/2018 12:03 PM	0.020	0.031
6/15/2018 11:41 AM	0.072	-0.794
7/31/2018 1:03 PM	0.920	-0.050
9/19/2018 11:47 AM	-0.175	0.138
10/31/2018 12:08 PM	0.125	-0.563
12/20/2018 11:52 AM	0.319	-0.715
1/23/2019 11:59 AM	0.320	0.341
3/15/2019 11:39 AM	0.319	-0.715
4/25/2019 12:27 PM	0.072	-0.794
6/20/2019 11:45 AM	0.441	-2.342
7/30/2019 11:55 AM	0.372	-0.484
9/19/2019 11:49 AM	1.120	0.989
10/31/2019 12:32 PM	0.267	0.110
12/19/2019 11:45 AM	-0.033	-0.200
1/21/2020 12:01 PM	-0.033	-0.200

(4) the resumption of QE, (5) the introduction of Comprehensive Monetary Easing, (6) the introduction of 1 percent of the Price Stability Goal in the Medium to Long Term, (7) the introduction of 2 percent of the Price Stability Target, (8) the introduction of QQE, (9) expansion of QQE, (10) the introduction of the negative interest rate policy, (11) the introduction of QQE with YCC.